US Army Corps of Engineers®
New York District

New York and New Jersey Harbor Deepening Channel Improvements

Navigation Study

Integrated Feasibility Report & Environmental Assessment

APPENDIX C:

Economic Analysis

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1. Introduction

This document presents the results of the economic evaluation performed for the New York and New Jersey Harbor Deepening Channel Improvement (NYNJHDCI) project. The Planning Guidance Notebook (ER 1105-2-100) was referenced in performing this economic analysis. The recommended was selected and justified based on National Economic Development (NED) benefit analysis. NED benefits are contributions to National Economic Development that increase the value of the national output of goods and services. The U.S. Army Corps of Engineers (USACE) New York District under the direction of the Deep Draft Navigation Planning Center of Expertise (DDNPCX) performed this analysis.

1.1. Study Purpose and Scope

The purpose of this study is to evaluate Federal interest in alternative plans (including the No-Action Plan) for reducing transportation costs and addressing navigation safety issues for the Port of New York & New Jersey and assess the effects of the alternatives on the natural system and human environment, including economic development. The economic analysis focuses on the overall efficiency of the system and comparison of transportation costs.

The current Federally authorized channel depth of the Port of New York & New Jersey is -50 feet mean lower low water (MLLW). Potential navigation improvements include deepening and widening of navigation channels. The purpose of these improvements is to increase the efficiency of vessel operations in the Port of New York & New Jersey. This study identifies and evaluates alternatives that will:

- Accommodate current and anticipated future growth in both containerized cargo volume and containership size and call frequency; and
- Improve the efficiency of operations for containerships calling the Port of New York & New Jersey

The period of analysis is 50 years. The planning horizon starts in year 2040 and ends in year 2089. Final benefit-cost analysis uses the vessel operating cost from the Economic Guidance Memorandum (EGM) 20-04 Deep Draft Vessel Operating Costs, 2021 Price Levels, and the Federal discount rate from EGM, 21-01, Federal Interest Rates for Corps of Engineers Projects for Fiscal Year (FY) 2021 of 2.5 percent[1]. NED benefits in the economic analysis are derived from transportation cost savings.

1.2. Data Sources and Uses

Data was collected from multiple sources to characterize the existing conditions for the analysis. Where possible, analysis confirms data across multiple sources; however, vessel operating data is subject to error, gaps, and limitations. The following data sources were used:

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[1] Initial alternatives analysis (Section 5.4. uses FY20 Federal Discount Rate and October 2019 price level. The recommended plan is updated to the FY21 discount rate and October 2020 price level.

- Waterborne Commerce Statistics Center
- National Navigation Operation & Management Performance Evaluation & Assessment System (NNOMPEAS)
- Port Authority of New York and New Jersey (PANYNJ)
- Sandy Hook Pilots Association

For the purposes of economic analysis, the Port of New York & New Jersey was represented in the HarborSym model. HarborSym is a planning-level simulation model designed to assist in the economic analyses of coastal harbors. Using this model, analysts can calculate the cost of any changes in overall transportation costs resulting from proposed modifications. Full methodology and model behavior are presented in Section 5.1.

2. Existing Condition

The existing conditions are defined in this report as the project conditions that exist as of 2018 plus any changes that are expected to occur prior to the base year, 2040[2]. The year 2018 is the most recent year for which complete data was obtained for containerized cargo volumes and fleet composition. Empirical data from 2009 to 2018 was used in the development of the commodity and fleet forecast to capture economic highs and lows in the forecast baseline[3].

2.1. Economic Study Area

The Port of New York & New Jersey is the largest East Coast container port and third largest US container port by twenty-foot-equivalent units (TEU) volume (USACE, 2019). The Port is comprised of both public and private terminals located in New York and New Jersey and is capable of handling containers, roll on-roll off (Ro-Ro) automobiles, liquid and dry bulk, breakbulk, and specialized project cargo. The port serves approximately 80 million consumers, primarily in the New York-New Jersey metropolitan area but extending to markets in New England, Mid Atlantic, Midwest, and other locations West of the Mississippi.

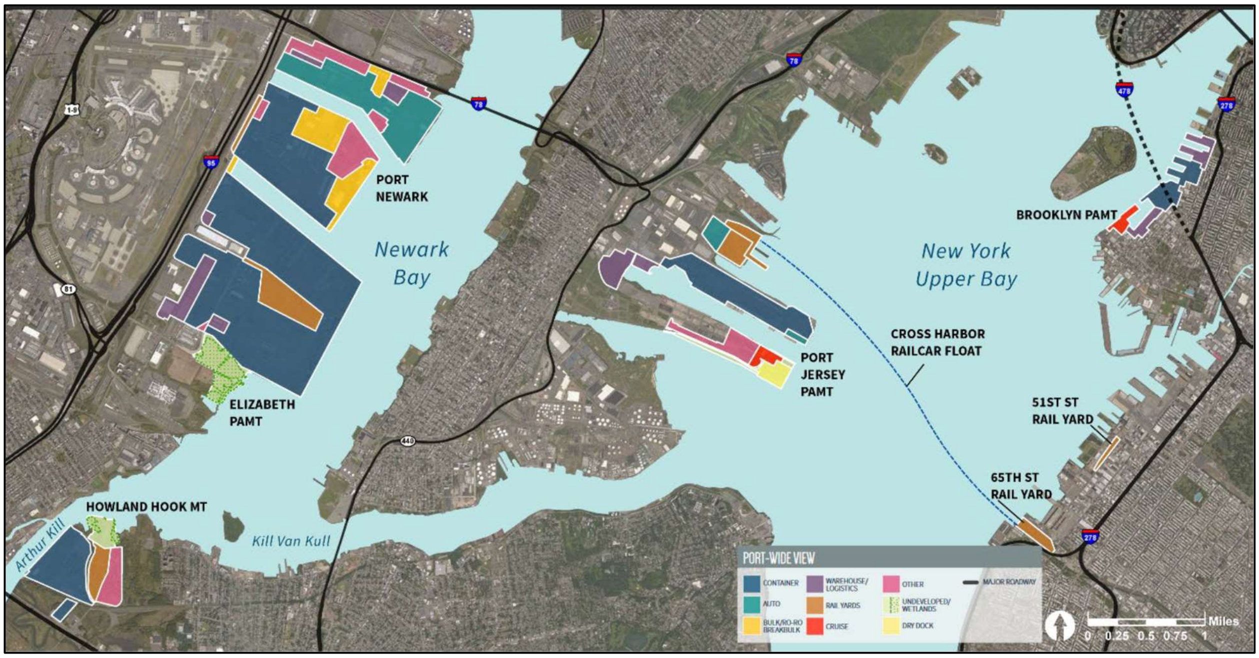
Of the approximately 51 marine terminals located in the study area, 22 facilities (43 percent) handle dry cargo and 29 (57 percent) facilities primarily handle liquid bulk cargo. Significant liquid bulk terminals include Bayway Terminal, International Matex Tank Terminals (IMTT) Bayonne, Buckeye Terminals, NuStar-Linden Terminal, and Shell Terminals.

Most dry cargo handled at the Port of New York & New Jersey is containerized. Major container terminals included in this study are Elizabeth-Port Authority Marine Terminal (EPAMT), Port Jersey-Port Authority Marine Terminal (PJPAMT), and Port Newark. Navigation improvement to Howland Hook were considered but removed from evaluation based on lack of potential benefits.

[2] Initial analysis assumes a base year of 2039. Final analysis uses a base year of 2040.
[3] Historical trade data from 2009 to 2018 captures economic downturn from the Great Recession (2009) and expansion through 2018, the most recent available year of data at the time of analysis.

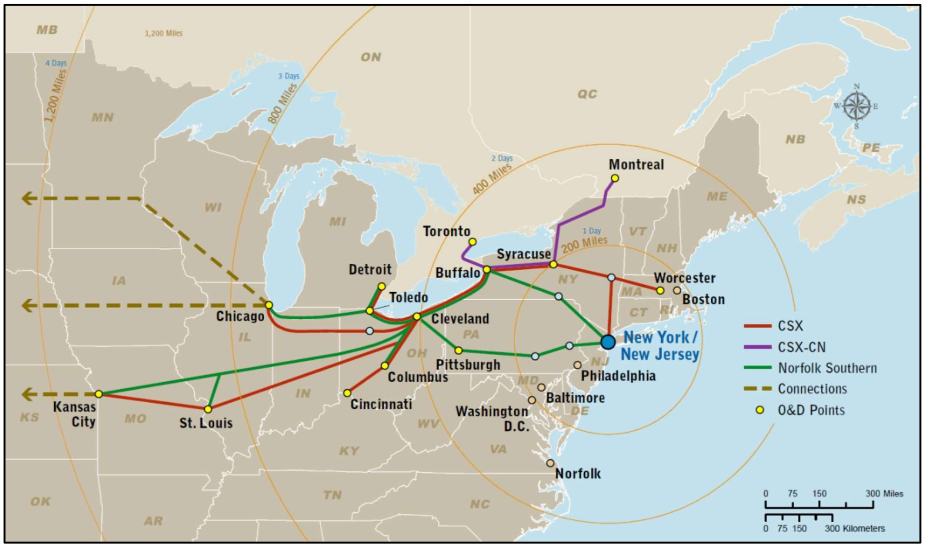
Figure 1 identifies container facilities in the study area (blue).

Figure 1: The Port of New York & New Jersey Layout



The Port of New York & New Jersey terminals are accessible via rail or truck. The rail system includes ExpressRail which connects to Regional Rails, which has dedicated facilities and additional support track and rail yards for each of the port's major container terminals. The New York and New Jersey region is served by three Class 1 railroads: Canadian-Pacific, CSX Intermodal and Norfolk Southern. The trucking and roadway network has capacity sufficient to reach 100 million consumers within a day. The port is located within 700 miles of major cities and population centers in the Northeast. Figure 2 depicts the rail network between the Port of New York & New Jersey and major inland population centers

Figure 2: The Port of New York & New Jersey Rail Network (PANYNJ, 2020)



2.1.1. Port Facilities

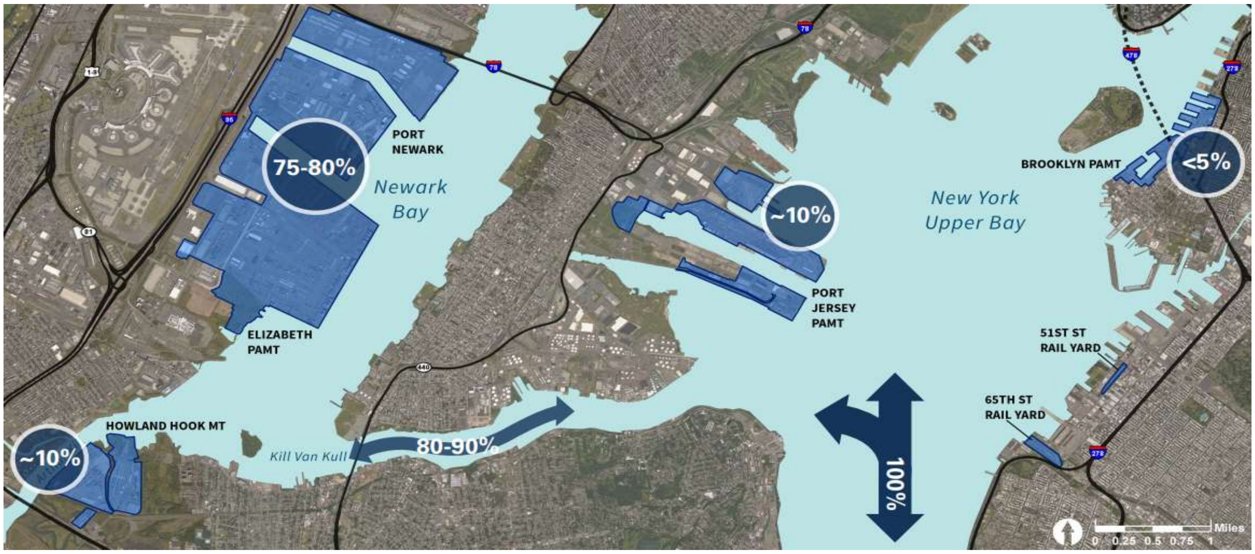
This study evaluates improvements for vessels calling six container terminals within the Port of New York & New Jersey: Red Hook Container Terminal[4], Global Container Terminal Bayonne, Global Container Terminal New York/Howland Hook[5], APM Terminal, Maher Terminal and Port Newark Container Terminal. Container facilities are leased by PANYNJ to individual terminal operators. The terminals are the first port of call for approximately 72 percent of vessels calling the East Coast. The terminals serve 23 ocean carriers including all the major global alliances as well as 11 independent carriers.

Estimated annual throughput capacity at all container terminals in the Port of New York & New Jersey is approximately 9 million TEUs. Current containerized cargo capacity is between 75 to 80 percent of capacity at EPAMT, approximately 10 percent of cargo at Howland Hook and PJPAMT, and less than 5 percent at Brooklyn PAMT. Figure 3 shows the current container terminal capacity distribution.

[4] Red Hook Container Terminal was not considered for channel improvements. The economic analysis included in the existing condition includes Red Hook throughput for a complete evaluation of the Port of New York and New Jersey. Red Hook is removed from consideration in subsequent sections.

[5] Initial evaluation of Howland Hook revealed low potential economic benefits and relatively high costs of improvements. The Terminal was screened out of consideration but may be further evaluated in subsequent analysis.

Figure 3: Current Container Terminal Capacity Distribution



2.1.1.1. Red Hook Container Terminal

The Red Hook Container Terminal is located on the east side of the Anchorage channel in Brooklyn, New York. The terminal handles containers, breakbulk and Ro-Ro vessels. It sits on approximately 65 acres with berths at -42 feet Mean Low Water (MLW). The terminal has five cranes with an outreach of up to 150 feet. The ship berth has an alongside length of 2,080 feet. The Red Hook Terminal connects to Express Rail Elizabeth via barge service. The scope of this study is limited to the currently constructed -50 feet MLLW channel. Because the channel segment leading to Red Hook Container Terminal in New York was not included in the -50 feet MLLW deepening project, it was screened from further consideration for this study.

Figure 4 and Figure 5 display the inbound and outbound sailing drafts, respectively, for vessels calling the Red Hook Container Terminal. Table 2-1 displays the historical inbound and outbound tonnage.

Figure 4: Inbound Sailing Drafts, Red Hook Container Terminal

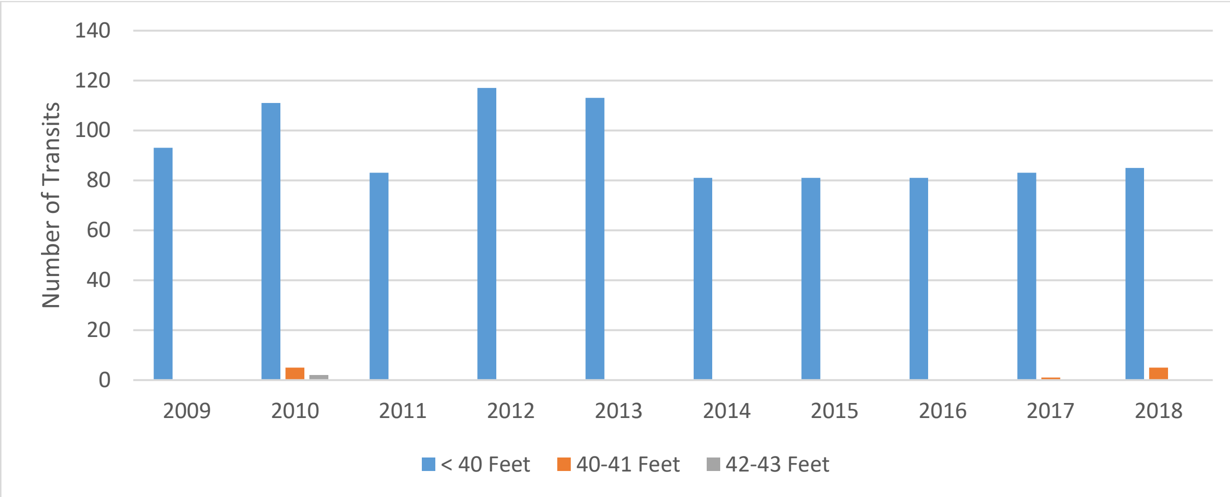


Figure 5: Outbound Sailing Drafts, Red Hook Container Terminal

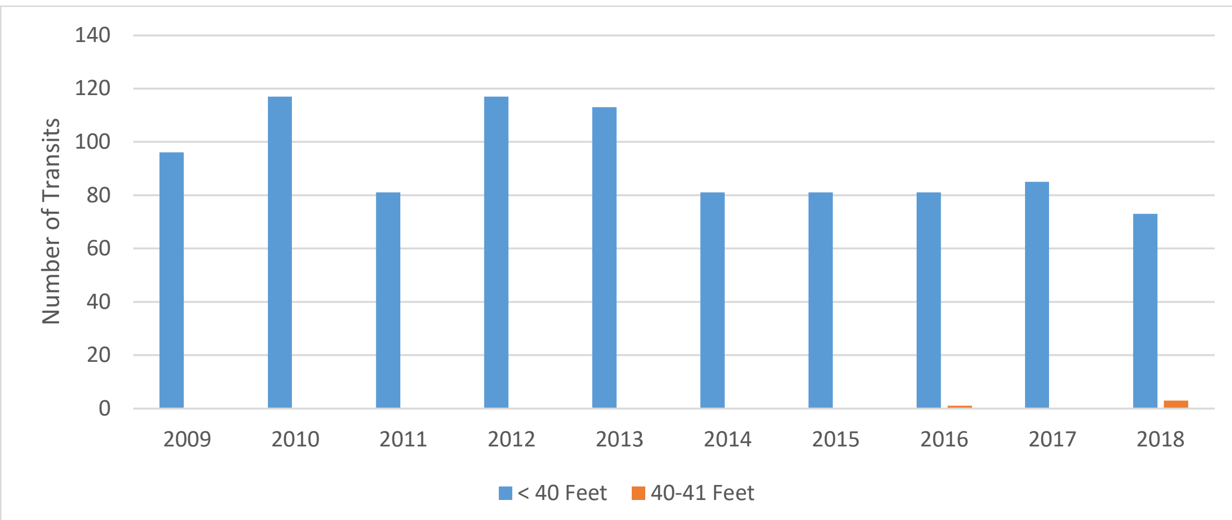


Table 2-1: Historical Containerized Tonnage, Red Hook Container Terminal (1,000 Metric Tons)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Imports	188	581	217	206	239	368	430	400	451	594
Exports	215	336	197	292	238	187	250	297	345	271

2.1.1.2. Global Container Terminal (GCT), Bayonne

GCT Bayonne is a 169-acre facility with 2,700 feet of berth length. There are eight container cranes: two super Post-Panamax with 203-foot outreach, two Post-Panamax cranes with 185-foot outreach and two Post-Panamax cranes with 180-foot outreach. The berth is -50 feet MLLW.

GCT is the closest container terminal to the harbor entrance. Rail service is provided by both the CSX and the Norfolk Southern Railroads. The terminal has direct access to the New Jersey

Turnpike and is minutes away from bridges connecting to New York, Long Island, and the Northeast. The facility currently has three calling services: Hapag-Lloyd, Ocean Network Express, and Yang Ming. The facility has an annual throughput capacity of approximately 600,000 container lifts.

Figure 6 and Figure 7 display inbound and outbound sailing drafts for vessels calling the GCT Bayonne Terminal.

Table 2-2 presents historical inbound and outbound tonnage.

Figure 6: Inbound Sailing Drafts, GCT Bayonne

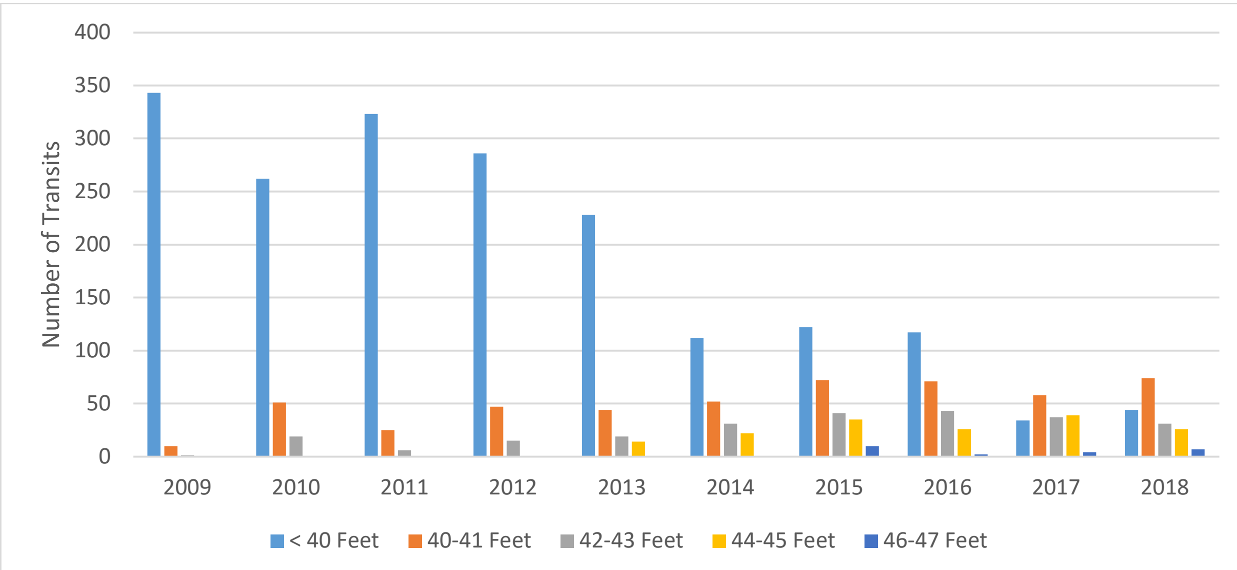


Figure 7: Outbound Sailing Drafts, GCT Bayonne

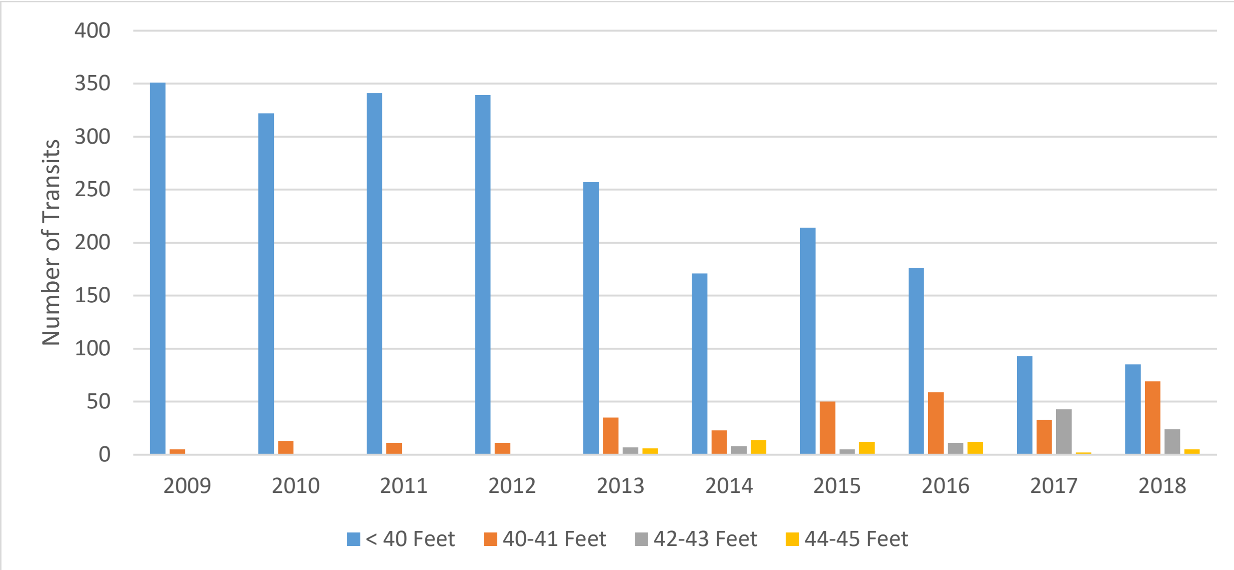


Table 2-2: Historical Containerized Tonnage, GCT Bayonne (1,000 Metric Tons)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Imports	2,087	2,333	2,732	2,921	2,990	3,670	5,105	4,299	3,720	3,203
Exports	967	1,145	1,384	1,165	1,238	1,494	1,558	1,425	1,526	1,254

2.1.1.3. Global Container Terminal (GCT), New York

The Global Container Terminal (GCT) New York is a 187-acre facility located at Howland Hook Marine Terminal, near the Goethals Bridge in Staten Island, New York. It has six ship-to-shore Post-Panamax cranes, with an outreach of up to 135 feet. It has a berthing length of 3,012 feet. The terminal is equipped with an expanded on-dock rail transfer service operated by ExpressRail Staten Island (ESI), which has 5 tracks totaling 6,000 linear feet. GCT New York has access to I-278, Route 440, I-95, I-78, Route 1, and Route 9 and is minutes away from bridges connecting to the tri-state area and the Northeast. The terminal has 7 ocean carrier services: ACL, Hapag Lloyd, Sealand, Grimaldi, Yang Ming, Hamburg Sud, and Ocean Network Express. Initial economic analysis and discussion with terminal operators indicated a low potential for benefits and high cost of improvements. As a result, the terminal was screened from further analysis.

Figure 8 and

Figure 9 display inbound and outbound sailing drafts for vessels calling the GCT Bayonne terminal. **Table 2-3** displays the historical inbound and outbound tonnage.

Figure 8: Inbound Sailing Drafts, GCT New York

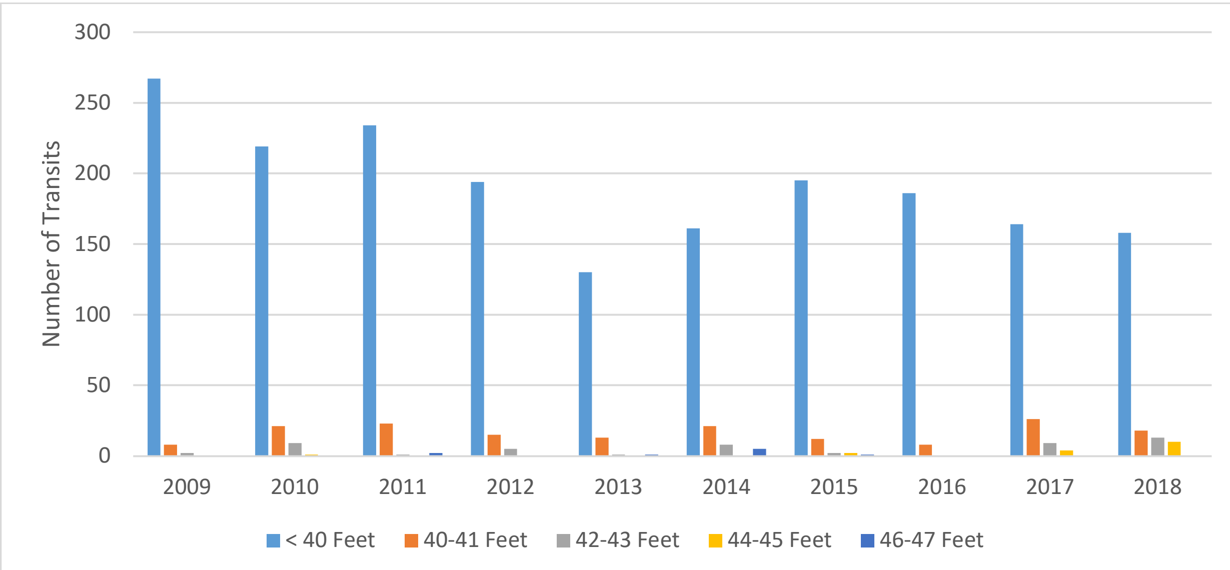


Figure 9: Outbound Sailing Drafts, GCT New York

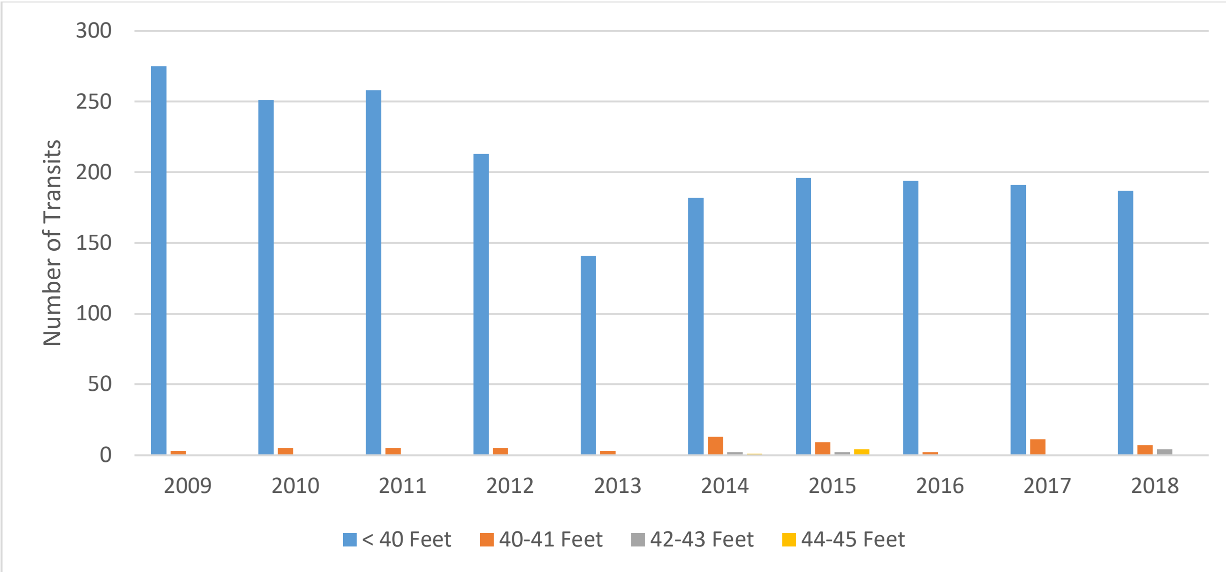


Table 2-3: Historical Containerized Tonnage, GCT New York (1,000 Metric Tons)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Imports	2,454	2,667	2,701	2,110	1,087	1,233	1,262	857	1,542	1,705
Exports	994	1,104	1,084	940	509	608	646	534	711	888

2.1.1.4. APM Terminals

The APM Terminal is a 350-acre facility located at the EPAMT in Elizabeth, New Jersey. The terminal is less than one mile from the New Jersey Turnpike, as well as Route 1 and Route 9, and less than two miles from I-78. The terminal has 15 ship-to-shore Post-Panamax cranes: four Super Post-Panamax cranes 206-foot outreach and 11 Post-Panamax cranes with 140-foot outreach. The terminal has a berthing length of 6,001 feet at -50 feet MLLW and a throughput capacity of approximately 2.3 million TEUs. APM terminal is adjacent to the ExpressRail Elizabeth (EMT). Vessels from sixteen ocean carriers service the terminal: ACL, CMA-CGM, COSCO, Evergreen, Hamburg Sud, Hapag Lloyd, Hyundai, Maersk, MSC, Nile Dutch, NYK, OOCL, Safmarine, Sealand, Turkon, and Zim Line. A 2018 berth modernization brought the berth depth to -50 feet MLLW with capacity for simultaneous berthing of up to four ULCV. Figure 10 and

Figure 11 display inbound and outbound sailing drafts for vessels calling at APM Terminal.

Table 2-4 shows historical tonnage.

Figure 10: Inbound Sailing Drafts, APM Terminal

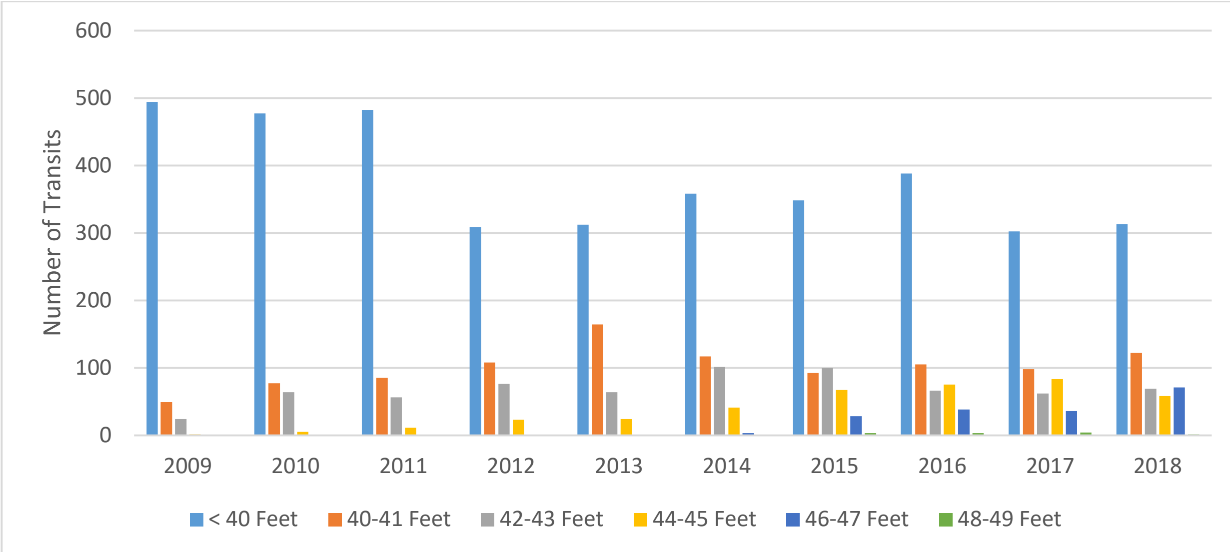


Figure 11: Outbound Sailing Drafts, APM Terminal

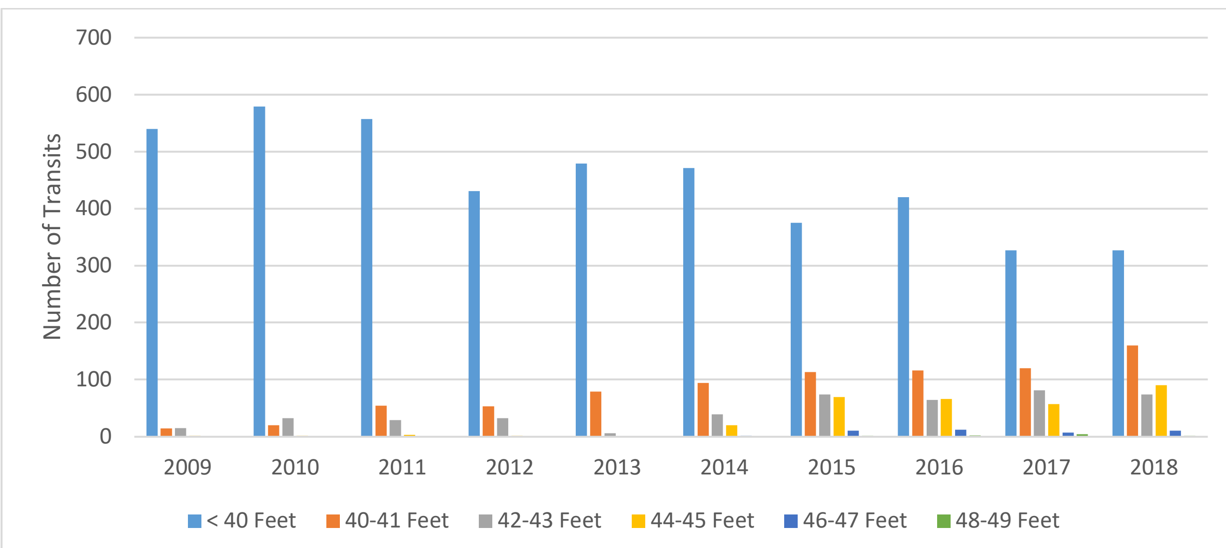


Table 2-4: Historical Containerized Tonnage, APM Terminal (1,000 Metric Tons)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Import	4,755	4,668	5,303	5,776	6,349	7,173	7,260	6,635	7,106	8,293
Export	3,016	2,806	3,464	3,525	3,554	3,535	3,737	3,895	3,483	4,371

2.1.1.5. Port Newark Container Terminal (PNCT)

The Port Newark Container Terminal (PNCT) is a 272-acre facility at the Port Newark in New Jersey. It has 13 Post-Panamax Class ship-to-shore cranes; seven accommodating the Super Post-Panamax vessels with an outreach of up to 225 feet and six accommodating the Post-Panamax vessels with an outreach of up to 200 feet. Moreover, PNCT has a total berthing area of 4,400 linear feet. PNCT has 2,650 linear feet of berth at -50ft depth, 1,150 feet with -41ft depth, and 1,000 linear feet with -35ft depth. PNCT currently serves 7 ocean carriers: Hamburg Sud, Hyundai, Maersk, MSC, Safmarine, Sealand, and ZIM. The depth at the berth ranges from -40 to -50 feet MLW.

At its current configuration, PNCT has a throughput capacity of approximately 1.3 million TEUs. Currently, the terminal moves 25% of its vessel container volume via rail. Additional improvements are planned for the terminal, including a new gate complex, increasing terminal capacity, and improving peak crane handling. PNCT plans to expand the terminal by developing 50 additional acres, deepening the berthing area, and upgrading the container handling equipment, including additional super Post-Panamax ship-to-shore cranes. It has a long-term lease agreement with the PANYNJ through the year 2050. Figure 12 and Figure 13 display the sailing drafts for vessels calling at PNCT. Table 2-5 displays historical tonnage for PNCT.

Figure 12: Inbound Sailing Drafts, PNCT

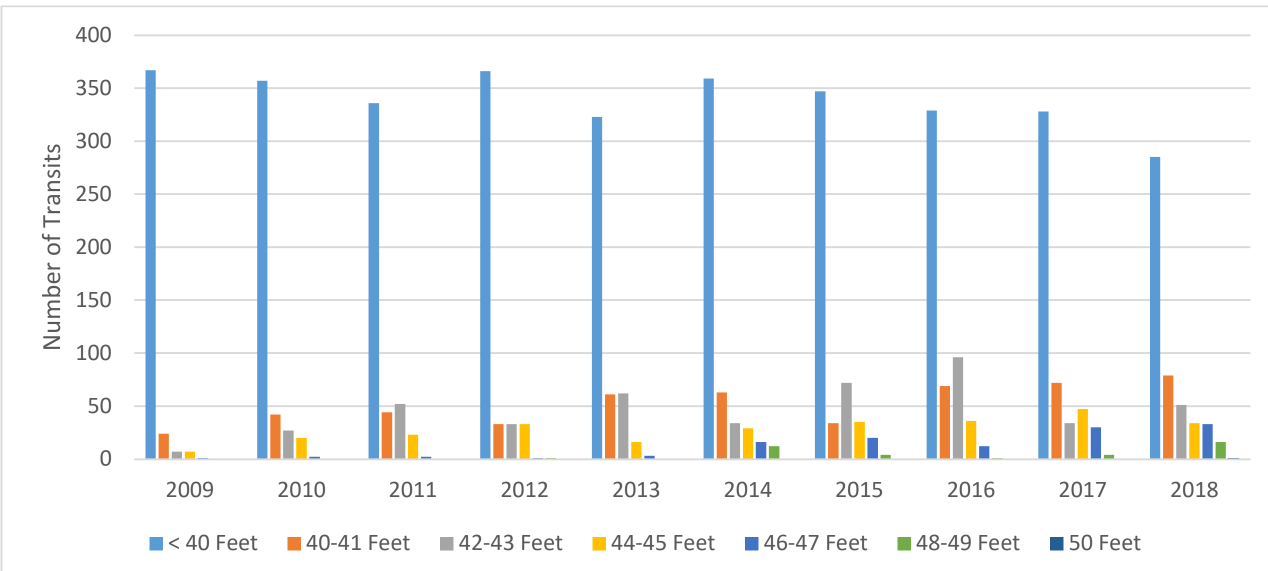


Figure 13: Outbound Sailing Drafts, PNCT

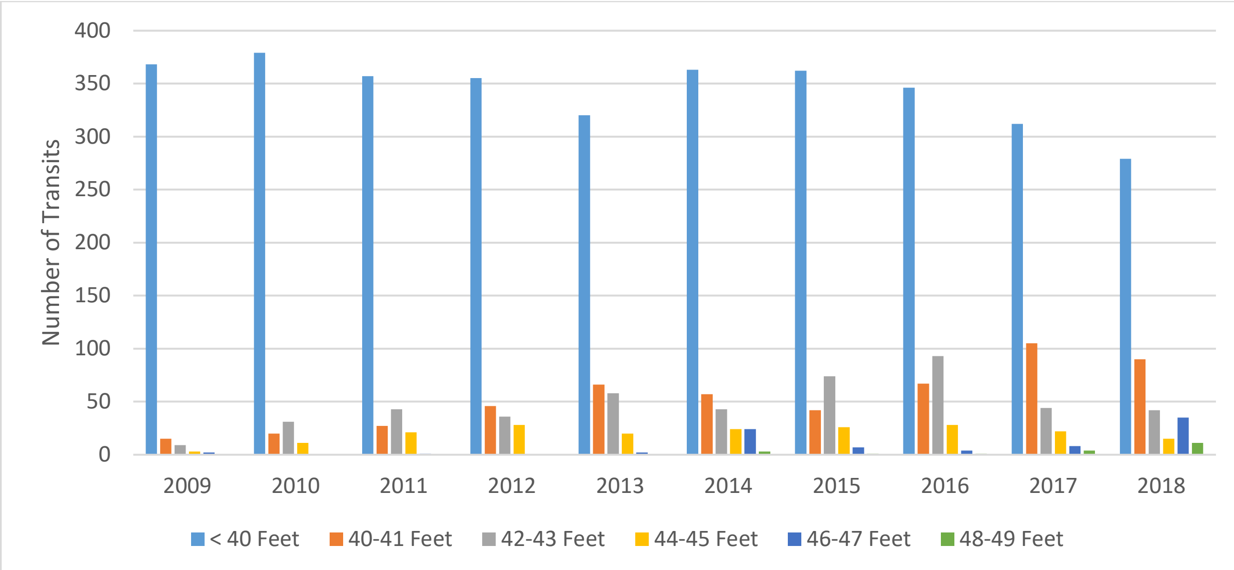


Table 2-5: Historical Containerized Tonnage, PNCT (1,000 Metric Tons)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Imports	2,806	3,910	4,514	4,858	4,704	4,893	5,053	4,801	6,127	6,187
Exports	2,047	2,592	2,957	3,209	3,047	2,670	2,178	2,539	2,545	2,627

2.1.1.6. Maher Container Terminal

The Maher Container Terminal is a 450-acre facility located at EPAMT in Elizabeth, New Jersey. It has 24 ship-to-shore Post-Panamax cranes; among them, eight are Super Post-Panamax cranes with an outreach of up to 225 feet and 16 are Post-Panamax cranes with an outreach of up to 200 feet. In addition, it has a total berthing length of 10,128 feet. The Maher Container Terminal is immediately adjacent to the Express Rail Elizabeth (EMT), which has 18 working tracks totaling 43,000 linear feet. The Maher Container Terminal services 14 ocean carriers, including: ACL, APL, Bermuda Container, CMA-CGM, COSCO, Evergreen, Hamburg Sud, Hapag Lloyd, K Line, MOL, OOCL, UASC, Yang Ming, and Zim Line. The depth at the berth is -50 ft MLW.

Figure 14 and Figure 15 display sailing drafts for vessels calling at Maher Container Terminal. Table 2-6 shows historical tonnage.

Figure 14: Inbound Sailing Drafts, Maher Container Terminal

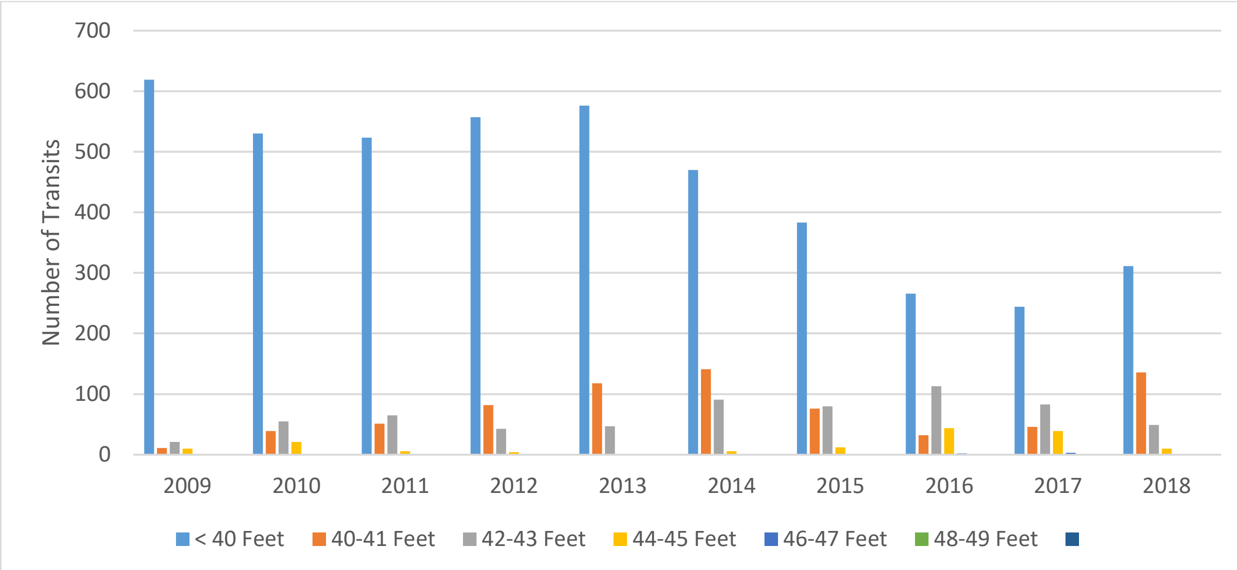


Figure 15: Outbound Sailing Drafts, Maher Container Terminal

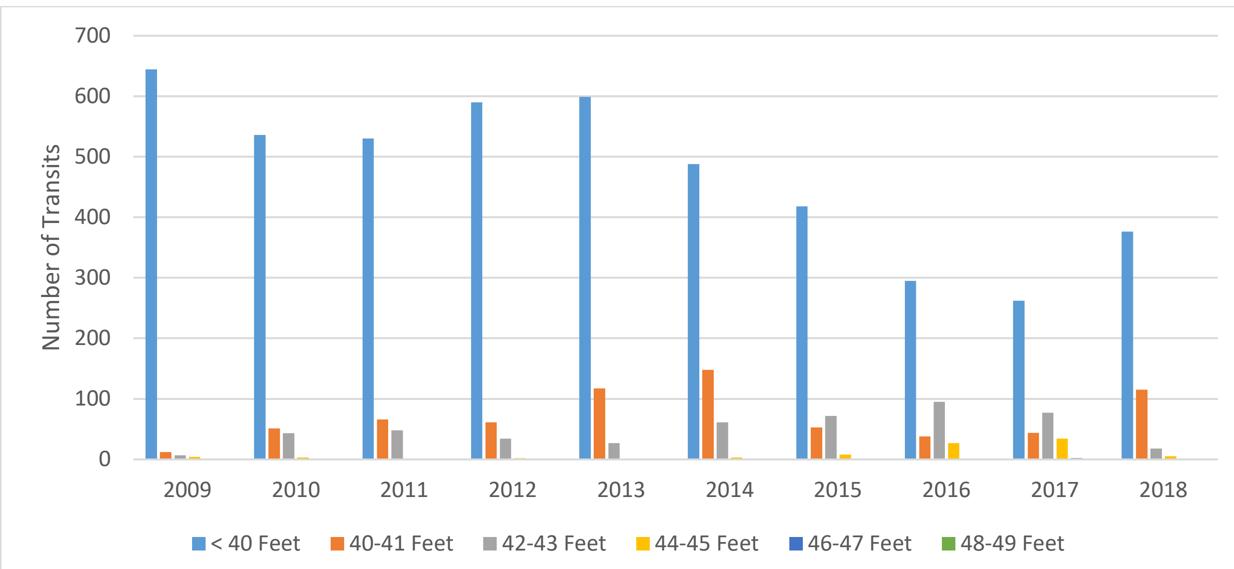


Table 2-6: Historical Containerized Tonnage, Maher Container Terminal (1,000 Metric Tons)

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Imports	4,802	5,504	5,270	5,740	5,731	6,245	6,096	6,590	8,185	9,669
Exports	2,866	3,710	3,562	3,481	3,122	3,231	3,275	3,301	3,807	3,312

2.1.2. Hinterland

The Port of New York and New Jersey is the third largest container port in the U.S., and the largest U.S. container port on the Atlantic Coast. The container terminals at the harbor serve two import markets: the primary, local truck market and the secondary, inland discretionary market. The latter is referred to as discretionary because it requires the Port to compete with other

Atlantic Coast ports for market share. As of 2016, approximately 85 percent of the Port's container market was a captive local truck market. The remaining balance consists of railing containers to inland discretionary markets that are also being served by other ports. Figure 17 shows the local truck market.

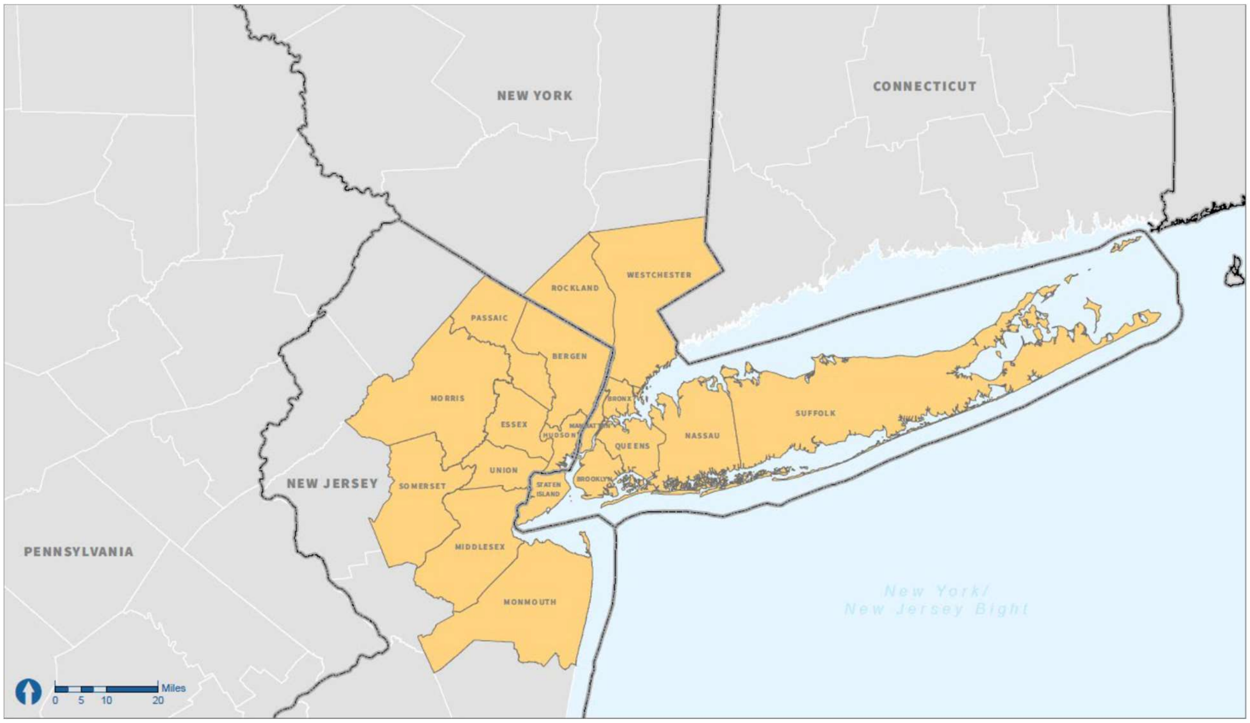


Figure 16. Local Truck Market

2.1.3. Distribution Centers

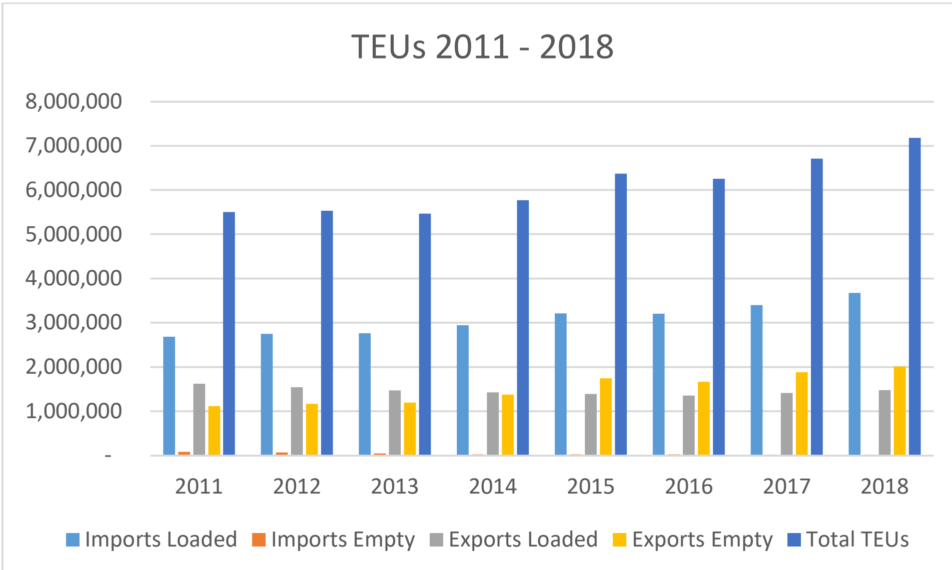
Approximately 1 billion square feet of warehousing and distribution space is located within 50 miles of the port. These facilities serve as a gateway for products headed to 13 million consumers in one hour, 27 million consumers in two hours, and 44.7 million within four hours. These facilities include:

- TRT International Ltd.
- Harbor Freight Transport
- Eastern Warehouse
- East Coast Warehouse & Distribution Corp.
- New York Container Terminal Inc.
- Red Hook Container Terminal; and
- Courier Systems

2.1.4. Cargo Profile

The Port of New York & New Jersey handled approximately 7.2 million TEUs in 2018 and ranks third in the United States in terms of total containerized volume exported and imported. The largest containerized import volumes are furniture followed by machinery & appliances, then plastic and beverages. The largest containerized export volumes are wood pulp followed by vehicle parts, plastic, and wood. The largest import and export trading partner in terms of volume is China followed by India. Germany and Spain are the third largest trading partners for imports and exports in terms of volumes, respectively. Figure 17 shows historical TEU volumes.

Figure 17: The Port of New York & New Jersey TEUs, 2011-2018

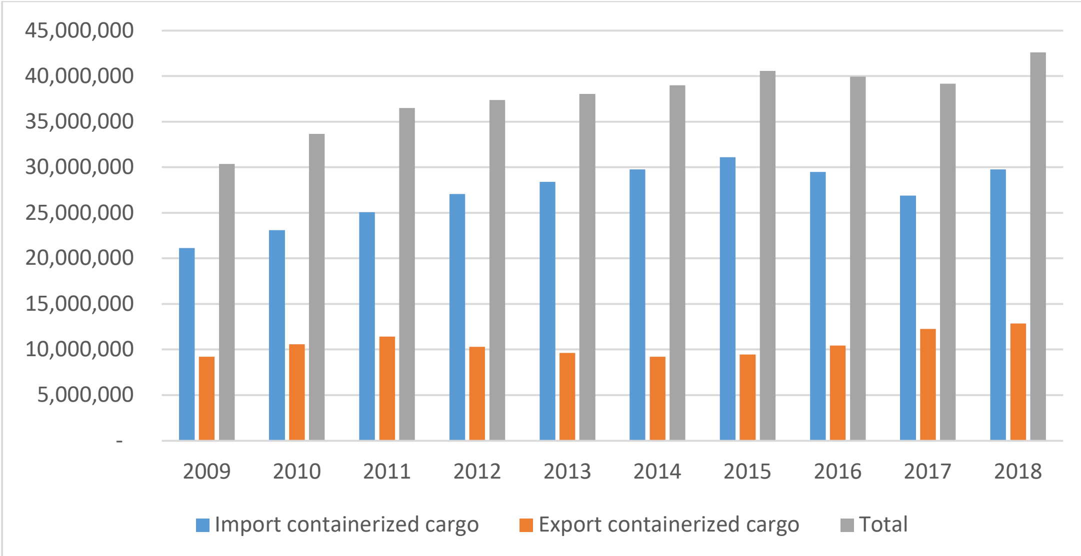


2.2. Historical Commerce

The Port of New York & New Jersey captures 53.5 percent of the North Atlantic market share, 32.8 percent of the East Coast market share and 15.9 percent of the U.S. market share. The Port is a net importer. The Port of New York & New Jersey is the first call for approximately 72% of all carrier services on the East Coast. The port is in the heart of the New York metropolitan region and provides access to 27 million local consumers. In addition, the Port's rail connections allow shippers to reach another 98 million consumers in destinations as far away as the Ohio Valley, Midwest, and Canada.

Based on data for years 2009 to 2018, foreign shipments averaged approximately 37.7 million metric tons. Of this total, imports accounted for approximately 27 million metric tons, or 72 percent, while exports accounted for 10.5 million tons, or 28 percent. Figure 18 shows historical containerized metric tonnage moving through the Port of New York & New Jersey.

Figure 18: The Port of New York & New Jersey Historical Containerized Tonnage, 2009-2018



Source: PANYNJ Data

2.3. Fleet Composition

Data for the container fleet was obtained from Waterborne Commerce Statistics Center, the National Navigation Operation & Management Performance Evaluation Assessment System (NNOMPEAs) and the Port Authority of New York & New Jersey to determine vessel characteristics of the fleet calling the port. The Port is a multi-use port and receives calls from bulkers, containerships, general cargo vessels, passenger vessels, RoRo vessels, and tankers. Non-containerized vessels transported approximately 50 percent of all cargo in 2018. Table 2-7 provides total cargo distribution for all facilities within the study area by vessel type. Behind containerships, tankers carry the most cargo as a percent of total throughput at the Port of New York & New Jersey.

Table 2-7: 2018 Port of New York & New Jersey Vessel Calls by Type

Vessel Type	Percent of Throughput Tonnage Carried	2018 Total Vessel Calls Estimate*
Bulker	7%	275
Containership	50%	2,206
General Cargo	0%	67
Other	0%	33
Passenger	0%	123
RoRo	1%	560
Tanker	40%	1,128
Total	**100%**	**4,238**

*NNOMPEAS estimates to determine vessel distribution. Actual calls may vary.

The focus of this economic evaluation is on benefits related to containerships. Containerships are classified as sub-Panamax, Panamax, Post-Panamax Generation I (PPX Gen 1), Post-Panamax Generation II (PPX Gen 2), Post-Panamax Generation III (PPX Gen 3) and Post-Panamax

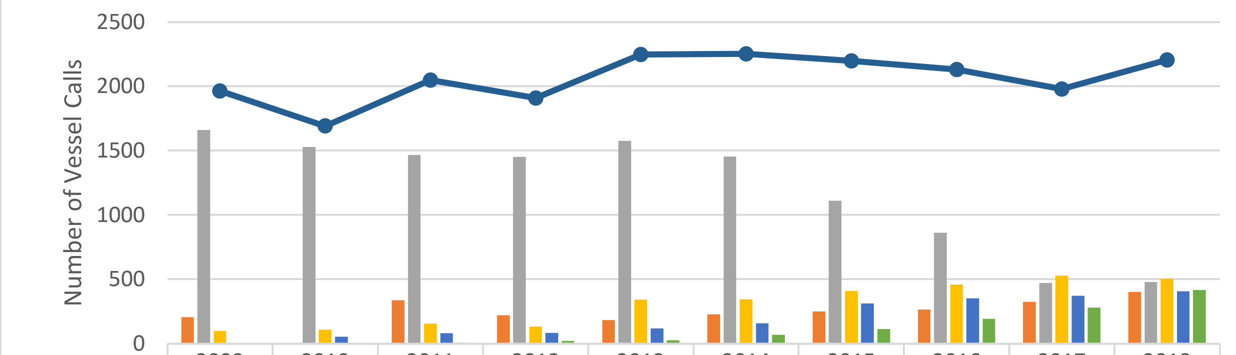
Generation IV (PPX Gen 4). The vessels are distinguished based on physical and operation characteristics, including lengths overall (LOA), design draft, beam, speed and TEU capacity. Containership classes overlap in all facets of dimensions, such as length, beam, depth, and TEU capacity. Table 2-8 shows the breakdown of the containership class sizes used in this evaluation. For the purposes of this analysis, beam width separates classes. The Port and industry tend to use the terms "very large container vessel (VLCV)" to describe vessels with TEU capacity between 11,000 and 15,000 TEU and "ultra large container vessel (ULCV)" to describe vessels with TEU capacity of 18,000 to 21,000 TEU. These industry classes roughly correspond with PPX3 and PPX4 vessel class, respectively.

Table 2-8: Containership Classes

Class	DWT (metric tons)	LOA (feet)	Beam (feet)	Design Draft (feet)
Sub-Panamax (SPX)	6,500 – 40,000	390 - 730	65 - 103	20 - 40
Panamax (PX)	24,000 – 69,000	558 - 930	105 - 107	27 - 45
Post-Panamax Generation 1 (PPX1)	71,200 – 80,900	930 – 1,000	108 - 133	45 - 47
Post-Panamax Generation 2 (PPX2)	80,901 – 110,000	1,026 – 1,100	134 - 145	46 - 49
Post-Panamax Generation 3 (PPX3)	117,500 – 144,500	1,100 – 1,200	149 - 177	49 - 51
Post-Panamax Generation 4 (PPX4)	150,000 – 194,600	1,201 – 1,308	178 - 194	51 – 52.5

Figure 19 shows historical trends in containership vessel sizes and fleet composition for the Port. As shown, Sub-Panamax vessels continue to be used at a relatively consistent rate. Panamax vessels show a dramatic reduction as larger Post-Panamax vessels have begun to experience more frequent use. The most significant change in vessel size comes with the growth in PPX2 and PPX3 class vessels from 2011 to 2018. As of 2018, 60 percent of calls are from Post-Panamax vessels compared with only 5 percent of calls in 2009.

Figure 19: Containership Vessel Trends



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
SPX	206	0	338	221	184	228	250	264	325	402
PX	1660	1529	1467	1452	1577	1453	1110	863	472	478
PPX1	98	109	156	134	342	344	410	459	528	504
PPX2	0	54	82	83	117	159	313	352	372	406
PPX3	0	0	5	20	27	69	114	192	281	416
Total	1,964	1,692	2,048	1,910	2,247	2,253	2,197	2,130	1,978	2,206

2.4. Container Services

The Port of New York & New Jersey received 40 weekly services and 54 total services in 2019. Table 2-9 shows the service count by region.

Table 2-9: Container Services

World Region	Service Count
Asia	11
Indian Subcontinent & Southeast Asia	10
Europe and Mediterranean Region	16
South America and Caribbean	17

Table 2-10 provides a list of all US ports that share a service with the Port of New York & New Jersey. Major US East Coast ports on container services also calling New York include Norfolk Harbor (-50 feet MLLW), Charleston Harbor (-47 feet MLLW), and Savannah Harbor (-48 feet MLLW).

Table 2-10: US Port Channel Depth and Improvements

US Port[6]	Depth (ft MLLW)
Norfolk	50
Savannah	48
Los Angeles/Long Beach	54
Oakland	50
Charleston	47
Baltimore	50
Port Everglades	42
Philadelphia	42
Houston	45
Miami	50
Boston	38
Wilmington, NC	42
Wilmington, DE	40
San Juan (PR)	39
Jacksonville	41

2.5. Route Groups

In 2019, the Port of New York & New Jersey received calls from 54 unique ocean carrier services. These services were aggregated into four primary route groups for forecasting, modeling, and presentation purposes based on world regions and fleet mix. Vessel service information was provided by the Port. Port and NNOMPEAS data were used to create general route groups. Table 2-11 shows the regions, route groups, and the distance of each route. The largest vessels tend to be deployed on Transatlantic routes servicing the Mediterranean and US East Coast, followed by Transpacific Routes with stops along the US East Coast. The smallest vessels (sub-Panamax class) are utilized on the services calling Africa, South America, and the Caribbean.

Each route group has unique characteristics such as cargo volume, cargo weight, ports of call, vessel types, and mix of vessels. Therefore, each route group is evaluated separately before being combined into one forecast.

[6] Depths based on IHS Maritime & Trade Sea-web Tool’s max draft. Actual channel depths and berth depths may differ.

Table 2-11: Route Group Information

Route Group Regions	Route Group Name	Distance Distribution		
		Min.	Most Likely	Max.
Africa – South America – Caribbean – Gulf of Mexico - East Coast United States	AF-SA-CAR-ECUS	1,450	7,300	16,100
Europe – Mediterranean – East Coast United States	EU-MED-ECUS	6,300	7,500	11,500
East Asia – Panama Canal – East Coast United States, including pendulum routes	EA-PAN-ECUS	19,400	29,800	31,900
East Asia – Indian Subcontinent – Southeast Asia – Suez Canal – East Coast United States	EA-SUEZ-ECUS	16,900	25,300	31,400

The cargo distribution by route group is the average cargo portion for the Port of New York and New Jersey from 2013 through 2017. Table 2-12 shows the cargo distribution used for the study. As shown, approximately 37 percent and 67 percent of cargo from Asia is routed through the Panama Canal and Suez Canal, respectively.

Table 2-12. Cargo Throughput by Route Group

Route Group	Percent Total Throughput
Africa-South America-Caribbean-US East Coast	5%
Europe-Mediterranean-US East Coast	31%
Asia-US East Coast via Panama Canal	24%
Asia-US East Coast via Suez Canal	40%

Recent shifts in production from China to Southeast Asia have the potential to shift more tonnage onto Suez Canal routes given the shorter distance through the Suez Canal from Ports in Southeast Asia. Table 2-13 provides a summary of the percent of throughput tonnage at NYNJ with an origin or destination of China versus Southeast Asia and India.

Table 2-13. Cargo by Origin (Port of NYNJ Cargo Data)

Country of Origin	2013	2014	2015	2016	2017	2018	2019	2020
China	31.8%	31.2%	31.3%	30.9%	31.3%	31.7%	28.5%	26.6%
S/E Asia and India	17.2%	18.0%	19.0%	19.4%	19.7%	20.1%	23.0%	24.8%

Importantly, distance is not the only consideration in vessel routing. Transit rates for the Panama versus Suez Canal and specific port rotations can influence carriers when choosing between canals. Additionally, vessels transiting the Suez over the Panama Canal are still limited by East Coast port capacity.

Evidence provided by the Port shows a 2 percent drop in tonnage to and from China was covered by an increase in Southeast Asian tonnage from 2019 to 2020. Over the same time, however, tonnage through the Panama Canal increased by 5 percent based on the Port's data. Table 2-14 summarizes canal usage for 2019 and 2020 vessel calls[7].

Table 2-14. Canal Usage for NYNJ Services

Year	Canal Transit	Total TEUs	Percent Total
2019	Both	949,524	34%
	None	38,667	1%
	Panama	823,425	29%
	Suez	988,504	35%
	Total	**2,800,120**	
2020	Both	893,036	28%
	None	45,488	1%
	Panama	1,074,960	34%
	Suez	1,183,800	37%
	Total	**3,197,284**	

USACE does not estimate significant changes to the existing distribution between Suez Canal and Panama Canal throughput distribution. The forecast used by USACE for both routes serving East Asia anticipates approximately 4 percent compound annual growth between 2020 and 2030 for these routes (see Section 4.2.2.1. .

While there is indication that a portion of the factors of production have moved from China to Southeast Asia, China will remain the largest trade partner in the region and carriers will continue to develop routes that serve Chinese ports and reach the study area via the Panama Canal.

2.6. Vessel Operations

2.6.1. Navigation Guidelines

The guidelines relevant to this study primarily relate to restrictions around ULCV and SULCV, which generally correspond to PPX3 and PPX4 class containerships, respectively. The Deep Draft Working Group of the Harbor Safety, Operations and Navigation Committee (1 May 2017)[8] set guidelines around these large containerships. They are subject to change but remain the best estimate of current and future operations at the Port of New York & New Jersey.

Prior to entering the Port of New York and New Jersey, a suitable berth of destination for a ULCV must be confirmed clear and an anchorage spot should be confirmed available for bailout purposes. Suitable berths have sufficient depth and large enough cranes to unload the vessel. Global Terminal Bayonne (Port Jersey - Port Authority Marine Terminal) has one such berth. ULCVs transiting to Global Terminal Bayonne (Port Jersey - Port Authority Marine Terminal) may draft up to -49 feet. Vessels that draft more than -47 feet must arrive and depart between 1 and 2 hours after high water as measured at the Battery. There cannot be a cruise ship at

[7] Actual cargo distribution (volume based) for Panama Canal over Suez Canal routes is 45 percent and 48 percent for 2019 and 2020, respectively. The forecasted (tonnage based) for Panama over Suez Canal routes is 33 percent.

[8] The Deep Draft Working Group is made up of representatives of all pilot groups and involved parties servicing deep draft vessels transiting within the Port of New York and New Jersey.

Bayonne Cruise Terminal and a ULCV at Port Jersey – Port Authority Marine Terminal at the same time; one or the other is acceptable. The approach to Port Jersey - Port Authority Marine Terminal must be made as wide as possible, pushing the north-end of the channel limits. The current width of the Port Jersey Channel is a key factor in the difficulty of maneuvering a ULCV in and out of Port Jersey - Port Authority Marine Terminal. The cross-current of the inbound lane results in substantial difficulty in stopping a ULCV. Vessels are not permitted to back into Global Terminal Bayonne, meaning that they must depart by backing out into Anchorage Channel. The current depth of the Anchorage Channel north of the Port Jersey Channel is insufficient to facilitate backing out a ULCV in an efficient manner. The efficiency constraint is the result of the extra time spent on completing a complicated maneuver.

Generally, ULCVs may not navigate beyond the Narrows when the maximum sustained winds are greater than 20 knots or maximum gusts are 25 knots or greater. This restriction is critical for the safe navigation of tight spaces such as the Kill Van Kull. Vessels must transit the Kill Van Kull to reach either Elizabeth - Port Authority Marine Terminal/Port Newark or Howland Hook. There are several restrictions specific to the Kill Van Kull. ULCVs are required to transit the Kill Van Kull at slow speeds, posing maneuverability challenges with respect to the wind. Vessels should not transit Bergen Point in sustained winds of 30 knots or greater or gusts greater than 34 knots as measured at Mariners Harbor. The vessels are required to transit the Kill Van Kull within 1 hour on either side of high water or low water as measured at the battery, and the maximum draft is 49 feet. Vessels no larger than 500 feet in length overall are permitted to meet or overtake ULCVs in the Kill Van Kull. This restriction imposes extensive delays on the majority of container, tanker, and other large-vessel traffic transiting to Howland Hook and Elizabeth. ULCV operators would not typically need to wait for the Kill Van Kull to be clear of smaller vessels such as barges. However, no bunker barges are allowed alongside a vessel berthed along the Kill Van Kull while a ULCV passes, and traffic is restricted to one-way from Constable Hook to the Ambrose Channel.

There are additional restrictions on vessels transiting to Global Terminal New York (Howland Hook), and this is largely due to the configuration of the federal channel. A key restriction is the tight turn from the North of Shooter's Island Reach into the Elizabethport Reach in the Arthur Kill. The vessels that have a destination of Howland Hook must not have an overall length greater than 1,100 feet, a draft greater than -47 feet (high water or low water). The wind restrictions applied to ULCVs navigating beyond the narrows apply to all large container vessels transiting to Howland Hook. The tight turn, the width of the channel, the length of the vessel l, and the wind conditions result in a difficult and perilous navigation situation. What's more, the largest beam a vessel may have and be safely berthed at Howland Hook is 150 feet. Vessels with beams any larger will violate the channel limits, threatening the safety of passing traffic. Vessels departing Howland Hook must back up out of the terminal and the full length of North of Shooters Island Reach, then executing a k-turn between the South Reach of Newark Bay and Bergen Point. During this operation, traffic is stopped until the k-turn is complete, imposing significant delays.

ULCVs are restricted to a maximum of two channel transits per tide window, which generally means a maximum of four transits per day. Many ULCV calls are located at Elizabeth - Port Authority Marine Terminal, which has several berths and cranes that are suited to accommodate a ULCV. ULCVs have berthed on the face of Elizabeth - Port Authority Marine Terminal and are now more commonly berthed on the Elizabeth Channel side. The width of the South Elizabeth channel is not sufficient to accommodate a ULCV. The maximum draft a vessel may have and transit to Elizabeth - Port Authority Marine Terminal is -49 feet. ULCVs are currently transiting the federal channel light-loaded and have met the -49-foot draft restriction. Transit to and from Elizabeth - Port Authority Marine Terminal through the Newark Bay Channel is restricted to one-way, imposing significant delay on the interacting traffic. ULCVs enter Elizabeth Channel bow-in, which means that the vessels must back out into the Newark Bay Channel in the direction of the Middle Reach (North).

2.6.2. Underkeel Clearance

The measure of underkeel clearance (UKC) for economic studies was applied according to the planning guidance. According to this guidance, UKC is evaluated based on actual vessel operator and pilot practices within a harbor and subject to present conditions, with adjustment as appropriate or practical for with-project conditions. The practices for UKC were determined through interviews with harbor pilots and analysis of actual past and present practices. Generally, analysis uses a minimum UKC of 3 feet. Additional clearance requirements exist for vessel sinkage (Section 5.1.5. . For purposes of this analysis, the UKC used in the existing condition for the current channel depth was used with an improved channel.

3. Analysis Overview

The container terminals carried forward in the economic analysis include GCT Bayonne, APM terminals, PNCT, Maher Terminals, and GCT New York. These terminals are included in the -50-foot channel footprint and have berth lengths, crane capabilities, depths and equipment that can accommodate super Post-Panamax containerships.

For evaluation purposes, channel pathways were created to analyze cost and benefits by channel segments to terminals mentioned above. The containership terminals are entities that differ in terms of annual throughput, ocean carriers, fleet distribution and volumes of cargo. Difference between terminals is considered throughout the forecast. A pathway represents a combination of channel segments to certain container terminals for the analysis. Benefits will be attributed to each pathway based on commodity growth, fleet mix and transportation cost. Channel deepening benefits and project costs will be estimated by pathway to determine net benefits by pathway. Figure 20 shows the pathways. Table 3-1 shows the terminals analyzed in each pathway. The study screened out the Pathway to Howland Hook after initial evaluation. This analysis may be considered again in subsequent efforts.

Figure 20: Pathways for Benefit Analysis

Table 3-1: Pathway Terminals

Pathways	Terminals
Pathway to EPAMT	APM, Maher, PNCT
Pathway to PJPAMT	GCT Bayonne
Pathway to Howland Hook	GCT New York/Howland Hook

3.1. Pathway to EPAMT

The Pathway to EPAMT includes the channel segments to APM, Maher and PNCT. The channel segment/reaches include the Ambrose Channel, Kill Van Kull, and Elizabeth Channel. Table 3-2 shows the overview of the terminals in Pathway to EPAMT.

Table 3-2: Overview of Pathway to EPAMT Terminals

Terminal	Ship Berth Length	Number of Container Cranes	Number of Super Post-Panamax Cranes	Number of Ocean Carriers/Services
APM	6,001	15	4	16
Maher	10,128	24	8	14
PNCT	4,400	13	6	7

3.1.1. Pathway to EPAMT Cargo Volumes and Trends

Figure 21 and Figure 22 show historical cargo volumes imported and exported through the three terminals from 2009 to 2018 in the Pathway to EPAMT. Data was obtained from NNOMPEAS for all container cargo in terms of metric tons. The NNOMPEAS data is approximately 90 percent of the volume that is reported by the PANYNJ. However, the volume changes should be accurately represented year by year.

Figure 21: Pathway to EPAMT Containerized (Metric Tons)

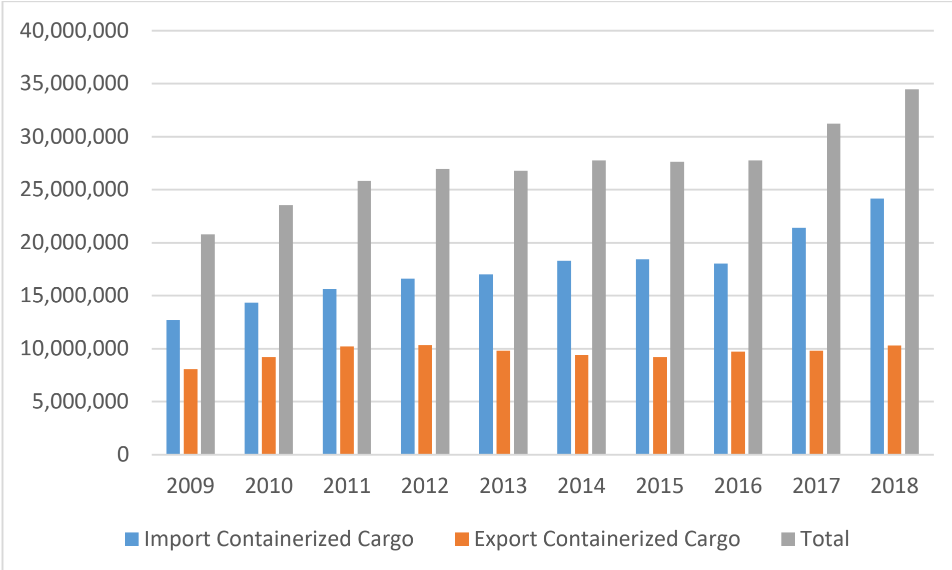
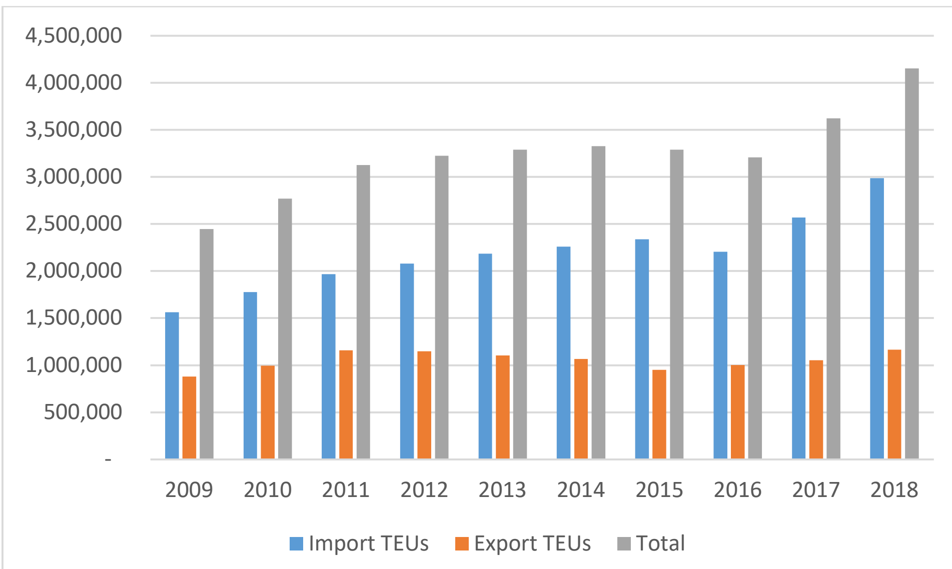


Figure 22: Pathway to EPAMT Loaded TEUs



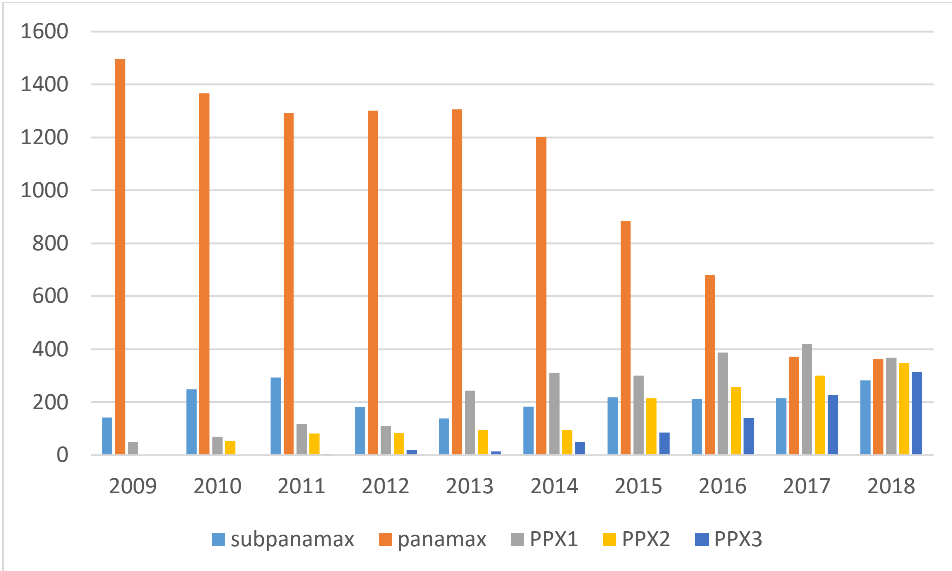
The routes of service that call the Pathway to EPAMT terminals were analyzed and condensed to fit into the route groups displayed in Table 2-11. Vessel service data was collected from the port for 2017 to 2019 to estimate a percentage of tonnage on each route to establish baseline tonnage on each route. Section 4.2.1. details the baseline tonnage by route.

3.1.2. Pathway to EPAMT Fleet Characteristics

Data was acquired from the PANYNJ, Waterborne Commerce Statistics Center, and NNOMPEAS to acquire containership characteristics of the fleet calling the Pathway to EPAMT. For trend analysis, containerships are divided into classes as shown in Table 2-8. The trend of containership usage for the Pathway to EPAMT is shown in Figure 23. From the 2009 through

2018, larger containerships have been deployed to take advantage of economies of scale.

Figure 23: Number of Inbound Vessels Calls by Containership Class



3.2. Pathway to PJPAMT

3.2.1. Pathway to PJPAMT Cargo Volume and Trends

Pathway to PJPAMT includes the GCT Bayonne container terminal. The berth is approximately 2,700 feet long and the terminal has 8 container cranes: 2 Super Post-Panamax and 6 Post-Panamax. Figure 24 and Figure 25 show historical cargo volumes imported and exported through the container terminal on the east side of the harbor from 2009 to 2018 in Pathway to PJPAMT. Data was obtained from NNOMPEAS for all container cargo in terms of metric tons.

Figure 24: Pathway to PJPAMT Containerized (Metric Tons)

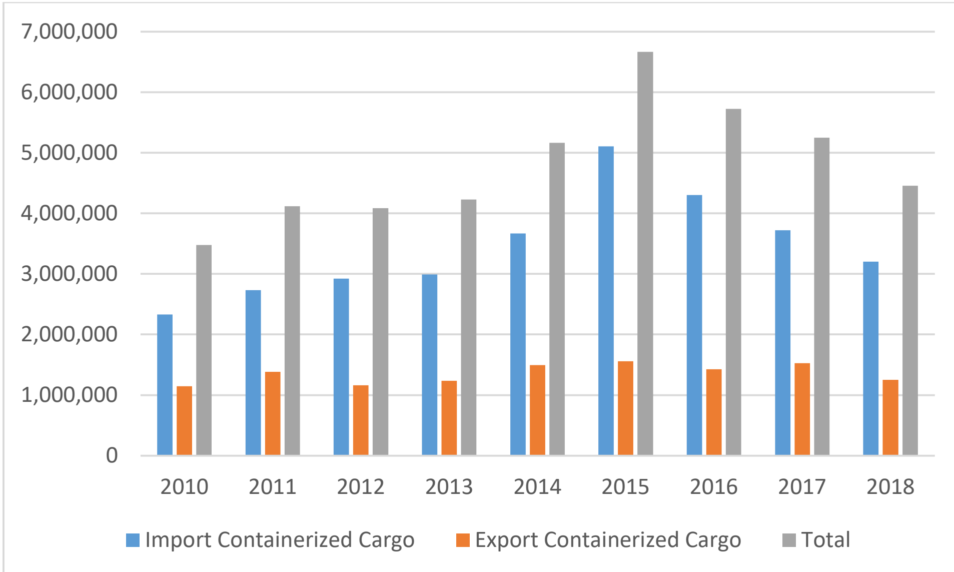
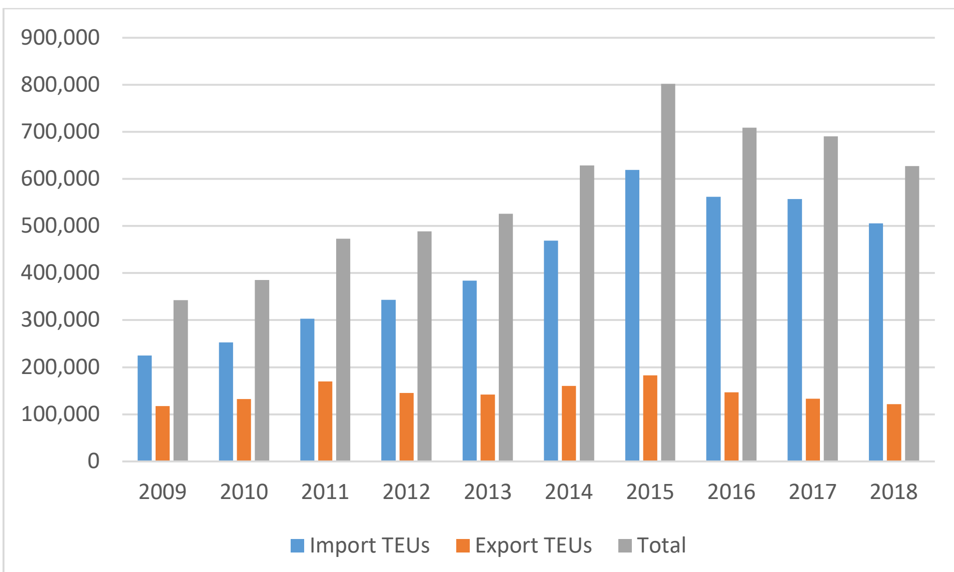


Figure 25: Pathway to PJPAMT Loaded TEUs

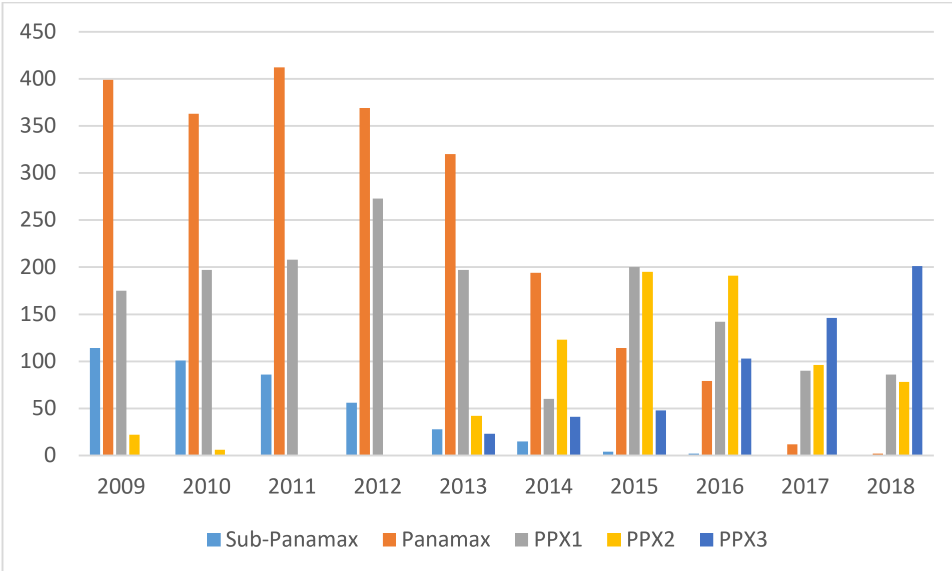


The routes of service that call the Pathway to PJPAMT terminal were analyzed and condensed to fit into the route groups in Table 2-9. Vessel service data was collected from the port for 2017 to 2019 to estimate a percentage of tonnage on each route to establish baseline tonnage on each route. Section 4.2.1. details the baseline tonnage by route.

3.2.2. Pathway to PJPAMT Fleet Characteristics

Data was acquired from the PANYNJ, Waterborne Commerce Statistics Center, and NNOMPEAS to acquire containership characteristics of the fleet calling the Pathway to PJPAMT. For trend analysis, containerships are divided into classes as shown in Table 2-8. The trend of containership usage for the Pathway to PJPAMT is shown in Table 4-9. From 2009 through 2018, larger containerships have been deployed to take advantage of economies of scale.

Figure 26: Number of Inbound Vessels by Containership Class



4. Future Conditions

4.1. Vessel Operations

The study assumes that proposed improvements does not change vessel operations throughout the channel. The same vessel classes are expected to call in the future without-project condition as the future with-project conditions. Restrictions related to wind, vessel meeting, and berthing will still apply. However, the study assumes channel deepening will lead to the lifting of the 49-foot draft restriction for container vessels from Sea to EPAMT and Sea to PJPAMT. Tide restrictions will still apply, and vessels will need to have sufficient underkeel clearance to transit the channel[9].

4.2. Commodity Forecast

The Port of New York & New Jersey's future commerce for the period of analysis is linked to the Port's hinterland and the extent to which it shares commodity flows with other ports. Under future without and future with project conditions, the same volume of cargo is assumed to move through the Port of New York & New Jersey. The port's share of the commodity projections remains the same as the existing condition. However, channel deepening will allow shippers to load vessels more efficiently and take advantage of economies of scale afforded by larger vessels. This efficiency translates to transportation cost savings, the main driver of NED benefits. Cargo projections ultimately drive vessel fleet projections in terms of the numbers and

[9] Based on conversations with Port Authority, Pilots, and feasibility-level ship simulation. Assumptions will be further refined during the design phase.

sizes of vessels for without- and with-project conditions.

The top import commodities for the Port of New York & New Jersey are furniture, machinery and appliances, plastic, and beverages. Top export commodities in terms of volume are wood pulp, vehicle parts, plastic, wood, and articles of wood. As of 2018, the major import growth commodities were apparel, iron and steel, and vehicle parts. The major export growth commodities were food waste, oil seeds and miscellaneous grains and iron and steel.

The methodology to determine the forecast of import and export tonnage used three steps. First, the baseline was established using an average of historical data. Second, the growth rates for each route group were established. Third, growth rates were applied to the baseline to determine the total import and export trade volumes for the Port of New York & New Jersey.

4.2.1. Cargo Baseline

To minimize the impact of potential variances in the trade volumes on long-term forecast, five years of data was used to establish the baseline for the commodity forecast. Empirical data from 2013 to 2017[10] was used to develop a baseline, allowing the forecast to capture both economic prosperity and downturn which occurred over that timeframe. Three years were used to estimate the percent tonnage by trade route. The baseline tonnage represents the starting point from which commerce was forecasted.

4.2.1.1. Pathway to EPAMT Cargo Baseline

Table 4-1 and

Table 4-2 show historical containerized imports and exports that moved through the Port from 2013 to 2017. During this period, imports mostly increased with a slight decrease in 2016, but recovered in 2017. Trade with Asia leads the Port of New York & New Jersey market for Pathway to EPAMT accounting for nearly 58% of import tonnage.

[10]The baseline for the commodity forecast is based off a five-year average (2013-2017), which was the most recent available at the time of analysis. Inclusion of 2018 data would lead to a 5 percent increase in the baseline and subsequent increase in forecasted volume through the study period. This, however, does not necessarily improve forecast accuracy. The forecast is based on a 50-year period of analysis. 2018 and 2019 data have been evaluated, and it does not appear necessary to update the baseline and forecast as there is no risk to changes in plan selection or project justification. Additional information has been added to Section 4.

Table 4-1: Pathway to EPAMT Historical Containerized Baseline Imports (metric tons)

	2013	2014	2015	2016	2017	Baseline Tonnage	Route Group	Route Group Percent	Baseline Tonnage by Route Group
Import Containerized Cargo	16,987,000	18,311,000	18,431,000	18,025,000	21,404,000	18,631,600	AF-SA-CAR-ECUS	6%	1,060,000
	Rate of Change by Year						EU-MED-ECUS	37%	6,894,000
		8%	1%	-2%	19%		FE-PAN-ECUS	17%	3,167,000
							FE-SUEZ-ECUS	41%	7,639,000

Table 4-2: Pathway to EPAMT Historical Containerized Baseline Exports (metric tons)

	2013	2014	2015	2016	2017	Baseline Tonnage	Route Group	Route Group Percent	Baseline Tonnage by Route Group
Export Containerized Cargo	9,801,600	9,434,700	9,197,200	9,736,300	9,826,200	9,599,200	AF-SA-CAR-ECUS	5%	513,000
	Rate of Change by Year						EU-MED-ECUS	26%	2,516,300
		-4%	-3%	6%	1%		FE-PAN-ECUS	20%	1,965,000
							FE-SUEZ-ECUS	48%	4,605,000

4.2.1.2. Pathway to PJPAMT Cargo Baseline

The Pathway to PJPAMT includes the channel segments to Global Container Terminal Bayonne which include the Ambrose Channel and the Anchorage Channel. GCT Bayonne handles approximately 10 percent of the port's container volumes. Table 4-3 and Table 4-4 show the historical volumes of metric tons moving through the terminal.

Table 4-3: Pathway to PJPAMT Historical Containerized Baseline Imports (metric tons)

	2013	2014	2015	2016	2017	Baseline Tonnage	Route Group	Route Group Percent	Baseline Tonnage by Route Group
Import Containerized Cargo	2,989,900	3,670,100	3,816,900	4,014,300	3,694,100	3,637,000	AF-SA-CAR-ECUS	7%	272,000
	Rate of Change by Year						EU-MED-ECUS	10%	346,000
		23%	4%	5%	-8%		FE-PAN-ECUS	40%	1,451,000
							FE-SUEZ-ECUS	43%	1,569,000

Table 4-4: Pathway to PJPAMT Historical Containerized Baseline Exports (metric tons)

	2013	2014	2015	2016	2017	Baseline Tonnage	Route Group	Route Group Percent	Baseline Tonnage by Route Group
Export Containerized Cargo	1,238,000	1,494,000	1,311,000	1,333,000	1,349,000	1,345,000	AF-SA-CAR-ECUS	4%	47,500
	Rate of Change by Year						EU-MED-ECUS	5%	67,200
		21%	-12%	2%	1%		FE-PAN-ECUS	47%	632,300
							FE-SUEZ-ECUS	44%	598,100

4.2.2. Trade Forecast Methodology

The long-term trade forecast for the Port of New York & New Jersey combined data from the PANYNJ, previous USACE East Coast analyses and a national forecast obtained by the Institute for Water Resources which was developed by IHS Global Insight. The task of estimating commodity growth rates has been completed for numerous USACE deep draft navigation studies along the East Coast in the past decade. Those analyses, along with information from the National IHS forecast, were used to develop growth rates for application to the Port of New York & New Jersey.

4.2.2.1. IHS Forecast

IHS is a research firm that develops trade forecast and provide economic and financial coverage of countries, regions, and industries. The company provides data collection of macroeconomic, regional and global economics; financial markets and securities; and international trade.

When making global trade forecasts, it employs sophisticated macroeconomic models which contain all commodities traded at port. The trade forecasts are produced with a system of linked world trade commodity models collectively called the World Trade Model (WTM). The commodities forecasted are grouped into IHS own categories derived from the International Standard Classification (ISIC) and cover 156 ISIC categories. For all trade partners in the world, the WTM has 103 major countries and regions according to their geographic location.

As mentioned, previously completed East Coast analyses and the IHS Global Insight forecast were used as sources for forecasting the throughput tonnage for the Port of New York & New

Jersey during the period of analysis. This analysis was obtained by IWR in 2017[11]. The information from this forecast provided tonnage through year 2025. Since this was the most recent forecast acquired, forecasting using IHS sources end at year 2025. From 2025 through 2040, Port information is used for forecasting.

4.2.2.2. PANYNJ Forecast

PANYNJ provided their growth rates for containerized imports and exports through 2037. The PANYNJ developed a long-range port master plan that includes a market analysis to determine the market potential for maritime trade volume. To complete the market analysis, the maritime industry trends were analyzed, market area identified and a comparison of Port facilities with competing ports. Based on this assessment, projected regional growth in cargo was estimated. These growth rates were used for years 2040 through 2050. Long-term effects from COVID-19 are still uncertain, but the fundamentals of the forecast are expected to hold up given its long-term nature.

4.2.3. Cargo Forecast Summary

Using the sources described above, growth rates were estimated from the baseline year of 2018 to 2030 through 2040. The forecast was held constant through the end of the period of analysis[12]. Table 4-5 shows the average growth rates for imports and exports for each period shown.

Table 4-5: Containerized Cargo Growth Rates

IMPORT CONTAINER ANNUAL GROWTH RATES					
	2019-2025	**2026-2030**	**2031-2035**	**2036-2040**	**2040-2050**
FE-SUEZ-ECUS	4.9%	2.8%	2.5%	2.5%	2.4%
FE-PAN-ECUS	5.1%	2.8%	2.5%	2.5%	2.4%
EU-MED-ECUS	3.1%	2.8%	2.5%	2.5%	2.4%
AF-SA-CAR-ECUS	3.8%	2.8%	2.5%	2.5%	2.4%
EXPORT CONTAINER ANNUAL GROWTH RATES					
	2019-2025	**2026-2030**	**2031-2035**	**2036-2040**	**2040-2050**
FE-SUEZ-ECUS	5.2%	2.8%	2.5%	2.5%	2.4%
FE-PAN-ECUS	5.7%	2.8%	2.5%	2.5%	2.4%
EU-MED-ECUS	4.2%	2.8%	2.5%	2.5%	2.4%
AF-SA-CAR-ECUS	4.2%	2.8%	2.5%	2.5%	2.4%

Using the baseline estimated commerce volumes, the estimated growth rates were applied to forecast import and export tonnage for the Port of New York & New Jersey by route group over

[11] The forecast used for this analysis is developed specifically for the USACE

[12] Period of Analysis for alternatives analysis is from 2039 to 2088. Final Benefit evaluation assumes a period of analysis from 2040 to 2089.

the period of analysis. For purposes of analysis, the forecast is held constant after 2050. From 2018 through 2025, the forecast estimates four percent compound annual growth for all facilities. Actual growth in 2019 and 2020 indicates lower than anticipated throughput at 0.3 percent compound annual growth. However, 2019 and 2020 tonnage have been subject to unprecedented disruptions in the global supply chain brought on by the COVID-19 pandemic, Suez Canal blockages, labor and warehousing constraints, and many other changes impacting cargo volumes. Throughput data through June 2021 indicate a likely upswing in annual volume more in line with the forecasted growth.

Since the Pathways are being analyzed separately, individual commodity forecasts were conducted. Although the tonnage is different based on route group volumes, the growth rates remain the same. Table 4-6 and Table 4-7 shows the import and export commodity forecast tonnage for the Pathway to EPAMT. Table 4-8 and Table 4-9 shows the import and export commodity forecast tonnage for Pathway to PJPAMT.

Table 4-6: Pathway to EPAMT Import Containerized Metric Tons Forecast

Import Forecast	2018 - Baseline	2030	2040	2050
FE-SUEZ-ECUS	7,639,000	12,242,000	15,702,000	19,164,000
FE-PAN-ECUS	3,110,000	5,053,000	6,481,000	12,272,000
EU-MED-ECUS	6,823,000	9,685,000	12,422,000	19,164,000
AF-SA-CAR-ECUS	1,060,000	1,576,000	2,022,000	2,019,000

Table 4-7: Pathway to EPAMT Export Containerized Metric Tons Forecast

Export Forecast	2018 - Baseline	2030	2040	2050
FE-SUEZ-ECUS	4,605,000	6,924,000	8,881,000	10,505,000
FE-PAN-ECUS	1,965,000	3,271,000	4,196,000	5,468,000
EU-MED-ECUS	2,516,000	3,743,000	4,801,000	7,541,000
AF-SA-CAR-ECUS	513,000	771,000	989,000	1,518,000

Table 4-8: Pathway to PJPMT Import Containerized Metric Tons Forecast

Import Forecast	2018 - Baseline	2030	2040	2050
FE-SUEZ-ECUS	2,115,000	3,389,000	4,347,000	5,530,000
FE-PAN-ECUS	1,497,000	2,432,000	3,120,000	3,969,000
EU-MED-ECUS	135,000	192,000	246,000	313,000
AF-SA-CAR-ECUS	96,000	143,000	183,000	233,000

Table 4-9: Pathway to PJPMT Export Containerized Metric Tons Forecast

Export Forecast	2018 - Baseline	2030	2040	2050
FE-SUEZ-ECUS	801,000	1,312,000	1,683,000	2,141,000
FE-PAN-ECUS	493,000	821,000	1,053,000	1,339,000
EU-MED-ECUS	22,000	33,000	42,000	53,000
AF-SA-CAR-ECUS	16,000	24,000	31,000	39,000

Table 4-10 provides estimated total TEU throughput (including empty TEUs) by Terminal. As shown, current terminal capacity will likely be exceeded by 2030 for PJPAMT and 2040 for EPAMT. By 2050 total capacity at EPAMT and PJMPT will be exceeded by approximately 66 percent. The forecast assumes port development over the next 10 to 20 years to meet the increasing cargo volume at the Port of New York & New Jersey[13]. Developments include improved TEU turn time through additional truck and rail access and expanded yard capacity as outlined in the Port Master Plan 2050[14].

Table 4-10: Forecasted TEU Throughput versus Current Port Capacity

Port	2020 Capacity	Forecasted TEU Throughput*		
		2030	2040	2050
EPAMT	7,200,000	6,960,000	8,930,000	11,360,000
PJPMT	900,000	1,280,000	1,650,000	2,100,000
Total	8,100,000	8,240,000	10,580,000	13,460,000

*assumes historical Empty TEU percentages (2013-2018 baseline)

4.3. Vessel Fleet Forecast

4.3.1. Design Vessel

For deep-draft projects, the design vessel is selected based on studies of the types and sizes of the fleet expected to use the proposed channel over the project life. The design ship is chosen as the maximum or near maximum size ship in the forecasted fleet (USACE 1984, 1995, 1999).

For the Port of New York & New Jersey, the study team recommends the PPX4 containership class as the design vessel. This selection is meant to incorporate the full range of potential dimensions of the largest, most frequently calling vessel at the Port of New York and New Jersey over the study period. By the project base year, vessels of this size are expected to call frequently. The Port of New York & New Jersey is also anticipating the use of these vessels in the future and has made significant investment to do so. The chosen specifications for the recommended design vessel class are as follows:

- 1,308.0 feet length overall (LOA)
- 193.5 feet beam
- 52.5 feet design draft
- 18,000 TEU capacity

There is inherent uncertainty in design vessel selection, especially given the base year of 2040. Vessel orderbooks are frequently changing, and deployment of vessel on services calling the Port of New York and New Jersey is based on fluctuating market forces and vessel availability. Vessels larger and smaller than the design vessel will call the Port over the study period. However, USACE has confidence the chosen vessel dimensions will remain relevant through the

[13] The Port Master Plan includes timing and sequence of decisions required to ensure that capacity remains sufficient to sustain growth including yard densification, berth expansions, and enhanced gate access projects.
[14] https://panynj.maps.arcgis.com/apps/Cascade/index.html?appid=58a11a89cc3a4385a51c3fca596b08da

study period as the design vessel represents the top 3 percentile of all containership LOA and TEU capacity, the top 2 percentile of all containership draft and beam. While there are vessel orders larger than the design vessel (e.g., larger than 20,000 TEU capacity), these vessels will begin to face landside and channel constraints at the Port of New York and New Jersey and other ports on services calling the Port of New York and New Jersey. As a result, these vessels are less likely to call on a frequent basis. Sensitivity analysis presented in Section 6. assesses the impact of uncertainty in the fleet forecast.

4.3.2. World Fleet

To develop projections of the future fleet calling the Port of New York & New Jersey, the study used world fleet data for containerships. The Institute of Water Resources provided general estimates for world fleet containerships based on Clarkson data and Lloyd's Registry-Fairplay through 2025. Sea-web data was also used as a source to for world containership estimates.

4.3.3. Container Fleet Forecast

Using the empirical data for the Port of New York & New Jersey and data sources in Section 4.3.2. , the forecast was adapted for the Port of New York & New Jersey to determine the expected fleet composition over the period of analysis. The forecast introduces a Post-Panamax Generation 4 containership vessel based on the historical transition of the fleet and analysis of the vessel orderbook. Table 4-11 shows the percent calling capacity by vessel size from 2025 to 2035 based on the fleet forecast adapted for the Port of New York & New Jersey. The transition to PPX3 and PPX4 class vessels represents the most critical assumption for project benefits. Despite the transition, many services will likely still use smaller, less-efficient vessels based on fleet availability and landside infrastructure constraints along all ports on a service. The distribution of capacity remains constant after 2035 for initial analysis. See Section 5.4. for updates to the fleet forecast.

Table 4-11: The Port of New York & New Jersey Forecasted Calling Capacity

Year	SPX	PX	PPX1	PPX2	PPX3	PPX4
2025	2%	10%	15%	25%	40%	8%
2035	2%	8%	12%	20%	47%	11%

The forecasted commodity volumes presented in Section 4.2. were loaded onto a simulated future vessel fleet using the HarborSym Model to determine the anticipated number of calls to the Port of New York & New Jersey by year.

5. Transportation Cost Savings Benefit Analysis

The study compares the benefits and costs of channel deepening up to seven feet in one-foot increments for containership transit at the Port of New York & New Jersey. Analysis follows evaluation procedures for navigation studies outlined in Engineer Regulation 1105-2-100 (ER 1105-2-100) and grounded in the economic and environmental Principles and Guidelines (P&G).

Section 5.1. describes the methodology used to estimate benefits of the proposed channel improvements at the Port of New York & New Jersey. National economic development (NED) benefits were estimated based on the expected transportation cost reduction associated with each project depth. Analysis uses the HarborSym Modeling Suite of Tools (HMST) Version 1.5.8.3 developed by the Institute for Water Resources (IWR) to estimate transportation costs for each alternative depth. The HMST is a certified USACE model, which follows the deep draft navigation evaluation framework established in ER 1105-2-100 and reflects USACE guidelines on transportation cost savings analysis.

Section 5.2. presents the expected vessels calls for each channel depth by port. This vessel call list is run through the HMST to calculate transportation costs for each channel depth and port. Section 5.3. provides the total transportation cost summary for each channel depth resulting from the model runs. Section 5.4. summarizes each alternative for evaluation and identifies the NED plan based on the analysis presented in Sections 5.1. through 5.3.

5.1. Methodology

The HMST is a discrete event Monte Carlo simulation model and is designed to be a general-purpose tool for use by USACE planners. The model is designed to allow users to forecast a port's future fleet, simulate vessel calls, and estimate transportation costs for comparative analysis of alternative channel depths and configurations. Channel improvements (e.g., channel deepening) result in reduced transportation costs by allowing carriers to load cargo more efficiently on vessels calling the Port of New York & New Jersey. This leads to a more efficient fleet mix and less waterway congestion. Additional transportation cost saving benefits result from the channel modifications aimed at reducing congestion and transit time within the harbor. The creation of meeting and passing zones reduces wait times within the harbor. HarborSym allows for detailed modeling of vessel movements and transit rules on the waterway.

To begin, HarborSym was setup with the basic required variables including channel configuration, vessel and port operations, and container service details. The HMST's Container Loading Tool (CLT) was used to generate a vessel call list by pairing the Port of New York & New Jersey's commodity forecast for a given year with the expected fleet distribution and loading practices for that year, factoring in changes in vessel operations caused by channel improvements. The resulting vessel traffic for each channel depth was simulated using HarborSym, producing an estimate of average annual vessel transportation costs. The NED Plan was identified by identifying the plan with the highest net benefits over costs based on estimated transportation cost saving benefits.

5.1.1. HarborSym Model Behavior

For each iteration, the vessel calls in the simulation period are accumulated and placed in a queue based on arrival time. When a vessel arrives at the port, the route to all docks in a vessel call is determined. This route is comprised of discrete legs (contiguous sets of reaches, from the entry to the dock, from a dock to another dock, and from the final dock to the exit). The vessel attempts to move along the initial leg of the route. Potential schedule conflicts with other vessels are evaluated according to the user-defined set of rules for each reach within the current leg, based on information maintained by the simulation as to the current and projected future state of each reach. If a rule activation occurs, such as no passing allowed in each reach, the arriving vessel must either delay entry or proceed as far as possible to an available anchorage, waiting there until it can attempt to continue the journey. Vessels move from reach to reach, eventually arriving at dock. Similarly, the model accounts for vessel sailing draft and UKC at each leg in a vessel call. If channel depth is insufficient to maintain required underkeel clearance (UKC), the vessel waits at the channel entrance or at the nearest available anchorage for which channel depth is sufficient until adequate depth is available.

After the cargo exchange calculations are completed and the time the vessel spends at the dock has been determined, the vessel attempts to exit the dock, starting a new leg of the vessel call; rules for moving to the next destination (another dock or an exit of the harbor) are checked in a similar manner to the rule checking on arrival before the vessel can proceed to the next leg. As with the entry into the system, the vessel may need to delay departure and re-try later to avoid rule violations and, similarly, the waiting time at the dock is recorded.

A vessel encountering rule conflicts may be able to move partially along the leg to an anchorage or mooring. If so, and if the vessel can use the anchorage, then HarborSym will direct the vessel to proceed along the leg to the anchorage and wait until it can proceed without causing rule conflicts in the remainder of the leg. The determination of the total time a vessel spends within the system is the summation of time waiting at entry, time transiting the reaches, time turning, time transferring cargo, and time waiting at docks or anchorages. HarborSym collects and reports statistics on individual vessel movements, including time in system, as well as overall summations for all movements in an iteration.

HarborSym was initially developed as a tool for analyzing channel widening projects, which were oriented toward determining time savings for vessels transiting within a harbor. It did not allow for assessing changes in vessel loading or in shipping patterns. More recent HarborSym versions are designed to assist analysts in evaluating channel-deepening projects, in addition to the original model capabilities. The deepening features consider fleet and loading changes, as well as incorporating calculations for both within harbor costs and costs associated with the ocean voyage.

Each vessel call has a known (calculated) associated cost, based on time spent in the harbor and ocean voyage and cost per hour. Also, each vessel call’s total quantity of commodity transferred to the port (both import and export) is known in terms of commodity category, quantity, tonnage, and value. The model allocates the total cost of the call to the various commodity transfers. Each commodity transfer record refers to a single commodity and specifies the import and export tonnage.

When a vessel leaves the system, the model records the total tonnage, export tonnage, and import tonnage transferred by the call as well as total transportation costs associated with the vessel’s time in the port. The cost per ton can be calculated at the call level (divide total cost by total tonnage).

The model calculates import and export tons, import and export values, and import and export allocated cost. This information allows for the calculation of total tons and total cost at the vessel class and call level. The model can thus deliver a high level of detail on individual vessel, class, and commodity volumes and transportation costs.

Either all or a portion of the at-sea costs are associated with the subject port, depending on whether the vessel call is a partial or full load. The at-sea cost allocation procedure is implemented within the HarborSym Monte-Carlo processing kernel and utilizes the estimated total trip cargo (ETTC) field from the vessel call information along with import tonnage and export tonnage. In all cases the ETTC is the user's best estimate of total trip cargo. Within the CLT, the ETTC field is estimated as cargo on board the vessel at arrival plus cargo on board the vessel at departure, in tons. ETTC can also be expressed as:

$$ETTC = 2 * Cargo\ on\ Board\ at\ Arrival - Import\ tons + Export\ tons$$

There is a basic algorithm implemented to determine the fraction of at-sea costs to be allocated to the subject port. First, if ETTC for a vessel call is equal to zero or null, then none of the at-sea costs are associated with the port. The algorithm then checks if import or export tons are zero for a vessel call. If either are zero, then the following equation is applied to determine the at-sea cost allocation fraction associated with the subject port:

$$At\ Sea\ Cost\ Allocation\ Fraction = (Import\ tons + Export\ tons)/ETTC$$

Finally, when both import and export tons are greater than zero, the following equation is applied to determine the at-sea cost allocation fraction associated with the subject port:

$$At\ Sea\ Cost\ Allocation\ Fraction = 0.5 * (Import\ tons/Tonnage\ on\ board\ at\ arrival) + 0.5 * (Export\ tons/Tonnage\ on\ board\ at\ departure)$$

Where:

$$Tonnage\ on\ board\ at\ arrival = (ETTC + Imports - Exports)/2$$

$$Tonnage\ on\ board\ at\ departure = Tonnage\ on\ board\ at\ arrival - Imports + Exports$$

5.1.2. Modeling Data Requirements

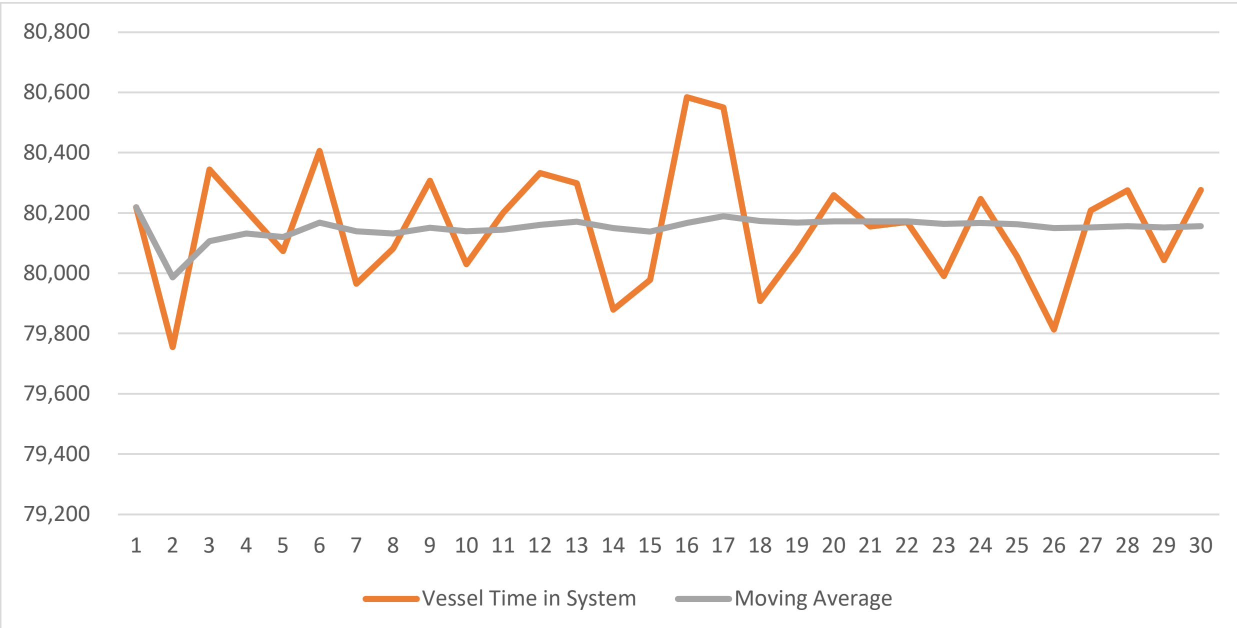
The data required to run HarborSym for the NYNJHDCI study are separated into six categories: simulation parameters, physical and descriptive harbor characteristics, general information, vessel speeds and operations, reach transit rules, and vessel operations. Details for each category specific to the Port of New York & New Jersey are described below.

Simulation Parameters. Parameters include start date, the duration of the iteration, the number of iterations, the level of detail of the result output, and the wait time before rechecking rule violations when a vessel experiences a delay. These inputs were included in the model runs for the NYNJHDCI study. The base year for alternatives evaluation is 2039[15]. Model runs were performed for 2030, 2040, and 2050. Benefits for 2039 are interpolated between the 2030 and 2040 model results. Generally, specific commodity studies and fleet distribution forecasts are of limited value for projections beyond 20 years. As a result, benefits are held constant after 2050.

[15] Final evaluation assumes a base year of 2040.

Each model run consisted of 30 iterations. The number of iterations was determined appropriate by as the moving average time in system does not deviate by more than 1 percent by the 30th iteration. Consequently, the study team believes that 30 iterations is enough to obtain a consistent estimate of transportation costs across alternatives. **Figure 27** shows the variation in vessel time in the system for the OD model runs in total hours. For the OD model run in 2030, the average total vessel time in the system after 30 iterations was 80,156 hours, with a standard deviation of 195 hours.

Figure 27: HarborSym Iterations – Time in System (Hours)



<u>Physical and Descriptive Harbor Characteristics.</u> These data inputs include the specific transportation network of the Port of New York & New Jersey such as the node location and type, reach length, width, and depth, in addition to current stations. This includes information about the docks in the harbor such as length and the maximum number of vessels the dock can accommodate at any given time. Figure 28 displays the Node network used for the Port of New York & New Jersey[16].

[16] This is a simplified depiction of the node network within HarborSym and is not to scale.

Figure 28. The Port of New York & New Jersey HarborSym Node Network

General Information. General information used as inputs to the model include: specific vessel and commodity classes, route groups (Table 5-1), commodity transfer rates at each dock (Table 5-2), specifications of turning area usage at each dock, and specifications of anchorage use within the harbor. Distances between the route groups were developed by evaluating the ten trade routes calling on the Port of New York & New Jersey in 2018.

Numerous container services call the Port of New York & New Jersey (Table 2-9). Section 2.4. describes the carriers and trade lanes included in this analysis. The study combines similar container services into groups for HarborSym modeling. Distances of the services included in the route group were evaluated to determine minimum, most likely, and maximum sailing distances in nautical miles to prior port, next port, and total remaining sailing distance (Table 5-1).

Table 5-1: HarborSym Route Groups

Route	Description	Total Sea Distance		
		Minimum	*Most Likely*	*Maximum*
AF-SA-CAR-ECUS	Africa-South America-Central America-East Coast US	1,450	7,343	16,108
EU-MED-ECUS	Europe-Mediterranean-East Coast US	6,308	7,457	11,534
EA-PAN-ECUS	East Asia-Panama Canal-East Coast US	19,368	29,813	31,908
EA-SUEZ-ECUS	East Asia-Suez Cana-East Coast US	16,884	25,321	31,422

The HarborSym Model uses a triangular distribution to estimate vessel loading and unloading times on docks. The estimates provided in Table 5-2 are based on historical loading and time at dock information provided by the Port Authority.

Table 5-2: HarborSym Commodity Transfer Rates for Containers

Dock Name	Min	Most Likely	Max
APM Terminal	500	800	1,000
Red Hook Container Terminal	500	800	1,000
GCT Bayonne	500	800	1,000
GCT New York	500	800	1,000
Maher Terminal	500	800	1,000
PNCT	500	800	1,000

The analysis also considered prior and next port depths, summarized in Table 5-3 for the services calling Port of New York New Jersey between 2013 and 2017. As shippers deploy larger containerships on transpacific services, rotations will continue to evolve to meet international demand. Analysis of container services showed that 24 percent of container volume is traded with ports with channel depths of -51 feet MLLW or deeper. This analysis shows the current limitations on services currently calling the Port of New York & New Jersey.

Table 5-3: Previous and Next Port Depths (2013-2017)

Prior/Next Port Depth	Percent Cargo (2013-2017)
0	100%
40	85%
45	70%
50	46%
51	24%
52	24%
53	15%
54	15%
55	14%
56+	14%

Future routes may change this distribution of prior and next port depths. Table 5-4 summarizes major US ports receiving vessel calls on services also calling the Port of New York & New Jersey. As shown, major US East Coast ports are preparing for future increases in vessel size with channel deepening. Norfolk Harbor, closest to the Port of New York & New Jersey, is planning to deepen to -55 feet MLLW. Charleston, Port Everglades, and Jacksonville also have planned or ongoing channel improvements.

Table 5-4: US Ports Channel Depth and Improvements on Services Calling the Port of New York & New Jersey

US Port	Depth (ft MLLW)	Pending Improvements
Norfolk	50	Deepening to 55ft
Savannah	48	
Los Angeles	54	
Oakland	50	
Charleston	47	Deepening to 52ft
Baltimore	50	
Port Everglades*	42	Deepening 48ft
Philadelphia	42	
Houston	45	
Miami	50	
Boston	38	Deepening to 45ft
Wilmington*	42	
San Juan (PR)*	39	
Jacksonville	41	Deepening to 47ft
***ongoing feasibility study**		

Vessel Speeds and Operations. The speed at which vessels operate in the harbor, by vessel class both loaded and light loaded, were determined for each channel segment by evaluating pilot logs and port records and verifying the data with the pilots. Hourly operating costs while in-port and at-sea were determined for both domestic and foreign flagged containerized vessels. Sailing speeds at-sea were also determined and are based on service speeds and operating expenses obtained from Institute for Water Resources (IWR) Vessel Operating Cost (VOC) spreadsheets and Economic

Guidance Memorandum (EGM) 15-04 (dated 28 September 2015), Deep-Draft Vessel Operating Costs FY 2016. Economical or slow-steam speeds at sea and associated costs were included in the evaluation. VOCs and speeds at sea are entered as a triangular distribution (minimum, most likely, maximum). Vessel speed and operations inputs are provided in Table 5-5 and Table 5-6 for each reach of the node network for containerized vessels. VOCs are not shown as some or much of the information integral to the estimates is considered sensitive or proprietary by commercial sources and is protected from open or public disclosure under Section 4 of the Freedom of Information Act.

Table 5-5: HarborSym Vessel Speed in Reach for Containerships (knots)

Reach	Speed (knots)
Ambrose Channel	9
Red Hook	10
Anchorage Channel	10
Kill Van Kull	7
Newark Bay	7

Table 5-6: Containerized Vessel Operations

Vessel Class	Speed at Sea (knots)		
	Minimum	Most Likely	Maximum
Sub-Panamax	19	20	21
Panamax	19	20	21
Post-Panamax 1	20.4	21.5	22.6
Post-Panamax 2	20.2	21.3	22.4
Post-Panamax 3	19.8	20.8	21.8
Post-Panamax 4	15.3	16.1	16.9

Reach Transit Rules. Vessel transit rules for each reach reflect restrictions on passing, overtaking, and meeting in the study area and are used to simulate actual conditions in each reach. The model incorporates UKC clearance requirements and tide forecasts to determine when a vessel can enter the system.

Vessel Calls. The vessel call lists consist of forecasted vessel calls for a given year as generated by the CLT (see Section 5.1.3.). Each vessel call list contains the following information: arrival date, arrival time, vessel name, entry point, exit point, arrival draft, import/export, dock name, dock order, commodity, units, origin/destination, vessel type, net registered tons, gross registered tons, dead weight tons, capacity, LOA, beam, draft, flag, tons per inch immersion (TPI) factor, ETTC, and the route group for which it belongs.

5.1.3. Containerized Vessel Call List

The CLT generates a vessel call list by first generating a synthetic vessel fleet based on user inputs. Each vessel in the fleet is randomly assigned physical characteristics based on parameters provided by the user.

To begin, tentative arrival draft is determined for each generated vessel based on user-provided cumulative distribution functions (CDFs). A random draw is made from the CDF and the arrival draft is initially set to this value. The maximum allowable arrival draft is then determined as the minimum of:

1. Prior port limiting depth,
2. Design draft, and
3. Limiting depth at the dock + UKC + sinkage adjustment + tidal availability + sea level change.

The tentative arrival draft is then compared to the maximum allowable arrival draft and set to the lesser value.

Next, the CLT conducts a Loading Factor Analysis (LFA) given the physical characteristics of each generated vessel. LFA explores the relationships between a ship's physical attributes, considerations for operations and attributes of the trade route cargo to evaluate the operating efficiencies of vessel classes at alternative sailing drafts. Several intermediate calculations are required. The following variables are used by the LFA algorithm but are calculated from the inputs.

$$Vessel\ operating\ cost\ per\ 1000\ miles\ is\ calculated\ as\ 1000\ miles\ divided\ by\ the\ applied\ speed\ times\ the\ hourly\ at\ sea\ cost$$
$$= (\ 1000\ miles\ /\ Applied\ Speed)\ X\ Hourly\ Cost$$

The allocation of vessel space to vacant slots, empty and loaded containers is calculated by adding the cargo weight per box plus the box weight plus an allowance for the empty containers

$$Total\ weight\ per\ loaded\ container = Average\ Lading\ Weight\ per\ Loaded\ TEU\ by\ Route\ (tonnes) + Average\ Container\ (Box\ only)\ Weight\ per\ TEU\ (tonnes)$$

Shares of vessel capacity are then calculated as:

$$Cargo\ Share\ = Average\ Lading\ Weight\ per\ Loaded\ TEU\ by\ Route\ (tonnes) /Total\ weight\ per\ loaded\ container\ in\ tonnes$$

$$Laden\ Container\ Share = Average\ Container\ (Box\ only)\ Weight\ per\ TEU\ (tonnes) /Total\ weight\ per\ loaded\ container\ in\ tonnes$$

$$Empty\ Container\ Share = ((Average\ Container\ (Box\ only)\ Weight\ per\ TEU\ (tonnes)) * (Percent\ Empty\ TEUs\ ))\ /\ Total\ weight\ per\ loaded\ container\ in\ tonnes)$$

Volume capacity limits are calculated as follows:

$$Number\ of\ vacant\ slots\ = Nominal\ TEU\ Rating\ *\ Percent\ vacant\ slots$$

$$Max\ Occupied\ Slots\ = Nominal\ TEU\ Rating\ -\ Number\ of\ vacant\ slots$$

$$Max\ Laden\ TEUs\ = Occupied\ Slots/(1 + Percent\ Empties)$$

$$Max\ Empty\ TEUs\ = Occupied\ Slots\ -\ Laden\ TEUs$$

Maximum Volume Restricted Tonnage is then calculated as:

$$Max\ weight\ for\ cargo\ (tonnes) = Max\ Laden\ TEUs * Average\ Lading\ Weight\ per\ Loaded\ TEU\ by\ Route\ (tonnes)$$

$$Max\ weight\ for\ laden\ boxes\ (tonnes) = Max\ Laden\ TEUs * Average\ Container\ (Box\ only)\ Weight\ per\ TEU\ (tonnes)$$

$$Max\ weight\ for\ empties (tonnes) = Max\ Empty\ TEUs * Average\ Container\ (Box\ only)\ Weight\ per\ TEU\ (tonnes)$$

$$Total\ volume\ restricted\ tonnage\ (cubed\ out\ tonnage)(tonnes) = Max\ weight\ for\ cargo + Max\ weight\ for\ laden\ boxes + Max\ weight\ for\ empties$$

The LFA proceeds as follows:

The initial draft is set between the vessel's maximum (loaded) to minimum (empty) sailing draft. At each sailing draft the total tonnage carried is calculated using the TPI rating for the vessel.

$$DWT\ Available\ for\ Vessel\ Draft = DWT\ Rating\ (tonnes) - [(Aggregate\ Maximum\ Summer\ Load\ Line\ Draft - Sailing\ Draft) * 12\ inches * TPI]$$

This capacity is then allocated, first to ballast and operations to yield capacity available for cargo.

$$Approximate\ Variable\ Ballast = DWT\ Available\ for\ Vessel\ Draft * Percent\ Assumption\ for\ Variable\ Ballast$$

$$Allowance\ for\ Operations\ in\ tonnes = DWT\ Rating\ (tonnes) * Percent\ Allowance\ for\ Operations$$

$$Available\ for\ Cargo = (DWT\ Available\ for\ Vessel\ Draft) - (Approximate\ Variable\ Ballast) - (Allowance\ for\ Operations)$$

The capacity available for cargo is restricted if the vessel has "cubed" or "volumed" out:

$$Available\ for\ Cargo\ adjusted\ for\ volume\ restriction\ if\ any\ (tonnes) = the\ lesser\ of\ Available\ for\ Cargo\ and\ Total\ volume\ restricted\ tonnage\ (cubed\ out\ tonnage)$$

The tonnage available for cargo is then allocated to cargo, laden and empty containers based on the shares of vessel capacity:

$$Distribution\ of\ Space\ Available\ for\ Cargo\ (tonnes) = Available\ for\ Cargo\ adjusted\ for\ volume\ restriction\ if\ any\ in\ tonnes * Cargo\ Share\ in\ percent$$

$$Distribution\ of\ Space\ Available\ for\ Laden\ TEUs\ (tonnes) = Available\ for\ Cargo\ adjusted\ for\ volume\ restriction\ if\ any\ in\ tonnes * Laden\ Container\ Share\ in\ percent$$

$$Distribution\ of\ Space\ Available\ for\ Empty\ TEUs\ (tonnes) = Available\ for\ Cargo\ adjusted\ for\ volume\ restriction\ if\ any * Empty\ Container\ Share$$

The number of TEUs is then estimated for each share use:

$$Number\ of\ Laden\ TEUs = Distribution\ of\ Space\ Available\ for\ Cargo / Average\ Lading\ Weight\ per\ Loaded\ TEU\ by\ Route\ (tonnes)$$

$$Number\ Empty\ TEUs = Distribution\ of\ Space\ Available\ for\ Empty\ TEUs / Average\ Container\ (Box\ only)\ Weight\ per\ TEU\ (tonnes)$$

$$Occupied\ TEU\ Slots\ on\ Vessel = Number\ of\ Laden\ TEUs + Number\ Empty\ TEUs$$

$$Vacant\ Slots = Nominal\ TEU\ Rating - Occupied\ TEU\ Slots$$

The CLT then calculates the ETTC (estimate of total trip cargo) for each vessel call as the cargo on board the vessel at arrival plus the cargo on board the vessel at departure, in tons (see description and equation for ETTC in Section 5.1.1.).

The CLT works to load each vessel available to carry the commodity on the given route until the forecast is satisfied or the available fleet is exhausted.

5.1.4. Sailing Draft Distribution

There are several data requirements to run the CLT including a commodity forecast (Section 4.2.), vessel fleet forecast (Section 4.2.3.), and vessel load factors. Vessel sailing draft distributions are a critical input for determining the benefits of channel deepening. In the CLT, vessel drafts are used to determine how much cargo a vessel carries and how many trips are required to satisfy a commodity forecast. The model allows deeper sailing drafts for alternatives with deeper channel depths. Deeper sailing drafts lead to higher cargo volumes per transit, less required vessel calls, and a reduction in total transportation costs.

At the Port of New York & New Jersey, vessels with a maximum sailing draft of less than 49 feet (SPX, PX, PPX1, and PPX2) have at least 99 percent channel reliability at maximum sailing draft under the FWOP condition (Table 5-7); therefore, analysis assumes no change to sailing draft distribution for these classes under all alternatives. Figure 29 and Figure 30 provide the arrival draft CDFs for PX and PPX1 vessels, respectively. The CDFs were developed by evaluating the arrival drafts of the container class vessels calling on the harbor from 2013 to 2017.

Figure 29: Panamax Sailing Draft CDF

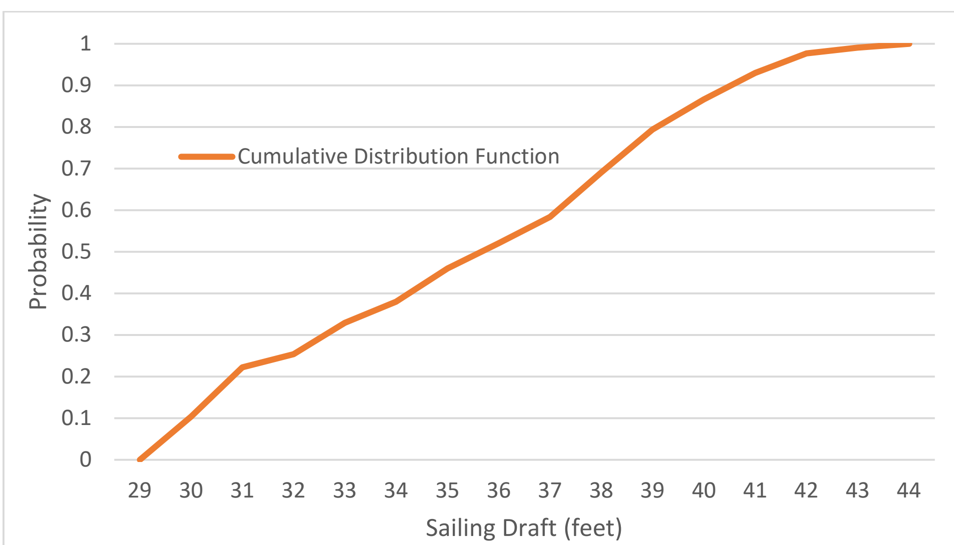
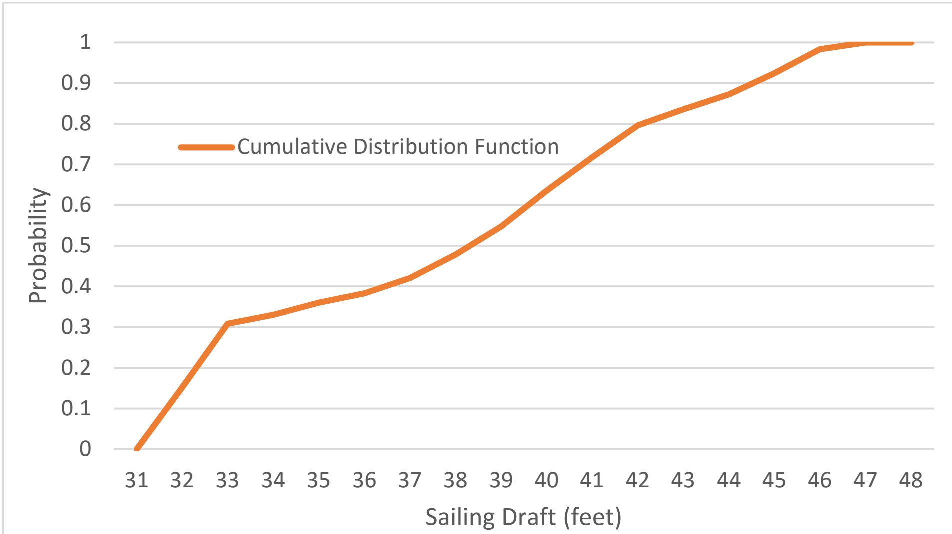


Figure 30: PPX1 Sailing Draft CDF



The CDFs in Figure 31, Figure 32, and Figure 33 estimate sailing draft distributions by alternative channel depth of PPX2, PPX3, and PPX4 vessels, respectively. FWOP sailing draft distributions for PPX2 and PPX3 vessels are based on historical vessel calls by class from 2013 through 2017. With-project (-51 feet through -58 feet MLLW) sailing draft CDFs for PPX2, PPX3, and PPX4 vessels were developed with the assistance of the IWR. The analysis assumes for each additional foot of channel depth the average container vessel will load an additional 0.6 to 0.8 feet deeper (0.7 feet on average). Analysis assumes PPX2 and PPX3 vessels can consistently sail at maximum draft with 2 feet and 4 feet of additional channel deepening, respectively. Sailing drafts remain constant once the class can reliably reach its maximum sailing draft. Similarly, analysis assumes PPX4 vessels can consistently load at maximum draft with 5 feet of channel deepening. The sailing draft remains constant for channel deepening alternatives beyond 5 feet.

Figure 31: PPX2 Sailing Draft CDF

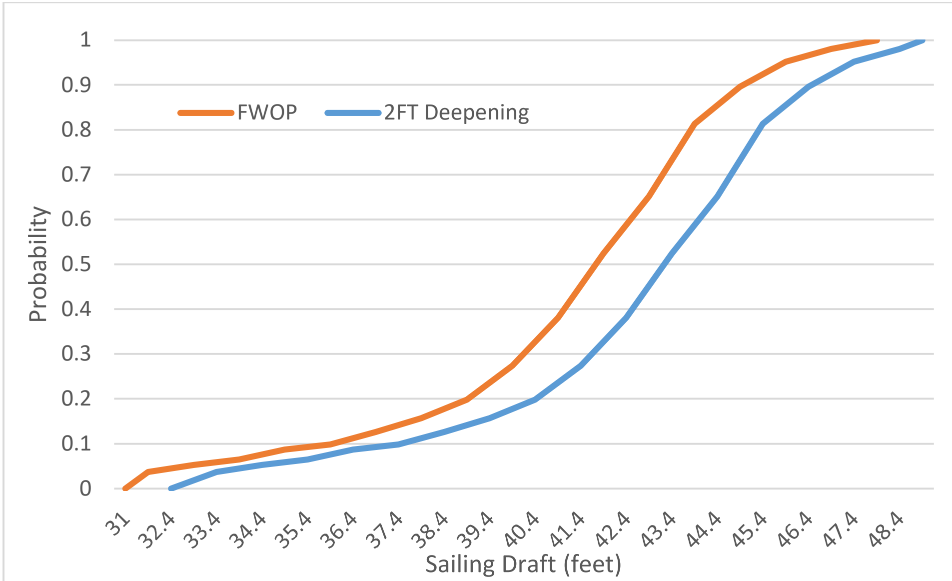


Figure 32: PPX3 Sailing Draft CDF

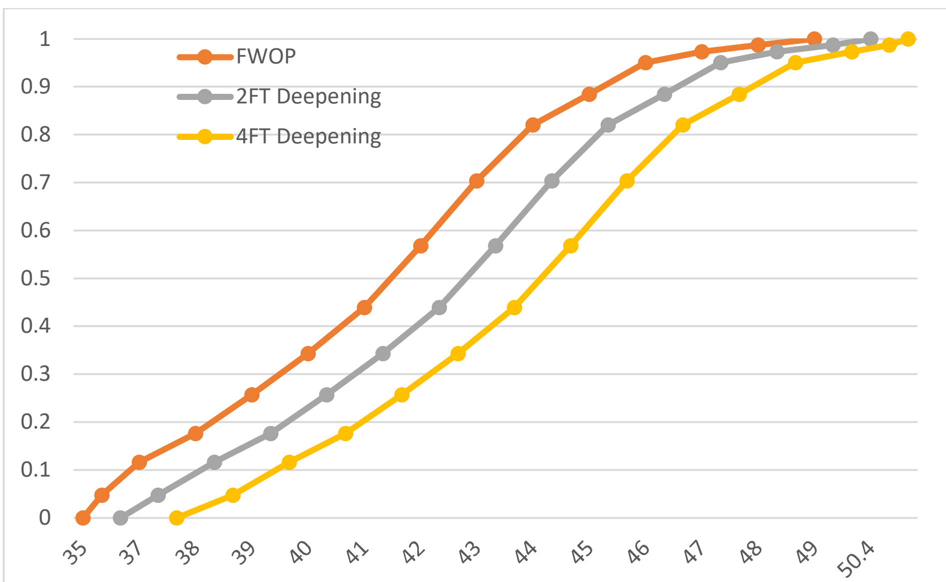
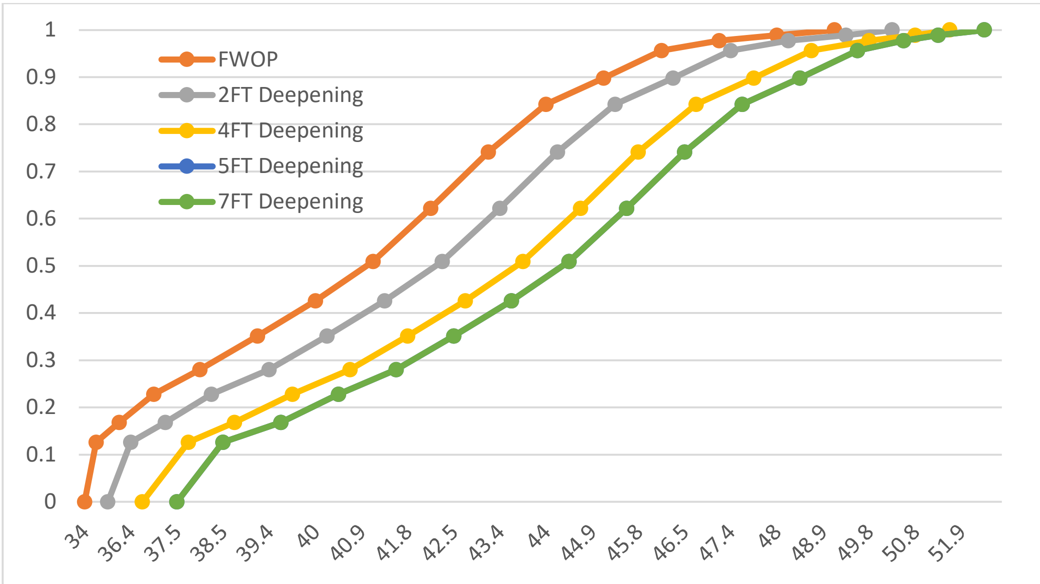


Figure 33: PPX4 Sailing Draft Distribution CDF



Shipping companies use consistently available channel depths to make vessel loading decisions; consequently, shippers would likely avoid loading vessels to any draft beyond 49 feet at the Port of New York & New Jersey at the current channel depth, which provides 52 feet of channel depth (49 foot sailing draft plus 3 feet minimum UKC) with 54% percent reliability in an aggregate tidal cycle (Table 5-7). Channel deepening allows vessels to consistently load deeper. Based on analysis conducted by IWR, vessels are expected to load an average of 0.6 to 0.8 feet deeper per each additional foot of channel depth. This study assumes an average 0.7 feet of additional vessel loading for each additional foot of channel depth. Consequently, an unrestricted PPX4 vessel may load as deep as 52.5 feet, requiring up to 56 feet of water depth for unrestricted transit. In an aggregate tidal cycle at current channel depths, 56 feet of depth is available only 2.5% of the time (Table 5-7). This is insufficient for PPX4 vessels to navigate the channel fully loaded. With 5 feet of channel deepening, vessels could expect approximately 82 percent channel reliability for a fully loaded PPX4 vessel with a sailing draft of 52.5 feet and a minimum 3 feet UKC.

Table 5-7: Channel Reliability by Alternative Depth

Alternative Depth (MLLW)	52.5' Design Draft Channel Reliability
FWOP	0.6%
2FT Deepening	8.7%
3FT Deepening	29.2%
4FT Deepening	46.8%
5FT Deepening	61.9%
6FT Deepening	81.7%
7FT Deepening	97.5%

5.1.5. Load Factor Analysis

Table 5-8 provides the vessel class assumptions used in the load factor analysis (LFA)[17], such as average lading weight per TEU, container (tare) weight, vacant slot allotment, variable ballast, etc. These inputs were developed using historical data provided by the Port (Import/Export fractions) and with the assistance of IWR (Lading Weight per Loaded TEU, Empty TEU and Vacant Slot allotment, Operations Allowance, and Variable Ballast). The analysis uses the historical cargo share for imports and exports based on NNOMPEAS Post-Panamax cargo data at the Port of New York & New Jersey from 2013 through 2017. The study assumes this cargo share will remain constant through the study period. Cargo share is a key input into the at-sea cost allocation detailed in Section 5.3. Load Factor analysis is not included for non-benefitting route groups.

Table 5-8: Vessel Class Inputs

Service	Class	Lading Wt. per TEU*	Empty TEU Allotment	Vacant Slot Allotment	Allowance for Ops. (% of DWT)	Variable Ballast (% of DWT)	Import / Export Cargo Share
East Asia (Panama Canal)	PX	8.5	6.5%	7.65%	6.7%	11%	.51/.15
	PPX1	8.5	6.5%	7.65%	6.7%	11%	.47/.13
	PPX2	8.5	6.5%	7.65%	6.7%	11%	.29/.12
	PPX3	8.5	6.5%	7.65%	6.7%	11%	.36/.1
East Asia (Suez Canal)	PX	8.5	8.7%	5%	6.7%	11%	.48/.2
	PPX1	8.5	8.7%	5%	6.7%	11%	.24/.15
	PPX2	8.5	8.7%	5%	6.7%	11%	.24/.15
	PPX3	8.5	8.7%	5%	6.7%	11%	.24/.15
	PPX4	8.5	8.7%	5%	6.7%	11%	.24/.15

*Container weight assumed to be 2 metric tons per TEU

Table 5-9 provides details on the vessel subclasses, which is used by the CLT to create vessels to satisfy the commodity forecast. The user provides the linkage between the HarborSym vessel class and the IWR-defined vessel subclass. The percentage share of each subclass was defined by historical data provided by the Port.

[17] LFA is the analytical effort to evaluate the disposition of vessel carrying capacity according to both weight and volume and evaluate resulting influences for immersion and associated transit draft as they relate to needs for waterway system depth.

Table 5-9: Vessel Subclass Inputs

Class	LOA	Beam	Max SLLD	Capacity (DWT)	TEU Rating	TPI	UKC	Sinkage	% Class
SPX CL 7	571	87	31.3	20,643	1,447	87.1	2.7	0.2	2
SPX CL 10	576	92	34.6	24,812	1,778	96.3	2.7	0.2	14
SPX CL 11	603	92	35.6	25,370	1,895	97.1	2.7	0.2	4
SPX CL 13	676	99	37.6	33,887	2,470	117.7	2.7	0.2	80
PX CL 4	846	106	41.2	50,070	3,841	162.7	2.8	0.2	28.3
PX CL 5	907	106	42.5	56,792	4,125	176.7	2.8	0.2	28.4
PX CL 6	887	104	43.4	54,885	3,993	170.4	2.8	0.2	43.3
PPX1 CL 2.00	928	131	41.4	75,623	5,534	214.7	3	0.3	14
PPX1 CL 4.00	900	130	44.4	78,284	4,912	208	3	0.3	4
PPX1 CL 5.00	935	131	46	78,618	5,793	215.1	3	0.3	21
PPX1 CL 5.40	965	132	46.1	80,504	6,295	225.4	3	0.3	19
PPX1 CL 5.30	981	132	46.1	110,448	6,441	230.7	3	0.3	2
PPX1 CL 5.25	984	132	46.1	75,898	6,505	230.9	3	0.3	33
PPX1 CL 5.15	992	132	46.2	102,179	6,600	233.7	3	0.3	7
PPX2 CL 7.00	1,106	143	42.7	104,549	9,148	290.3	3	0.3	3.4
PPX2 CL 9.00	1,018	143	46.1	103,865	7,200	260.3	3	0.3	19.3
PPX2 CL 10.00	1,090	142	47.6	104,657	8,212	284.9	3	0.3	39.8
PPX2 CL 10.65	1,099	143	47.6	105,458	8,528	289.2	3	0.3	3.4
PPX2 CL 10.25	1,114	144	47.7	92,875	8,916	293.5	3	0.3	18.2
PPX2 CL 10.15	1,127	145	47.7	96,687	9,294	300.3	3	0.3	15.9
PPX3-1	984	158	48.6	112,729	9,365	394	3	0.3	20
PPX3-2	1,106	158	50.9	119,510	10,100	394	3	0.3	30
PPX3-3	1,202	158	51.2	148,542	13,102	394	3	0.3	50
PPX4-1	1,305	185	52.5	158,200	15,550	453	3	0.3	5
PPX4-2	1,299	176	52.5	186,470	16,022	453	3	0.3	12
PPX4-3	1,310	194	52.5	195,118	18,340	453	3	0.3	45
PPX4-4	1,312	193	52.5	218,000	20,150	453	3	0.3	38

Table 5-10 shows the maximum sailing draft for each vessel class at which vessel cargo capacity is maximized.

Table 5-10: Maximum Depth by Vessel Class

Vessel Class	Vessel Cargo Capacity Maximizing Depth (Max Sailing Draft)
SPX	37.6
PX	43.4
PPX1	46.1
PPX2	47.7
PPX3	48.6 - 51.2
PPX4	52.5

5.2. Containerized Vessel Calls

5.2.1. Forecasted Vessel Calls by Class

Forecasted vessel calls by class for EPAMT and PJPAMT are shown in Table 5-11 and Table 5-12, respectively. The results incorporate the containerized trade forecast (Section 4.2.3.), container fleet forecast (Section 4.3.3.), LFA inputs (Section 5.1.5.), and the Container Loading Tool algorithm (Section 5.1.3.).

Table 5-11: EPAMT Average Vessel Calls by Vessel Class and Channel Depth (30 iterations)

Vessel Class	FWOP	-52FT	-54FT	-55FT	-57FT
2030					
Panamax Containership	150	150	150	150	150
PPX Gen1 Containership	326	224	153	151	151
PPX Gen2 Containership	620	620	613	613	613
PPX Gen3 Containership	610	610	610	610	610
PPX Gen4 Containership	39	39	39	39	39
Total	**1,745**	**1,643**	**1,565**	**1,563**	**1,563**
2040					
Panamax Containership	125	125	125	125	125
PPX Gen1 Containership	318	215	146	142	142
PPX Gen2 Containership	688	640	603	601	601
PPX Gen3 Containership	890	890	890	890	890
PPX Gen4 Containership	78	78	78	78	78
Total	**2,099**	**1,948**	**1,842**	**1,836**	**1,836**
2050					
Panamax Containership	90	90	90	90	90
PPX Gen1 Containership	373	261	178	178	178
PPX Gen2 Containership	830	790	736	729	729
PPX Gen3 Containership	1,155	1,155	1,155	1,155	1,155
PPX Gen4 Containership	117	117	117	117	117
Total	**2,565**	**2,413**	**2,276**	**2,269**	**2,269**

Table 5-12: PJPAMT Average Vessel Calls by Vessel Class and Channel Depth (30 iterations)

Vessel Class	FWOP	-52FT	-54FT	-55FT	-57FT
2030					
Panamax Containership	5	5	5	5	5
PPX Gen1 Containership	35	22	13	12	12
PPX Gen2 Containership	93	88	84	84	84
PPX Gen3 Containership	155	155	155	155	155
PPX Gen4 Containership	13	13	13	13	13
Total	**301**	**283**	**270**	**269**	**269**
2040					
Panamax Containership	5	5	5	5	5
PPX Gen1 Containership	35	27	13	11	11
PPX Gen2 Containership	67	60	54	54	54
PPX Gen3 Containership	242	242	242	242	242
PPX Gen4 Containership	26	26	26	26	26
Total	**375**	**360**	**340**	**338**	**338**
2050					
Panamax Containership	5	5	5	5	5
PPX Gen1 Containership	44	23	4	2	2
PPX Gen2 Containership	79	70	63	63	63
PPX Gen3 Containership	309	309	309	309	309
PPX Gen4 Containership	39	39	39	39	39
Total	**476**	**446**	**420**	**418**	**418**

5.2.2. The Port of New York & New Jersey Share of World Fleet

The following tables estimate the share of the world fleet represented by the fleet forecast in Section 5.2.2. . This analysis serves as a check on the projected number of calls by estimating the percent of the world fleet dedicated to services calling the Port of New York and New Jersey. The analysis combines the EPAMT and PJPAMT vessel calls and assumes an average service consists of 8 vessels with at least one vessel calling weekly based on vessel counts from 2019 services. The equivalent vessel numbers are a result of dividing the number of calls in the previous tables by 52 weeks and multiplying by 8 vessels per service. The percent of world fleet value is derived by dividing the number of vessels per year from the previous step by the number of vessels in the historical and projected world fleet.

As shown in Table 5-13, the historical share of the world fleet calling the Port of New York & New Jersey remained between 6 percent and 7 percent of the total world fleet. As of 2018, the Port of New York & New Jersey vessel calls composed nearly 7 percent of the world fleet of vessels calling weekly with the greatest share of vessels in the PPX2 class (21.5 percent of the world fleet dedicated to routes serving the Port of New York & New Jersey).

Table 5-13: The Port of New York & New Jersey Share (%) of World Fleet Calling Weekly by Vessel Class, 2008-2017

Vessel Class	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
SPX	1.4	0.0	2.2	1.4	1.2	1.6	1.7	1.9	2.5	3.1
PX	16.8	14.8	14.2	14.5	16.4	15.7	12.1	9.3	5.2	5.3
PPX1	3.8	4.0	5.2	4.2	9.9	9.5	11.1	12.4	14.1	13.0
PPX2	0.0	3.5	4.9	4.7	6.4	8.6	16.8	18.8	19.8	21.5
PPX3	0.0	0.0	0.5	1.5	1.5	3.1	4.3	6.4	8.8	12.4
PPX4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	7	6	6	6	7	7	6.7	6.5	6.1	6.7

Table 5-14 presents the estimated future percent of the world fleet dedicated to services calling the Port of New York & New Jersey ("vessels" column). World fleet forecasts are only available through 2035. The analysis extends the 5-year trend from 2035 through 2050 to estimate the Port of New York & New Jersey's share of the world fleet through the forecast period. Consistent with historical fleet usage at the Port of New York & New Jersey, the analysis assumes the port's share of the world fleet remains under 6 percent for all forecast years. The greatest change from the existing condition is the increased PPX2 usage. The forecast estimates up to 33 percent of the world fleet of PPX2 vessel will call by 2030, a 12 percent increase from 2018. The growth in PPX2 usage is expected to continue through 2050. Importantly, the Port of New York & New Jersey's share of PPX3 and PPX4 vessels, which are most sensitive to channel deepening, remains relatively constant through the forecast period. This projection will be discussed further as a sensitivity analysis in Section 6. The analysis confirms the projected vessel calls for the Port of New York & New Jersey do not result in an excessive amount of the total world fleet in the without or with-project conditions.

Table 5-14. Future Percent of World Fleet Calling the Port of New York & New Jersey per week

Vessel Class	2030		2040		2050	
	Vessels	% World Fleet	Vessels	% World Fleet*	Vessels	% World Fleet*
FWOP (-50FT MLLW)						
PX	24	1.8%	20	1.6%	15	1.3%
PPX1	57	4.8%	56	3.1%	66	2.4%
PPX2	112	33.2%	119	33.5%	143	38.4%
PPX3	121	14.1%	178	14.4%	231	12.8%
PPX4	8	1.0%	16	1.1%	25	0.9%
Total	**322**	**5.1%**	**390**	**4.8%**	**479**	**4.5%**
-52FT MLLW						
PX	24	1.8%	20	1.6%	15	1.3%
PPX1	39	3.3%	38	2.1%	45	1.6%
PPX2	112	33.0%	110	31.0%	135	36.3%
PPX3	121	14.1%	178	14.4%	231	12.8%
PPX4	8	1.0%	16	1.1%	25	0.9%
Total	**303**	**4.8%**	**364**	**4.5%**	**450**	**4.2%**
-54FT MLLW						
PX	24	1.8%	20	1.6%	15	1.3%
PPX1	26	2.2%	25	1.4%	29	1.0%
PPX2	110	32.4%	103	29.1%	126	33.7%
PPX3	121	14.1%	178	14.4%	231	12.8%
PPX4	8	1.0%	16	1.1%	25	0.9%
Total	**289**	**4.5%**	**344**	**4.3%**	**425**	**3.9%**
-55FT MLLW						
PX	24	1.8%	20	1.6%	15	1.3%
PPX1	26	2.2%	24	1.3%	28	1.0%
PPX2	110	32.4%	103	29.0%	125	33.4%
PPX3	121	14.1%	178	14.4%	231	12.8%
PPX4	8	1.0%	16	1.1%	25	0.9%
Total	**289**	**4.5%**	**342**	**4.3%**	**423**	**3.9%**
-57FT MLLW						
PX	24	1.8%	20	1.6%	15	1.3%
PPX1	26	2.2%	24	1.3%	28	1.0%
PPX2	110	32.4%	103	29.0%	125	33.4%
PPX3	121	14.1%	178	14.4%	231	12.8%
PPX4	8	1.0%	16	1.1%	25	0.9%
Total	**289**	**4.5%**	**342**	**4.3%**	**423**	**3.9%**
*Extrapolated from 5-year trend						

5.3. Transportation Cost Savings Benefits by Project Depth

Transportation cost benefits were estimated using the HarborSym Economic Reporter, a tool developed by IWR to summarize HarborSym results from multiple simulations and present benefit-cost summaries. This tool collects the transportation costs from various model run output files and generates the transportation cost reduction for all project years, then produces an Average Annual Equivalent (AAEQ) value for comparison.

5.3.1. Elizabeth-Port Authority Marine Terminal (EPAMT) Transportation Cost Savings

Transportation costs were estimated for a 50-year period of analysis for the years 2039 through 2088. The study team developed HarborSym models for 2030, 2040, and 2050, interpolated transportation costs for intermediate years, and held transportation costs constant past 2050. Transportation costs were annualized to determine AAEQ costs and savings by discounting the cost stream to Base Year 2039[18] at the current FY 2020 Federal Discount rate of 2.75 percent[19]. Estimates were determined for each alternative project depth and pathway. Final benefit cost estimates in Section 5.4.4. update the recommended plan using FY21 discount rate and price level.

Table 5-15 provides the annual transportation costs in total and for the at-sea and in-port portions for channel deepening to EPAMT. At-sea cost savings are primarily the result of the reduction in the number of total vessels required to transport the same cargo volume under deeper channel conditions. In-port transportation cost savings are the result of fewer vessels calling the Port of New York & New Jersey and an overall reduction in channel congestion. The study does not model vessel interaction with non-containerized vessel calls. The primary congestion reduction is likely realized by containerized vessels. As a result, the study assumes the model captures all congestion-related benefits through modeling containerized vessel calls only. The table consists of three sub-tables. The first sub-table shows total costs by year for origin-destination (OD) at-sea and in-port transportation costs allocated to the Port of New York & New Jersey. The second sub-table shows the in-port proportion of total transport costs. The third sub-table shows the at-sea proportion of total costs. The total cost is the sum of the in-port and at-sea transportation costs by year. The transportation cost saving benefit is provided in Table 5-16 using the same three sub-tables.

[18] Final benefit estimates use a Base Year of 2040.

[19] Alternatives analysis took place in Fiscal Year 2020. After plan selection, the plan was refined in FY21 at FY21 prices and discount rate. The final benefit-cost summary is presented in FY22 prices and price level.

Table 5-15: EPAMT Origin-Destination Annual Transportation Costs ($1,000s)

Total At-Sea and In-Port Transportation Cost Allocated to Port ($1,000s)					
Year	FWOP	-52FT MLLW	-54FT MLLW	-55FT MLLW	-57FT MLLW
2030	$1,942,106	$1,854,381	$1,782,534	$1,779,828	$1,779,828
2039	$2,444,352	$2,311,873	$2,217,227	$2,211,966	$2,211,966
2040	$2,500,158	$2,362,706	$2,265,526	$2,259,982	$2,259,982
2050	$3,156,758	$3,015,331	$2,891,214	$2,883,231	$2,883,231
In-Port Transportation Costs ($1,000s)					
Year	FWOP	-52FT MLLW	-54FT MLLW	-55FT MLLW	-57FT MLLW
2030	$136,129	$135,365	$134,464	$134,409	$134,409
2039	$172,821	$170,787	$169,483	$169,429	$169,429
2040	$176,897	$174,722	$173,375	$173,320	$173,320
2050	$224,034	$223,360	$221,525	$221,486	$221,486
At-Sea Transportation Cost Allocated to Port ($1,000s)					
Year	FWOP	-52FT MLLW	-54FT MLLW	-55FT MLLW	-57FT MLLW
2030	$1,805,977	$1,719,016	$1,648,070	$1,645,419	$1,645,419
2039	$2,271,532	$2,141,086	$2,047,744	$2,042,538	$2,042,538
2040	$2,323,260	$2,187,983	$2,092,152	$2,086,662	$2,086,662
2050	$2,932,723	$2,791,971	$2,669,689	$2,661,746	$2,661,746

Table 5-16: EPAMT Origin-Destination Transportation Cost Savings Benefits by Channel Depth ($1,000s)

Change in At-Sea and In-Port Vessel Transportation Costs ($1,000s)				
Year	-52FT MLLW	-54FT MLLW	-55FT MLLW	-57FT MLLW
2030	$87,726	$159,572	$162,278	$162,278
2039	$132,479	$227,125	$232,386	$232,386
2040	$137,452	$234,631	$240,176	$240,176
2050	$141,427	$265,543	$273,526	$273,526
In-Port Transportation Cost Reduction Benefit by Alternative ($1,000s)				
Year	-52FT MLLW	-54FT MLLW	-55FT MLLW	-57FT MLLW
2030	$764	$1,665	$1,719	$1,719
2039	$2,034	$3,337	$3,392	$3,392
2040	$2,175	$3,523	$3,578	$3,578
2050	$675	$2,509	$2,549	$2,549
Change in At-Sea Vessel Transportation Costs ($1,000s)				
Year	-52FT MLLW	-54FT MLLW	-55FT MLLW	-57FT MLLW
2030	$86,962	$157,907	$160,559	$160,559
2039	$130,445	$223,788	$228,994	$228,994
2040	$135,277	$231,108	$236,598	$236,598
2050	$140,752	$263,034	$270,977	$270,977

Table 5-17 provides the AAEQ transportation costs and cost savings by channel depth for deepening to EPAMT. Table 5-18 presents cost statistics for the benefits estimate. As shown, benefits are maximized with a -55FT channel deepening. There is no additional benefit estimated for deepening past 5 feet.

Table 5-17: EPAMT Origin-Destination AAEQ Transportation Costs by Alternative Depth ($1,000s)

Alternative	AAEQ Transportation Cost	AAEQ Transportation Cost Savings
FWOP	$3,014,023	$-
-52FT	$2,873,627	$139,281
-54FT	$2,755,375	$255,474
-55FT	$2,747,925	$264,532
-57FT	$2,747,925	$264,532

Table 5-18: EPAMT Origin-Destination AAEQ Cost Statistics by Alternative and Depth ($1,000s)

Statistic	FWOP	-52FT	-54FT	-55FT	-57FT
Mean	$3,014,023	$2,873,627	$2,755,376	$2,747,926	$2,747,926
SD	$4,524	$5,276	$5,570	$5,611	$5,611
Median	$3,014,652	$2,873,128	$2,754,343	$2,746,604	$2,746,604
Min	$3,001,310	$2,860,842	$2,745,389	$2,736,236	$2,736,236
Max	$3,026,150	$2,886,344	$2,768,655	$2,763,595	$2,763,595
Range	$24,840	$25,502	$23,266	$27,358	$27,358
Confidence of Mean +/-	$1,773	$2,069	$2,184	$2,199	$2,199

Confidence calculation assumes a normal distribution and 95% confidence level.
Transportation costs include only those allocated to subject port.

5.3.2. PJPAMT Transportation Cost Savings

Table 5-19 provides the estimated transportation costs for PJPAMT. Again, transportation costs for Base Year 2039[20] are based on interpolation between 2030 and 2040 model runs. Values are also interpolated between 2040 and 2050. All costs are held constant after 2050. Table 5-20 presents transportation cost savings for channel deepening to PJPAMT.

[20] Final benefit evaluation uses base year 2040.

Table 5-19: PJPAMT Origin-Destination Annual Transportation Costs ($1,000s)

Total At-Sea and In-Port Transportation Cost Allocated to Port ($1,000s)					
Year	FWOP	-52FT MLLW	-54FT MLLW	-55FT MLLW	-57FT MLLW
2030	$478,433	$452,427	$435,062	$434,478	$434,478
2039	$583,493	$558,056	$530,998	$528,965	$528,965
2040	$595,167	$569,793	$541,658	$539,463	$539,463
2050	$759,268	$717,847	$680,847	$678,948	$678,948
In-Port Transportation Costs ($1,000s)					
Year	FWOP	-52FT MLLW	-54FT MLLW	-55FT MLLW	-57FT MLLW
2030	$24,674	$24,478	$24,414	$24,341	$24,341
2039	$31,213	$31,341	$31,138	$31,107	$31,107
2040	$31,940	$32,103	$31,885	$31,858	$31,858
2050	$42,146	$41,956	$41,537	$41,586	$41,586
At-Sea Transportation Cost Allocated to Port ($1,000s)					
Year	FWOP	-52FT MLLW	-54FT MLLW	-55FT MLLW	-57FT MLLW
2030	$453,759	$427,950	$410,648	$410,137	$410,137
2039	$552,280	$526,716	$499,860	$497,858	$497,858
2040	$563,227	$537,690	$509,773	$507,605	$507,605
2050	$717,121	$675,891	$639,311	$637,361	$637,361

Table 5-20: PJPAMT Origin-Destination Transportation Cost Savings Benefits by Channel Depth ($1,000s)

Change in At-Sea and In-Port Vessel Transportation Costs ($1,000s)				
Year	-52FT MLLW	-54FT MLLW	-55FT MLLW	-57FT MLLW
2030	$26,005	$43,370	$43,954	$43,954
2039	$25,437	$52,495	$54,528	$54,528
2040	$25,374	$53,509	$55,703	$55,703
2050	$41,421	$78,421	$80,320	$80,320
Change in In-Port Vessel Transportation Costs ($1,000s)				
Year	-52FT MLLW	-54FT MLLW	-55FT MLLW	-57FT MLLW
2030	$196	$260	$332	$332
2039	$(127)	$76	$107	$107
2040	-$163	$55	$82	$82
2050	$191	$610	$560	$560
Change in At-Sea Vessel Transportation Costs ($1,000s)				
Year	-52FT MLLW	-54FT MLLW	-55FT MLLW	-57FT MLLW
2030	$25,809	$43,111	$43,622	$43,622
2039	$25,564	$52,419	$54,422	$54,422
2040	$25,537	$53,454	$55,621	$55,621
2050	$41,230	$77,811	$79,760	$79,760

Table 5-21 provides the AAEQ transportation costs and cost savings by channel depth for deepening to EPAMT. Table 5-22 presents cost statistics for the benefits estimate. Like channel deepening alternatives to EPAMT, benefits are maximized with a 5-foot channel deepening. There is no additional benefit estimated for deepening past 5 feet.

Table 5-21: PJPAMT Origin-Destination AAEQ Transportation Costs by Alternative Depth ($1,000s)

Alternative	AAEQ Transportation Cost	AAEQ Transportation Cost Savings
FWOP	$723,677	$-
52FT	$685,693	$37,984
54FT	$650,631	$73,046
55FT	$648,675	$75,002
57FT	$648,675	$75,002

Table 5-22: PJPAMT Origin-Destination AAEQ Cost Statistics by Alternative and Depth ($1,000s)

Statistic	FWOP	52FT	54FT	55FT	57FT
Mean	$723,677	$685,693	$650,631	$648,675	$648,675
SD	$4,524	$5,276	$5,570	$5,611	$5,611
Median	$722,862	$685,708	$650,971	$648,281	$648,281
Min	$718,242	$680,365	$646,248	$642,852	$642,852
Max	$731,475	$692,397	$659,649	$656,747	$656,747
Range	$13,233	$12,032	$13,401	$13,895	$13,895
Confidence of Mean +/-	$1,152	$984	$1,137	$1,163	$1,163

Confidence calculation assumes a normal distribution and 95% confidence level.
Transportation costs include only those allocated to subject port.

5.4. Alternatives Benefit-Cost Analysis

The study team completed the alternatives benefit-cost analysis in three phases:

- Phase I: determine the increment with the highest net benefits. The study team evaluates channel deepening benefits by Pathway for each depth (2 feet to 7 feet deepening).
- Phase II: determine the second added increment. The study team evaluates the incremental costs and benefits of channel deepening the second Pathway, assuming construction of the first Pathway.
- Phase III: evaluate additional navigation efficiency components. The study team evaluates economic justification of channel widening at the eastern entrance of the Kill van Kull.

5.4.1. Phase I Benefit-Cost Analysis

Table 5-23 presents alternative costs including IDC, OMRR&R, and local service facility improvement cost assumptions. Estimated first costs include the cost to construct the proposed depth, including contingency, PED and CM costs presented at current price levels (October 2019). IDC is based on an assumed 16-year construction duration, depending on the alternative, calculated to the midpoint of construction. Total economic costs represent implementation costs and includes project first costs, IDC (calculated using total economic costs), and local service facility costs.

Table 5-23: Alternatives Costs ($1,000s, October 2019 Price Level, 2.75% Discount Rate)

Depth	Project First Costs	IDC	Berth Costs	Total Econ. Costs	AAEQ Total Investment	AAEQ OMRR&R	Total AAEQ Costs
Sea to EPAMT							
-52FT	$2,805,008	$433,696	$112,791	$3,351,495	$124,103	$4,147	$128,250
-53FT	$3,065,290	$558,241	$126,410	$3,749,941	$138,725	$4,147	$142,872
-54FT	$3,328,028	$728,070	$139,691	$4,195,789	$155,125	$4,147	$159,272
-55FT	$3,634,007	$884,762	$138,123	$4,656,892	$173,676	$4,147	$177,823
-56FT	$3,994,782	$1,073,855	$137,979	$5,206,616	$193,124	$4,147	$197,272
-57FT	$4,285,876	$1,226,566	$147,960	$5,660,402	$210,168	$4,147	$214,315
Sea to PJPAMT							
-52FT	$345,284	$34,986	$27,412	$407,682	$15,101	$136	$15,237
-53FT	$410,393	$47,966	$27,747	$486,106	$18,006	$136	$18,142
-54FT	$477,958	$71,148	$28,132	$577,238	$21,381	$136	$21,517
-55FT	$543,702	$89,873	$28,010	$661,585	$24,506	$136	$24,642
-56FT	$664,243	$132,254	$27,955	$824,452	$30,538	$136	$30,674
-57FT	$791,507	$185,365	$28,080	$1,004,952	$36,224	$136	$36,360

The study team compared benefits and costs for both pathways (Sea to EPAMT and Sea to PJPAMT) at each alternative depth to determine the Pathway and depth with the highest net benefits. Table 5-24 summarizes the results of the benefit cost analysis.

Table 5-24: Benefit-Cost Summary Assuming Pathway to EPAMT to 4FT ($1,000s, 2019 Price Level, 2.75% Discount Rate)

Depth	Total Economic Costs	Total AAEQ Costs	Total AAEQ Benefits	Total Net Benefits	Benefit/Cost Ratio
SEA TO EPAMT					
-52FT	$3,351,495	$128,250	$139,281	$11,031	1.1
-53FT	$3,749,941	$142,872	$197,377	$54,505	1.4
-54FT	**$4,195,789**	**$159,272**	**$255,474**	**$96,202**	**1.6**
-55FT	$4,656,892	$177,823	$264,532	$86,709	1.5
-56FT	$5,206,616	$197,272	$264,532	$67,260	1.3
-57FT	$5,660,402	$214,315	$264,532	$50,217	1.2
SEA TO PJPAMT					
-52FT	$407,682	$15,237	$37,984	$22,747	2.5
-53FT	$486,106	$18,142	$55,515	$37,373	3.1
-54FT	**$577,238**	**$21,517**	**$73,045**	**$51,528**	**3.4**
-55FT	$661,585	$24,642	$75,002	$50,360	3.0
-56FT	$824,452	$30,674	$75,002	$44,328	2.4
-57FT	$1,004,952	$36,360	$75,002	$38,642	2.1

The benefit-cost analysis indicates benefits for both Pathways maximize with a 4-foot deepening. Sea to EPAMT deepening to -54FT MLLW yields the highest net benefits of any alternative.

5.4.2. Phase II Benefit-Cost Analysis

Analysis then determines the second Pathway increment which maximizes net benefits. Phase II benefit-cost analysis only evaluates incremental costs of channel improvements beyond 4-foot deepening from Sea to EPAMT. Table 5-25 presents alternative costs of deepening to PJPAMT assuming 4-foot deepening from Sea to EPAMT. Costs include incremental IDC (calculated using total economic costs), OMRR&R, and local service facility improvement costs for deepening to PJPAMT by channel depth. Total economic costs represent implementation costs and includes project first costs, IDC, and local service facility costs. Approximately $345 million in joint costs are attributed to Sea to EPAMT under the -54 feet MLLW deepening and $364 million under the -55 feet MLLW deepening.

Table 5-25: Phase II Costs ($1,000s, October 2019 prices, 2.75% Discount Rate)

Depth	Project First Costs	IDC	Associated Costs	Total Econ. Costs	AAEQ Total Investment	AAEQ OMRR&R	Total AAEQ Costs
PJPAMT Optimization (assuming EPAMT deepened to -54FT MLLW)							
-52FT	$199,485	$20,213	$27,412	$247,110	$9,216	$73	$9,289
-53FT	$215,627	$25,202	$27,747	$268,576	$10,011	$73	$10,084
-54FT	$231,770	$27,089	$28,132	$286,991	$10,693	$73	$10,766
-55FT	$297,515	$44,288	$28,010	$369,812	$13,761	$73	$13,834
-56FT	$418,055	$76,104	$27,955	$522,115	$19,266	$73	$19,340
-57FT	$545,320	$127,709	$28,080	$701,109	$25,736	$73	$25,809

Table 5-26 summarizes the results of Phase II benefit-cost analysis. Costs are incremental costs assuming Pathway to EPAMT is dredged to -54FT MLLW. The analysis shows NED benefits are maximized with a 4-foot deepening.

Table 5-26: Pathway to PJPAMT Incremental Benefit-Cost Summary ($1,000s, October 2019 Price Level, 2.75% Discount Rate)

Depth	Total Economic Costs	Total AAEQ Costs	Total AAEQ Benefits	Total Net Benefits	Benefit/Cost Ratio
*PJPAMT INCREMENTAL ANALYSIS (Assuming Elizabeth deepened **4FT**)*					
-52FT	$247,110	$9,289	$37,984	$28,695	4.1
-53FT	$268,576	$10,084	$55,515	$45,431	5.5
-54FT	**$286,991**	**$10,766**	**$73,045**	**$62,279**	**6.8**
-55FT	$369,812	$13,834	$75,002	$61,168	5.4
-56FT	$522,115	$19,340	$75,002	$55,662	3.9
-57FT	$701,109	$25,809	$75,002	$49,193	2.9

Like the Pathway to EPAMT, the Pathway to PJPAMT maximizes net benefits with 4-feet of channel deepening. The results of Phase I and Phase II analysis indicates NED benefits are maximized at 4FT for both Pathways.

5.4.3. Phase III Benefit-Cost Analysis

In Phase III the study team evaluates navigation efficiency components. Of the three efficiency components originally formulated, the Port of New York & New Jersey pilots determined two as necessary for navigation. The study team evaluated an efficiency component at the eastern entrance of Kill Van Kull. This component is a widening meant to allow vessels to meet and pass. The location of the potential widening component also allows vessel to navigate closer to the Kill Van Kull to pass outbound vessels.

The study assumes vessels would use the passing component in place of the Gravesend Anchorage. This would allow vessels to proceed to the east entrance of the Kill Van Kull to pass vessels, saving approximately 15 minutes of wait time. The study assumes 30 percent of container vessels will take advantage of the efficiency component based on the historical percentage of container vessels using the Gravesend Anchorage. The study team developed models for 2030, 2040, and 2050. Benefits are interpolated for intermediate years and held constant after 2050. Table 5-27 summarizes the benefit-cost estimate for the efficiency component.

Table 5-27: Efficiency Component Benefit-Cost Summary (October 2019 Price Level, 2.75% Discount Rate)

Total Economic Costs	AAEQ Costs	AAEQ Benefits	Net Benefits	Benefit-Cost Ratio
$28,883,000	$1,074,000	$367,000	$(707,000)	0.34

5.4.4. Recommended Plan

The study team identified the recommended plan as channel deepening up to -55 feet MLLW. NED benefits are maximized at -54 feet MLLW, but the study team chose to carry 5 feet deepening forward for additional analysis. The sensitivity of both the -54 feet and -55 feet deepening plans is described in Section 6. Table 5-28 and Table 5-29 present the updated benefit-cost analysis for 4-foot deepening and 5-foot deepening, respectively. The tables include updated benefit and cost analyses. As shown, net AAEQ benefits are maximized with a 4-foot deepening.

Table 5-28: Updated -54FT Deepening Benefit-Cost Analysis for (Oct 2020 Price Level, 2.50% Discount)

Project Phase	Total AAEQ Costs	Total AAEQ Benefits	Total Net Benefits	Benefit/Cost Ratio
Phase I: -54FT	$145,812,826	$255,854,000	$110,041,174	1.75
Phase II: -54FT	$22,917,315	$73,252,000	$50,334,685	3.20
Total	**$168,730,141**	**$329,106,000**	**$160,375,859**	**1.95**

Table 5-29: Updated -55FT Deepening Benefit-Cost Analysis (Oct 2020 Price Level, 2.50% Discount)

Project Phase	Total AAEQ Costs	Total AAEQ Benefits	Total Net Benefits	Benefit/Cost Ratio
Phase I: -55FT	$156,052,331	$264,876,000	$108,823,669	1.70
Phase II: 55FT	$24,685,974	$75,206,000	$50,520,026	3.05
Total	**$180,738,305**	**$340,082,000**	**$159,343,695**	**1.88**

5.4.5. Depth Optimization

As agreed at the Tentatively Selected Plan (TSP) Milestone in August 2020, The Deep Draft Navigation Planning Center of Expertise (DDNPCX) conducted further analysis of both the -54-foot and -55-foot deepening alternatives. The DDNPCX reviewed newly available vessel call and cargo data from 2018 through 2020 provided by PANYNJ and determined an update to the Future Fleet Mix was appropriate for this study. An estimated 453 vessels with TEU capacity between 13,100 TEU and 15,128 called the Port of New York and New Jersey from 2018 through 2020. This size vessel was underrepresented in the initial fleet forecast when compared to actual vessel calls at the Port of New York and New Jersey. As a result, the economic team updated the fleet forecast based on the recent transition to larger vessels in the PPX3 class calling the Port, especially after the raising of the Bayonne Bridge.

The economics analysis for the NYNJHDCI feasibility study uses fleet distributions developed by IWR and IHS Global Insights. Table 5-30 compares the actual distribution of cargo in 2020 by vessel class and forecasted distributions used in the economic analysis for 2020, 2030, 2040, and 2050. Table 5-30 shows a higher portion of cargo allocated to PPX4 vessels than anticipated by the USACE forecast; however, this difference is primarily the result of the representative vessels used in the economic analysis. The current HarborSym model does not include a representative vessel within the 13,000 to 15,000 TEU range (see Economic Appendix, Table 33).

*Table 5-30. Cargo Distribution by Vessel Class**

Year	SPX	PX	PPX1	PPX2	PPX3	PPX4
2020 – actual**	**15%**	**10%**	**14%**	**36%**	**13%**	**28%**
2020 – forecast	**6%**	**10%**	**15%**	**25%**	**40%**	**0-4%*****
2030	0%	3%	11%	32%	50%	4%
2040	0%	2%	9%	25%	58%	6%
2050	0%	1%	9%	24%	59%	7%

*Values differ from estimates provided in Section 4.3.3 based on actual HarborSym modeling output
**Based on Port's estimate. PPX4 vessels identified as any vessel with over 13,100 TEU capacity. HarborSym modeling allows some overlap in TEU capacity between the PPX3 and PPX4 classifications making comparison of PPX3 plus PPX4 more appropriate (35% actual versus 40%-44% forecast PPX3 plus PPX4).
***Interpolation: PPX4 vessel class distributions were only forecasted for model years 2030, 2040, and 2050.

Table 5-31 provides a more detailed summary of throughput cargo distribution by vessel class and TEU capacity. As shown, the forecast estimated PPX3 and PPX4 vessels would carry 45 percent of total throughput as opposed to 42 percent of actual throughput recorded by the Port in 2020[21]. The primary difference between the forecast and actual tonnage distribution is the number of vessels between 13,000 and 15,000 TEU capacity.

[21] Percentages differ from Table 54 due to overlap in TEU Capacities between classes. For simplicity, Table 55 avoids overlapping TEU capacity between classes.

Table 5-31. Cargo Distribution by TEU Capacity

Vessel Class Definitions	TEU Band	Percent Throughput by Class		Percent Throughput by TEU Band	
		2020 - Actual	2020 - Forecast	2020 - Actual	2020 - Forecast
SPX	<1,999	5%	5%	2%	1%
	2,000-2,999			3%	4%
PX	3,000-3,999	10%	10%	3%	7%
	4,000-4,999			8%	3%
PPX1	5,000-5,999	15%	15%	4%	6%
	6,000-6,999			12%	9%
PPX2	7,000-7,999	28%	25%	4%	5%
	8,000-8,999			24%	20%
PPX3	9,000-9,999	14%	40%	8%	8%
	10,000-10,999			4%	12%
	11,000-11,999			1%	0%
	12,000-12,999			0%	20%
	13,000-13,999	28%	0%	21%	0%
	14,000-14,999			7%	0%
PPX4	15,000-15,999	0%	5%	0%	0%
	16,000-16,999			0%	1%
	17,000-17,999			0%	0%
	18,000-18,999			0%	2%
	19,000-19,999			0%	0%
	20,000-20,999			0%	2%

The influx of 13,000 to 15,000 TEU vessels is likely to continue through the study period. The trend toward the use of larger vessels is already captured in the fleet forecast; however, the fleet distribution used in the HarborSym model is not accounting for vessels in the 13,000 to 15,000 TEU capacity range.

The fleet forecast was updated to account for the vessel sizes currently calling the Port of New York and New Jersey by adding vessels in this TEU band. In 2020, 66 percent of TEUs carried on vessels 9,000 TEU capacity and larger were carried on vessels with 13,000 TEU capacity and greater. Table 5-32 summarizes the cargo distribution of “PPX3” to “PPX4” vessel classes. The HarborSym model was updated to reflect the 2020 distribution (i.e., cargo will be redistributed from smaller, PPX3 class vessels to vessels in the 13,00 to 15,000 TEU band).

Table 5-32. Cargo Distribution PPX3-PPX4 Vessels (2019-2020)

PPX3 TEU Bands	2019	2020
9,000-9,999	23%	**18%**
10,000-10,999	11%	**10%**
11,000-11,999	2%	**3%**
12,000-12,999	0%	**1%**
13,000-13,999	45%	**50%**
14,000-14,999	17%	**17%**

Post-Panamax Generation 3 Representative Fleet. The economics team updated the representative fleet for the Post-Panamax Generation 3 (PPX3) class vessels (9,000 to 14,000 TEU capacity) to reflect the 2020 fleet calling the Port of New York and New Jersey. The economics team calculated average TEU capacity for each TEU band (e.g., 12,000 to 13,000) and selected a vessel from the Port's 2020 call list with the closest TEU capacity. Table 5-33 summarizes the updated PPX3 representative fleet and class distribution.

Table 5-33. PPX3 Representative Vessel Fleet

Class	LOA	Beam	Max SLLD	Capacity (DWT)	TEU Rating	% Class
PPX3-1	984	158	48.6	112,729	9,365	19
PPX3-2	1,106	158	50.9	119,510	10,100	10
PPX3-3	1,193	150	50.9	131,292	11,356	3
PPX3-4	1,095	158	53.8	127,076	12,118	1
PPX3-5	1,201	158	50.9	145,237	13,386	50
PPX3-6	1,204	158	52.5	148,992	14,414	17

Post-Panamax Generation 3 Sailing Draft Distribution. Approximately 17 percent of the PPX3 representative fleet would benefit from deepening beyond -54 feet mean lower low water (MLLW). This is based on the percentage of the world fleet within this vessel class with maximum sailing drafts of 52.5 feet or more. The DDNPCX updated the project to allow this portion of the PPX3 class to load additional cargo past the 54-foot alternative.

Post-Panamax Generation 4 Cargo Distribution. The update increases the number of PPX4 vessels (14,000 TEU capacity and greater) calling both study terminals (EPAMT and PJPAMT). Preliminary analysis showed greater capacity for PPX4 class vessels at EPAMT. This update follows that conclusion and estimates EPAMT will receive approximately 1 PPX4 call per week in 2030, 2 in 2040, and 3 in 2050. The study estimates PJPAMT will receive approximately half as many PPX4 calls per year compared to EPAMT based on berth and yard capacity[22]. These PPX4 vessels are most likely to be in the 16,000 to 18,000 TEU range based on the likely fleet of vessels to call US East Coast Ports; however, this class may include vessels with a TEU up to

[22] Preliminary revisions allowed up to 1 PPX 4 vessel to PJPAMT in 2030, 2 in 2040, and 3 and 2050. This volume of PPX4 calls created berth congestion and cargo distributions that were unrealistic when compared to similar Port studies and route forecasts.

approximately 20,000 TEU Capacity.

Table 5-34 and Table 5-35 compare the previous and updated fleet forecasts for the NYNJHDCI feasibility study at EPAMT and PJPAMT, respectively. As a result of the update, vessel call reductions increased relatively more for the -54 feet MLLW versus the -55ft MLLW alternatives. Generally, the update leads to a minor change in total vessel calls. The update also revealed an inconsistency between the commodity forecast and HarborSym modeling for certain scenarios leading to an underestimate of total tonnage in the initial modeling. All inconsistencies were updated, leading to an increase in vessel calls for EPAMT 2040, EPAMT 2050, and PJPAMT 2030.

Table 5-34. EPAMT Vessel Calls by Class (Previous vs Updated Output Summary)

EPAMT	PREVIOUS			UPDATE		
Class	FWOP	54FT	55FT	FWOP	54FT	55FT
2030						
PX	150	150	150	150	150	150
PPX1	326	153	151	292	167	160
PPX2	620	613	613	615	583	579
PPX3	610	610	610	610	610	610
PPX4	39	39	39	52	52	52
Total	**1,745**	**1,565**	**1,563**	**1,719**	**1,562**	**1,551**
2040						
PX	125	125	125	125	125	125
PPX1	318	146	142	300	240	239
PPX2	688	603	601	695	545	530
PPX3	890	890	890	890	890	890
PPX4	78	78	78	104	104	104
Total	**2,099**	**1,842**	**1,836**	**2,114**	**1,904**	**1,888**
2050						
PX	90	90	90	90	90	90
PPX1	373	178	178	413	107	96
PPX2	830	736	729	930	887	874
PPX3	1,155	1,155	1,155	1,155	1,155	1,155
PPX4	117	117	117	156	156	156
Total	**2,565**	**2,276**	**2,269**	**2,744**	**2,395**	**2,371**

Table 5-35. PJPAMT Vessel Calls by Class (Previous vs Updated Output Summary)

PJPAMT	PREVIOUS			UPDATE		
Class	FWOP	54FT	55FT	FWOP	54FT	55FT
2030						
PX	5	5	5	5	5	5
PPX1	35	13	12	67	44	41
PPX2	93	84	84	91	80	80
PPX3	155	155	155	155	155	155
PPX4	13	13	13	26	26	26
Total	**301**	**270**	**269**	**344**	**310**	**307**
2040						
PX	5	5	5	0	0	0
PPX1	35	13	11	24	9	8
PPX2	67	54	54	74	49	45
PPX3	242	242	242	200	200	200
PPX4	26	26	26	52	52	52
Total	**375**	**340**	**338**	**350**	**310**	**305**
2050						
PX	5	5	5	5	5	5
PPX1	44	4	2	0	0	0
PPX2	79	63	63	99	50	44
PPX3	309	309	309	270	270	270
PPX4	39	39	39	78	78	78
Total	**476**	**420**	**418**	**452**	**403**	**397**

Table 5-36 estimates the percent of the world fleet estimated to call the Port of New York and New Jersey to assess whether the forecast number of vessel calls is reasonable. The forecast follows the methodology detailed in Section 5.2.2. The updated fleet increases the share of the PPX4 world fleet calling at the Port of New York and New Jersey weekly by about 0.5%.

Otherwise, the share of the world fleet remains relatively constant compared to the initial fleet forecast. As a result, the updated forecast seems reasonable when compared to the world fleet of container vessels.

Table 5-36. Updated Fleet Forecast Estimated Percent of World Fleet Calling Weekly

Vessel Class	2030		2040		2050	
	Vessels	% World Fleet	Vessels	% World Fleet*	Vessels	% World Fleet*
FWOP						
PX	24	1.8%	20	1.6%	15	1.3%
PPX 1	57	4.8%	51	2.8%	65	2.3%
PPX 2	111	32.9%	121	34.1%	162	43.4%
PPX 3	121	14.1%	172	13.8%	224	12.5%
PPX 4	12	1.5%	25	1.7%	37	1.4%
Total	**325**	**5.1%**	**388**	**4.8%**	**503**	**4.7%**
4 Feet Deepening						
PX	24	1.8%	20	1.6%	15	1.3%
PPX 1	33	2.8%	39	2.2%	17	0.6%
PPX 2	104	30.9%	94	26.3%	148	39.5%
PPX 3	121	14.1%	172	13.8%	224	12.5%
PPX 4	12	1.5%	25	1.7%	37	1.4%
Total	**295**	**4.6%**	**349**	**4.3%**	**441**	**4.1%**
5 Feet Deepening						
PX	24	1.8%	20	1.6%	15	1.3%
PPX 1	32	2.7%	39	2.1%	15	0.5%
PPX 2	104	30.7%	91	25.5%	145	38.7%
PPX 3	121	14.1%	172	13.8%	224	12.5%
PPX 4	12	1.5%	25	1.7%	37	1.4%
Total	**293**	**4.6%**	**345**	**4.3%**	**436**	**4.1%**
*Extrapolated from 5-year trend						

5.4.6. Updated Benefit-Cost Summary

Table 5-37 presents the updated benefit-cost summary for the NYNJHDCI feasibility study's -54 feet MLLW and -55 feet MLLW alternatives. As a result of the update, benefits of the -54 feet MLLW alternative increased approximately 20 percent, and benefits of the -55 feet MLLW alternative increased 26 percent.

Table 5-37. Updated Benefit-Cost Summary (October 2020 Price Level, FY21 discount rate[23])

Project Depth	Total AAEQ Costs	Total AAEQ Benefits[1]	Total Net Benefits	Benefit/Cost Ratio
-54FT MLLW	$168,730,000	$394,690,000	$225,960,000	2.34
-55FT MLLW	$180,738,000	$429,362,000	$248,624,000	2.38

Refined Benefit-Cost Estimate for the Recommended Plan

Based on the updated benefit numbers, the -55 feet MLLW alternative increases net NED benefits by 10 percent compared to the -54 feet MLLW alternative. The incremental net benefit from the -54 feet MLLW alternative to the -55 feet MLLW alternative are $22,664,000. Based on the criteria for plan selection outlined in ER 1105-2-100, the -55 feet MLLW alternative reasonably maximizes net benefits.

Based on selection of -55-feet MLLW as the recommended plan, cost engineering refined the -55-foot depth cost estimate only. It is unlikely that the relative difference in cost between the -54 feet MLLW and -55 feet MLLW alternative would change by enough to impact plan selection based on the cost update performed by New York District Cost Engineering. Analysis completed subsequent to release of the Draft Report also led to a refined project Base Year. Analysis presented in this section assumes a project Base Year of 2040 with a period of analysis from 2040 through 2089. Benefits are held constant past 2050 through 2089.

The results of the cost updates and the final benefit-cost analysis are presented in Table 5-38. Total AAEQ costs of $244,806,000 compared to total AAEQ benefits of $433,473,000 lead to net benefits of $188,667,000 and a benefit-cost ratio of 1.77 at the 2.25% discount rate.

[23] Comparison of the -54 ft MLLW and -55 ft MLLW alternative depths took place in Fiscal Year 2021 and the benefit-cost summary is reported in FY2021 prices. Only the -55 ft MLLW depth price level was updated once the final recommended depth was selected.

Table 5-38. Recommended Plan Benefit-Cost Summary (October 2021 Price Level, FY22 discount rate)

	Recommended Plan Cost and Benefit Summary (October 2021 Price Level)
Interest Rate (Fiscal Year 2022)	*2.25%*
Construction Period, Years	*16*
Period of Analysis, Years	*50*
Project First Costs	**$5,563,899,000**
Interest During Construction[1]	$1,549,410,000
Estimated Local Service Facilities	$85,267,000
Estimated Aids to Navigation	$-
Total Economic Costs	**$7,198,576,000**
AAEQ Costs	
Amortized Cost	$241,284,000
OMRR&R	$3,521,000
Total AAEQ Costs	**$244,806,000**
AAEQ Benefits	**$433,473,000**
AAEQ Net Benefits (AAEQ Benefits - AAEQ Costs)	**$188,667,000**
Benefit-to-Cost Ratio *(2.25% discount rate)*	**1.77**
[1]Calculated using the construction duration with contingency (See Appendix B4)	

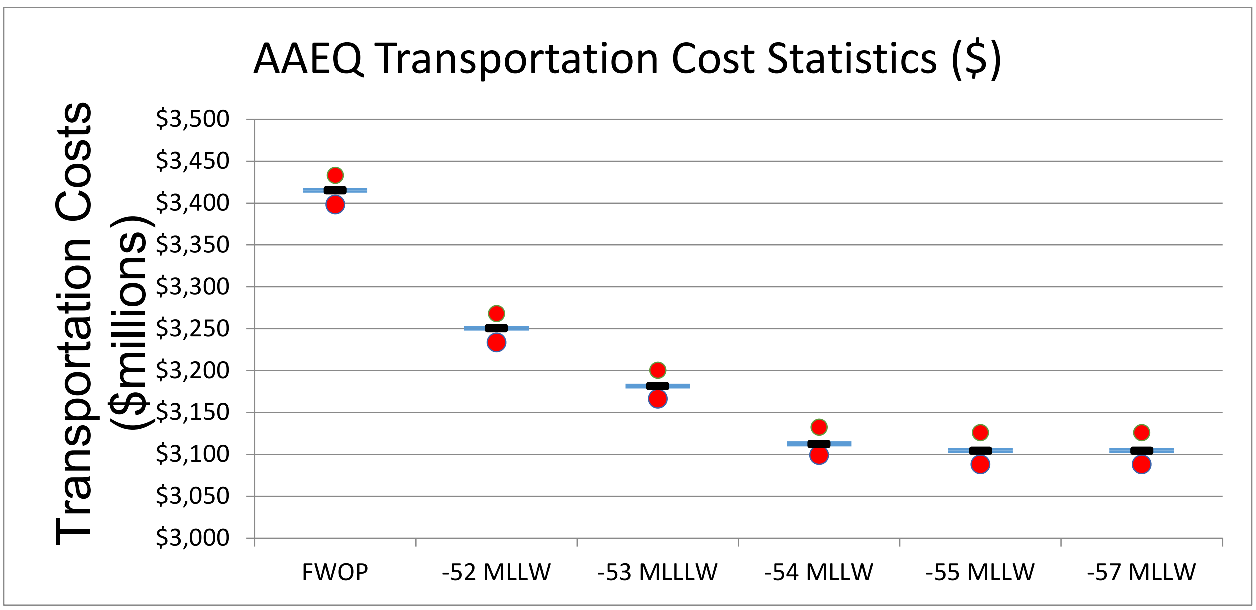
6. Sensitivity Analysis

The Principles and Guidelines (P&G) and subsequent Engineering Regulation (ER) 1105-2-100 recognize the inherent variability to water resources planning. Navigation projects and container studies are especially fraught with uncertainty given the volatility of international trade.

6.1. Model Uncertainty

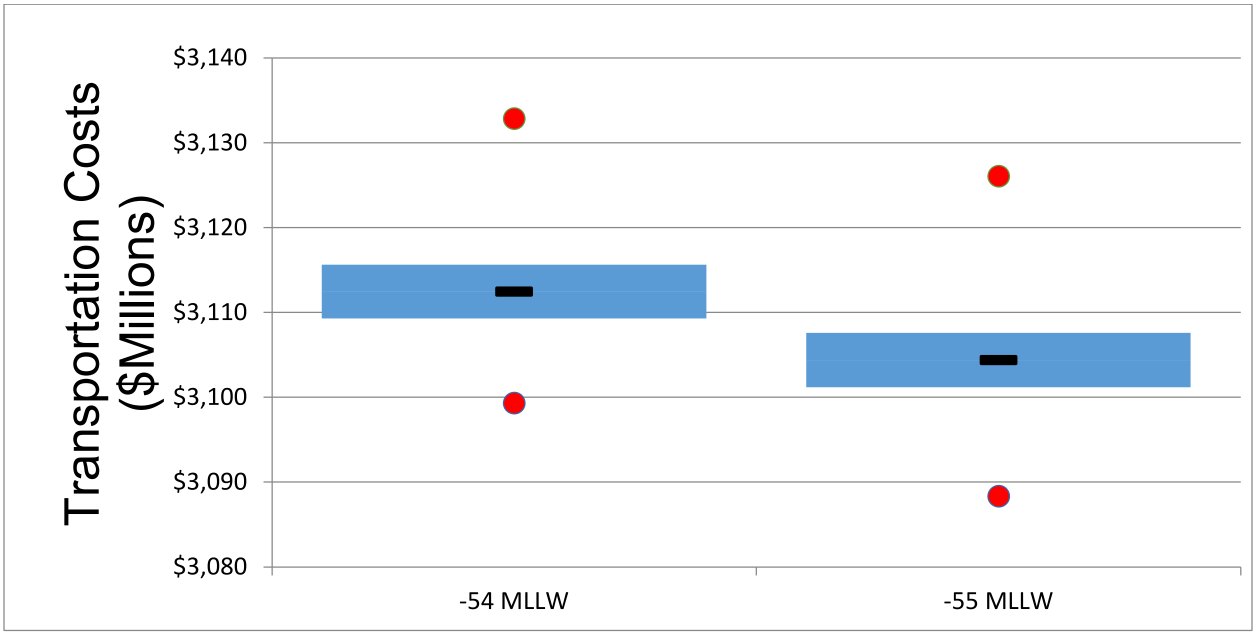
Port and individual operations are subject to change based on various conditions including weather, congestion, labor availability, schedule, pilot practices, and other factors leading to variability. The HarborSym model included variations or ranges for many of the variables involved in the vessel costs, loading, distances, speeds, etc. **Figure 34** plots mean of transportation costs computed by the HarborSym model for each depth alternative (black marker), the 95 percent confidence interval (blue marker), and the minimum and maximum values for 30 iterations. The distribution shows variation in the total transportation costs; however, there is minimal overlap in total transportation cost between alternatives.

Figure 34: AAEQ Transportation Cost Statistics



Additional consideration is given to the difference between the 4-foot and 5-foot deepening plan. Section 5 presents 54 feet as the depth which maximizes net benefits. Additional benefits in could be realized with a 5-foot deepening. Specifically, PPX4 vessels could fully load more consistently. Figure 35 shows the difference in the mean transportation costs between a 4-foot deepening and 5-foot deepening and provides the 95 percent confidence interval for both plans. The figure shows at least a 95 percent confidence in the difference of means between transportation costs and, therefore, transportation cost savings between the 4-foot deepening and 5-foot deepening. Construction cost ranges are not available for this study. However, when incorporating the difference in costs between the 54-foot and 55-foot plan, the difference in net benefits is more pronounced.

Figure 35: Transportation Cost Sensitivity Analysis (54FT vs 55FT)



The lack of overlap between plans is because variability built into the model primarily addresses in-port vessel operations[24]. For this study, in-port transportation costs account for only 6 to 7 percent of total transportation costs. As a result, assumptions based on the commodity forecast, fleet forecast, and vessel loading assumptions have greater impact on total transportation costs and the difference between plans.

6.2. Commodity and Fleet Uncertainty

The long-term trade forecast assumes compound average annual growth of 3.5 percent through 2050. While the study assumes long-term positive GDP growth will drive continued increases in containerized trade, future trade volumes are difficult to predict with certainty. Commodity flows are subject to the ups and downs of the business cycle, individual commodity markets, and political influence. The COVID-19 pandemic, for example, created significant uncertainty in GDP growth and trade volumes, especially in the short and medium-term.

The Port of New York & New Jersey fleet forecast assumes PPX3 vessels will comprise a larger percentage of calls and carry a larger share of total cargo over the study period. This assumption is based on analysis of containerized vessel order books and firms' preference for the economies of scale and lower unit transportation costs realized by larger, more efficient vessels. However, vessel scrap rates and deployment are firm-level decisions based on operating costs, fleet availability, trade volume, landside infrastructure constraints, scheduling, and other exogenous factors. As a result, forecasting the fleet distribution at the Port of New York & New Jersey over the study period involves significant uncertainty. More importantly, the share of cargo carried on

[24] Variability exists for at-sea inputs into the model including vessel speed, operating costs, and wait times. The study shows these variables change across all alternatives and have relatively low impact on the relative benefit difference between alternatives.

PPX3 and PPX4 vessels, the benefitting classes of containerships for this project, is subject to change.

The study uses the methodology and vessel fleet forecast described in Section 5.4.5. as a baseline, then tests the following alternative fleet and commodity growth scenarios[25]:

(1) No-growth from the base year,

(2) Half-growth from base year to 2050, and

(3) Breakeven growth. This analysis is meant to test the confidence in plan selection and economic justification.

6.2.1. No Growth from the Base Year

Under the No Growth Scenario, the study assumes no commodity throughput growth or additional fleet transition after 2039. This scenario is likely the lower bound of benefit estimates. Over the long-run, commodity throughput and vessel size have continued to grow across the US. There is no indication that this will change in the future for the Port of New York and New Jersey. Even under this conservative scenario, the project remains justified for EPAMT (Table 6-1) and PJPAMT (Table 6-2).

Table 6-1. No Growth Scenario, Benefit-Cost Summary (EPAMT)

EPAMT	Total AAEQ Costs	Total AAEQ Benefits	Total Net Benefits	Benefit/Cost Ratio
-54FT MLLW	$145,813,000	$170,341,000	$24,528,000	1.17
-55FT MLLW	$156,052,000	$185,843,000	$29,791,000	1.19

Table 6-2. No Growth Scenario, Benefit-Cost Summary (PJPAMT)

PJPAMT	Total AAEQ Costs	Total AAEQ Benefits	Total Net Benefits	Benefit/Cost Ratio
-54FT MLLW	$22,917,000	$47,019,000	$24,102,000	2.05
-55FT MLLW	$24,686,000	$50,354,000	$25,668,000	2.04

6.2.2. Low-Growth Scenario

The low-growth scenario assumes commodity growth occurs at approximately half the rate of the study's forecast (about 1.25 percent compound annual growth from 2030 through 2050). Similarly, vessel transition occurs approximately 10 years slower than anticipated by the fleet forecast. The -55ft MLLW depth is the NED plan for both EPAMT (Table 6-3) and PJPAMT (Table 6-4), yielding combined net benefits of $227 million.

[25] Sensitivity analysis uses Base Year 2039, which was subsequently updated to 2040 for the final benefit-cost analysis. Implications of the sensitivity analysis would not change based on change to the Base Year.

Table 6-3. Low Growth Scenario, Benefit-Cost Summary (EPAMT)

EPAMT	Total AAEQ Costs	Total AAEQ Benefits	Total Net Benefits	Benefit/Cost Ratio
-54FT MLLW	$145,813,000	$243,349,000	$97,536,000	1.67
-55FT MLLW	$156,052,000	$334,281,000	$178,229,000	2.14

Table 6-4. Low Growth Scenario, Benefit-Cost Summary (EPAMT)

PJPAMT	Total AAEQ Costs	Total AAEQ Benefits	Total Net Benefits	Benefit/Cost Ratio
-54FT MLLW	$22,917,000	$67,215,000	$44,298,000	2.93
-55FT MLLW	$24,686,000	$73,530,000	$48,844,000	2.98

6.2.3. Breakeven Scenario

The following breakeven analysis determines the minimum fleet transition required for project justification. This analysis further demonstrates the project's sensitivity to fleet transition. The results of the breakeven analysis indicate a relatively low threshold for project justification.

The study estimates the minimum fleet transition possible by looking at the number of benefitting PPX3 vessels required to justify a -54 MLLW depth, then justifying the incremental depth from -54 MLLW to -55 MLLW using PPX4 vessels only. This method should result in an estimate of the smallest fleet in terms of capacity possible for project justification. The study team uses the following assumptions to complete the breakeven analysis:

- Each benefitting PPX3 or PPX4 vessel adds volume by loading 0.7 feet deeper
- Benefitting PPX3 and PPX4 vessels pull tonnage from PPX1 vessels only
- Benefits equal the product of total PPX1 calls reduced and average total PPX1 transportation costs allocated to the Port of New York and New Jersey

The analysis does not incorporate additional in-port costs associated with more fully loaded PPX3 and PPX4 vessels. However, these costs are relatively minor compared to the at-sea cost savings (5 percent). With fewer PPX3 and PPX4 calls and no change in the commodity forecast, more PPX1 and PPX2 calls will be necessary for operation. Additional dock and channel congestion would likely lower overall capacity and increase in-port costs for all vessels.

Using average parcel size by vessel class and average total voyage cost allocated to the Port of New York and New Jersey for PPX1 vessels, the study team estimates a breakeven average annual call volume of 885 benefitting PPX3 vessels to justify -54 MLLW and approximately 201 benefitting PPX4 plus 2 PPX3 vessels to justify the incremental cost between -54 MLLW and -55 MLLW. This represents a 42 percent drop in benefitting PPX3 vessel calls for -54 MLLW alternative and a 0 percent drop in PPX4 vessels plus a 98 percent drop in PPX3 vessels for the -55 MLLW alternative (or some combination of PPX3 and PPX4 vessels). The breakeven analysis shows the threshold for justification is well below the forecasted fleet transition, indicating relatively low project risk associated with fleet transition. The sensitivity also reveals that benefits to the PPX3 class are a necessary condition of project justification for the -55 feet MLLW alternative.

7. Multiport Analysis

This study is not reliant on cargo shifting to the Port of New York & New Jersey from other locations. The analysis assumes the Port of New York & New Jersey receives the same share of regional cargo volumes with or without channel deepening.

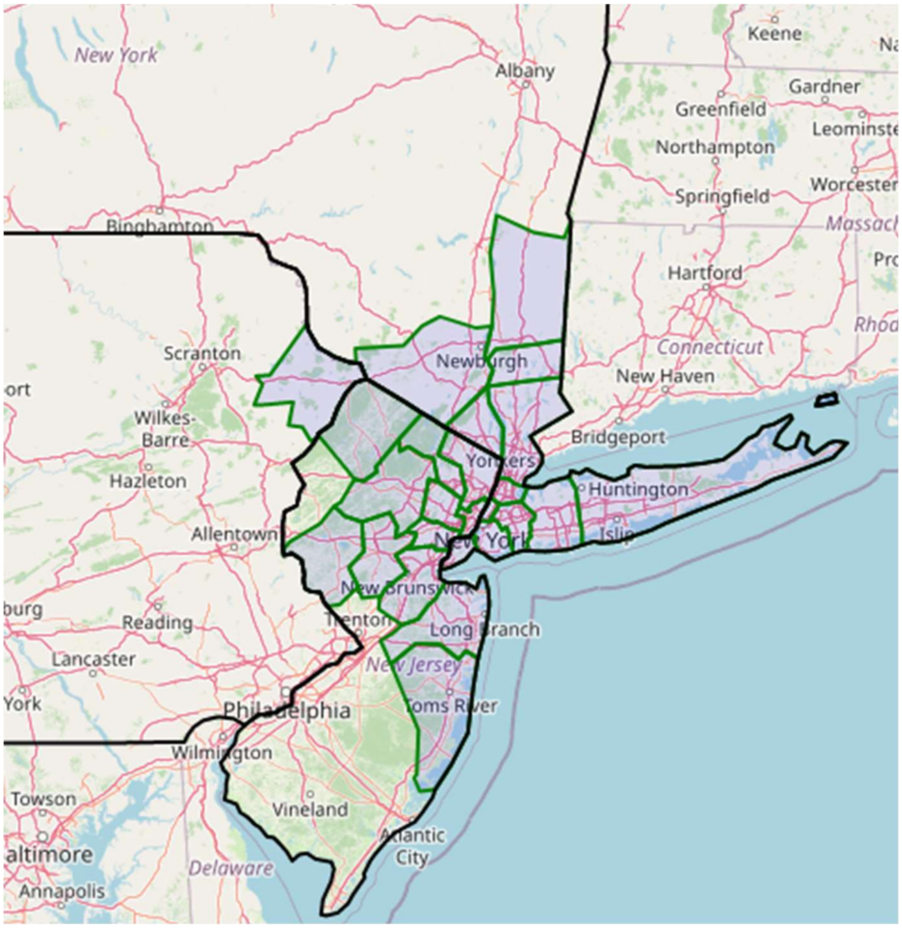
The recommended plan includes a deeper channel to operate larger containerships more efficiently. Many factors besides channel depth may influence the growth of a particular harbor: landside development and infrastructure, location of Distribution Centers for imports, source locations for exports, population and income growth, location, port logistics and fees, business climate and taxes, carrier preferences, labor stability and volatility, and business relationships. Additionally, growth in total trade is not dependent on cargo diversion from other US ports. The analysis based the commodity forecast on the assumption that the Port of New York & New Jersey's share of East Coast cargo would remain constant over the long-term between the FWOP and FWP conditions.

8. Socioeconomic and Regional Analysis

This section addresses the regional economic development impact of the proposed project. The study will estimate local capture rates from the navigation investment, impacts on employment and labor income, as well as economic value added to the regional economy. The parameters used to describe the demographic and socioeconomic environment include population data, private sector employment, wage earnings, race, age, poverty levels, and environmental justice (EJ).

Figure 36 provides a map of the 25 counties given additional consideration for this analysis within the New York-Newark-Jersey City, NY-NJ-PA Metropolitan Statistical Area (MSA): Bergen (NJ), Essex (NJ), Hudson (NJ), Hunterdon (NJ), Middlesex (NJ), Monmouth (NJ), Morris (NJ), Ocean (NJ), Passaic (NJ), Somerset (NJ), Sussex (NJ), Union (NJ), Bronx (NY), Dutchess (NY), Kings (NY), Nassau (NY), New York (NY), Orange (NY), Putnam (NY), Queens (NY), Richmond (NY), Rockland (NY), Suffolk (NY), Westchester (NY), Pike (PA). Additional consideration is given to the counties immediately adjacent to EPAMT and PJPAMT container facilities (Hudson (NJ), Essex (NJ), and Union (NJ) counties).

Figure 36: Regional Economic Impact Area



8.1. Socioeconomic Overview

This section provides an overview of the socioeconomic conditions immediately adjacent to the study area and in the surrounding areas likely impacted by project implementation. Data for this overview is based on publicly available data from the US Census Bureau's American Communities Survey.

8.1.1. Population

The New York-Newark-Jersey City MSA is the largest MSA in the US with an estimated 2019 population of 19,216,000. The MSA experienced relatively slow population growth over the past 10 years, growing at a compound annual growth rate (CAGR) of less than 1 percent. Between 2010 and 2019, New York-Newark-Jersey City MSA's population increased by 1.5 percent (Table 8-1). This growth rate was one-quarter the national growth rate and one-fifth the growth rate of all US MSAs over the same period.

Table 8-1: Study Area Population Growth (2010-2019)

Geographical Area	Population		Compound Annual Growth Rate (2010-2019)
	2010	2019	
New York-Newark-Jersey City MS	18,923,407	19,216,182	0.2%
New Jersey	8,801,624	8,882,190	0.1%
New York	19,392,283	19,453,561	0.0%
Pennsylvania	12,709,630	12,801,989	0.1%
All US MSAs	**263,659,728**	**282,828,515**	**0.8%**
United States	**309,349,689**	**328,239,523**	**0.7%**

8.1.2. Employment and Income

Estimated employment in 2019 totaled 15,584,000. Table 8-2 presents employment by sector for the latest available year, 2017. Total employment in 2017 for the New York-Newark-Jersey City MSA was 16,446,000. The largest sector by number of employees and total annual payroll was NAICS Sector 62: Health Care and Social Assistance. Professional, scientific, and technical services was the next largest sector in 2017 (1,595,000 employees) followed by wholesale trade (994,000 employees), retail trade (963,000 employees), and accommodation and food services (789,000 employees).

Table 8-2: 2017 Employment and Income by Sector

2017 NAICS		Sum of Annual payroll ($1,000)	Sum of Number of employees
22	Utilities	$4,686,000	42,855
31-33	Manufacturing	$19,545,000	324,200
42	Wholesale trade	$82,211,000	994,163
44-45	Retail trade	$29,474,000	962,724
48-49	Transportation and warehousing	$17,278,000	333,736
51	Information	$39,096,000	331,931
52	Finance and insurance	$122,419,000	614,115
53	Real estate and rental and leasing	$12,841,000	210,074
54	Professional, scientific, and technical services	$151,210,000	1,594,982
56	Administrative and support and waste management and remediation services	$40,934,000	775,989
61	Educational services	$5,293,000	157,108
62	Health care and social assistance	$165,997,000	3,303,152
71	Arts, entertainment, and recreation	$18,183,000	383,634
72	Accommodation and food services	$19,531,000	788,707
81	Other services (except public administration)	$25,411,000	640,872

Median household incomes for New York-Newark-Jersey City MSA in 2019 are shown in Table 8-3. The MSA median household income is 23 percent above the national median.

Table 8-3: Median Income in Study Area (2019)

Geography	Median Income, 2019	% National Median Income
New York-Newark-Jersey City	$61,392	123%
New Jersey	$61,132	122%
New York	$56,534	113%
Pennsylvania	$50,695	101%
United States	$50,078	100%
Source: 2019 American Community Survey, US Census Bureau		

The estimated unemployment rate for the New York-Newark-Jersey City MSA was 4.6 percent in 2019, 0.1 percent higher than the national average. State unemployment levels for New Jersey, New York, and Pennsylvania are all within 0.2% of the MSA and national average. Table 8-4 provides the estimated 2019 unemployment rate for the study area.

Table 8-4: 2019 Unemployment Rate in Study Area

Geographical Area	Unemployment Rate
New York-Newark-Jersey City	4.6%
New Jersey	4.7%
New York	4.4%
Pennsylvania	4.5%
United States	4.5%
Source: 2019 American Community Survey, US Census Bureau	

8.1.3. Racial Composition

As shown in Table 8-5, New York-Newark-Jersey City MSA has a higher minority population than each individual state and the nation. Black or African American is the single largest minority population in the MSA comprising approximately 18 percent of the MSA. Additionally, 25 percent of the MSA identifies as Hispanic or Latino compared with 18 percent nationally.

Table 8-5: 2019 Racial Composition of Study Area

Race	NY-Newark-Jersey City		New Jersey		New York		Pennsylvania		United States	
	Pop.	%	Pop.	%	Pop.	%	Pop.	%	Pop.	%
All races	19,216	100	8,882	100	19,454	100	12,802	100	328,240	100
White	10,970	57.1	5,964	67.1	12,294	63.2	10,194	79.6	236,475	72
Black or African American	3,368	17.5	1,204	13.6	3,084	15.9	1,455	11.4	41,990	12.8
American Indian and Alaska Native	60	0.3	18	0.2	74	0.4	27	0.2	2,847	0.9
Asian	2,209	11.5	857	9.6	1,680	8.6	454	3.5	18,637	5.7
Native Hawaiian and Other Pacific Islander	6	0	3	0	8	0	4	0	629	0.2
Some other race	1,977	10.3	571	6.4	1,664	8.6	336	2.6	16,353	5
Two or more races	626	3.3	264	3	649	3.3	333	2.6	11,309	3.4

8.1.4. Age Distribution

The age characteristics of the MSA are shown in Table 8-6. As of 2019, the MSA has lower median ages than the states of New Jersey, New York, and Pennsylvania. The median age is 0.6 years higher than the national median.

Table 8-6: 2019 Age Distribution in Study Area

Age	New York-Newark-Jersey City		New Jersey		New York		Pennsylvania		United States	
	Pop.	%	Pop.	%	Pop.	%	Pop.	%	Pop.	%
Under 18	4,534	24%	2,155	24%	4,523	23%	2,977	23%	81,872	25%
18-64	11,567	60%	5,252	59%	11,634	60%	7,436	58%	192,293	59%
65 or above	3,115	16%	1,475	17%	3,296	17%	2,388	19%	54,074	16%
Median Age	39.1	-	40.2	-	39.2	-	40.8	-	38.5	-

Source: US Census (American Community Survey, 2019)

8.1.5. Income and Poverty

The US Census Bureau American Community Survey income and poverty data for the New York-Newark-Jersey City MSA are summarized in Table 8-7. Nearly 12 percent of the MSA is determined to be poverty status, less than one percent below the national average.

Table 8-7: Regional Income and Poverty in Study Area

Regional Income and Poverty Data	New York-Newark-Jersey City	New Jersey	New York	Pennsylvania	United States
Median Household Income	$61,392	$61,132	$56,534	$50,695	$50,078
Total for whom poverty status is determined	18,877,126	8,712,974	18,932,499	12,387,178	320,118,791
Percent of Persons Below Poverty Level	11.6%	9.2%	13.0%	12.0%	12.3%
Source: US Census Bureau, 2019 American Community Survey					

8.2. Regional Economic Development Analysis

The regional economic development (RED) account measures changes in the distribution of regional economic activity resulting from each alternative. Evaluations of regional effects are measured using nationally consistent projection of income, employment, output, and population.

The USACE Online Regional Economic System 2.0 (RECONS) is a system designed to provide estimates of regional, state, and national contributions of federal spending associated with Civil Works and American Recovery and Reinvestment Act (ARRA) Projects. It also provides a means for estimating the forward linked benefits (stemming from effects) associated with non-federal expenditures sustained, enabled, or generated by USACE Recreation, Navigation, and Formally Utilized Sites Remedial Action Program (FUSRAP). Contributions are measured in terms of economic output, jobs, earnings, and/or value added.

These reports provide estimates of the economic impacts of Civil Works Budget Analysis for investments to the federal navigation channel at New York Harbor and Newark Bay. The Corps' IWR, the Louis Berger Group, and Michigan State University developed RECONS to provide estimates of regional and national job creation, and retention and other economic measures such as income, value added, and sales. This modeling tool automates calculations and generates estimates of jobs and other economic measures, such as income and sales associated with USACE's ARRA spending, annual Civil Works program spending, and stem-from effects for Ports, Inland Water Way, FUSRAP, and Recreation. This is done by extracting multipliers and other economic measures from more than 1,500 regional economic models built specifically for USACE project locations. These multipliers are then imported to a database and the tool matches various spending profiles to the matching industry sectors by location to produce economic impact estimates.

The RECONS model uses fixed allocations to local, state, and national sources to avoid double counting. RECONS uses the IMpact analysis for PLANning (IMPLAN©) software and data system, provided by the Minnesota IMPLAN Group, to estimate the economic impact or contribution of Civil Works spending and associated economic effects of USACE programs and infrastructure. IMPLAN created IO models for all the impact areas defined by the project team. The multipliers within these models were created with RPCs based on the trade flow dataset included in IMPLAN

The expenditures associated with the proposed project are estimated to be $5,563,899,000. Of this total expenditure, $3,812,152,750 will be captured within the local impact area. The remainder of the expenditures will be captured within the state impact area and the nation. These direct expenditures generate additional economic activity, often called secondary or multiplier effects. The direct and secondary impacts are measured in output, jobs, labor income, and gross regional product (value added) as summarized in the following tables. The regional economic effects are shown for the local, state, and national impact areas. In summary, the Civil Works expenditures $5,563,899,000 support a total of 51,589.0 full-time equivalent jobs, $4,277,300,297 in labor income, $5,118,673,690 in the gross regional product, and $7,316,791,241 in economic output in the local impact area. More broadly, these expenditures support 88,093.3 full-time equivalent jobs, $6,313,786,208 in labor income, $8,488,626,874 in the gross regional product, and $14,409,773,386 in economic output in the nation.

Table 8-8 summarizes the results of the regional analysis by impact area. Table 8-9, Table 8-10, and Table 8-11 present the detailed impacts for the local impact area, state, and nation, respectively.

Table 8-8: Overall Summary of Regional Economic Development Benefits

Area	Local Capture ($1,000s)	Output ($1,000s)	Jobs (000s)*	Labor Income ($1,000s)	Value Added ($1,000s)
Local					
Direct Impact		$3,812,153	34.2	$2,948,585	$2,883,524
Secondary Impact		$3,504,638	17.4	$1,328,715	$2,235,149
Total Impact	$3,812,153	$7,316,791	51.6	$4,277,300	$5,118,674
State					
Direct Impact		$4,145,001	38.0	$3,058,666	$3,042,004
Secondary Impact		$4,387,489	22.2	$1,580,134	$2,668,358
Total Impact	$4,145,001	$8,532,490	60.2	$4,638,800	$5,710,362
US					
Direct Impact		$5,337,284	44.7	$3,464,400	$3,569,531
Secondary Impact		$9,072,489	43.4	$2,849,387	$4,919,096
Total Impact	$5,337,284	$14,409,773	88.1	$6,313,786	$8,488,627

* Jobs are presented in full-time equivalence (FTE)

Table 8-9: Local Impacts

Industry	Output ($1,000s)	Jobs* (1,000s)	Labor Income ($1,000s)	Value Added ($1,000s)
Direct Impacts				
Construction of other new nonresidential structures	$505,251	5.14	$440,704	$255,021
All other food manufacturing	$26,218	0.07	$5,260	$6,267
Petroleum refineries	$72,743	0.01	$1,872	$17,784
Cement manufacturing	$6,501	0.01	$844	$2,012
Iron and steel mills and ferroalloy manufacturing	$8,779	0.01	$1,064	$1,442
Valve and fittings, other than plumbing, manufacturing	$24,644	0.07	$7,346	$10,418
All other industrial machinery manufacturing	$2,432	0.01	$854	$1,024
Switchgear and switchboard apparatus manufacturing	$2,251	0.01	$624	$803
Ship building and repairing	$143,459	0.51	$48,823	$61,869
Wholesale trade	$3,065	0.01	$652	$1,515
Retail - Building material and garden equipment and supplies stores	$30,463	0.10	$10,790	$18,915
Air transportation	$30,085	0.14	$12,121	$16,532
Rail transportation	$43,142	0.02	$2,792	$39,801
Water transportation	$27,952	0.07	$8,434	$17,660
Truck transportation	$14,345	0.19	$24,695	$12,752
Pipeline transportation	$24,938	0.16	$9,890	$18,138
Insurance carriers	$2,770	0.01	$878	$1,923
Environmental and other technical consulting services	$1,364	0.00	$0	$0
Office administrative services	$3,544	0.00	$603	$1,182
Limited-service restaurants	$26,761	0.14	$11,676	$13,040
Commercial and industrial machinery and equipment repair and maintenance	$3,708	0.00	$1,874	$3,041
Employment and payroll of federal govt, non-military	$97,941	0.11	$17,775	$55,139
Private Labor	$42,534	0.31	$37,260	$31,690
Direct Impact	$388,948	4.09	$548,475	$216,033
Secondary Impact	$38,505	0.35	$12,755	$20,695
Total Impact	$611,775	3.06	$356,448	$430,798

*Jobs are presented in full-time equivalence (FTE)

Table 8-10: State Impacts

Industry	Output ($1,000s)	Jobs* (1,000s)	Labor Income ($1,000s)	Value Added ($1,000s)
Direct Impacts				
Construction of other new nonresidential structures	$505,251	5.33	$440,704	$255,021
All other food manufacturing	$36,507	0.10	$7,324	$8,726
Petroleum refineries	$141,086	0.02	$3,631	$36,050
Cement manufacturing	$38,182	0.06	$5,274	$15,372
Iron and steel mills and ferroalloy manufacturing	$50,096	0.05	$6,070	$9,138
Valve and fittings, other than plumbing, manufacturing	$39,401	0.11	$11,744	$16,656
All other industrial machinery manufacturing	$7,644	0.03	$2,684	$3,220
Switchgear and switchboard apparatus manufacturing	$8,187	0.02	$2,270	$2,919
Ship building and repairing	$164,380	0.60	$55,943	$70,892
Wholesale trade	$3,068	0.01	$653	$1,516
Retail - Building material and garden equipment and supplies stores	$31,623	0.11	$11,201	$19,636
Air transportation	$30,085	0.14	$12,121	$16,532
Rail transportation	$54,125	0.02	$3,503	$49,934
Water transportation	$27,952	0.08	$8,434	$17,660
Truck transportation	$14,345	0.19	$24,695	$12,752
Pipeline transportation	$27,068	0.19	$10,735	$19,686
Insurance carriers	$2,770	0.01	$878	$1,923
Environmental and other technical consulting services	$3,851	0.01	$1,034	$1,425
Office administrative services	$3,544	0.00	$603	$1,182
Limited-service restaurants	$28,177	0.15	$12,293	$13,785
Commercial and industrial machinery and equipment repair and maintenance	$8,922	0.01	$9,200	$8,229
Employment and payroll of federal govt, non-military	$100,173	0.13	$18,180	$56,396
Private Labor	$43,141	0.34	$37,791	$32,142
Direct Impact	$388,948	4.43	$548,475	$216,033
Secondary Impact	$41,560	0.40	$13,767	$22,338
Total Impact	$716,882	3.92	$418,918	$504,811

*Jobs are presented in full-time equivalence (FTE)

Table 8-11: US Impacts

Industry	Output ($1,000s)	Jobs* (1,000s)	Labor Income ($1,000s)	Value Added ($1,000s)
Direct Impacts				
Construction of other new nonresidential structures	$505,251	5.70	$440,704	$255,021
All other food manufacturing	$95,479	0.25	$19,155	$22,822
Petroleum refineries	$372,644	0.04	$9,941	$95,217
Cement manufacturing	$39,288	0.06	$5,713	$15,817
Iron and steel mills and ferroalloy manufacturing	$102,536	0.10	$12,423	$21,646
Valve and fittings, other than plumbing, manufacturing	$104,141	0.29	$31,041	$44,025
All other industrial machinery manufacturing	$33,725	0.12	$11,840	$14,207
Switchgear and switchboard apparatus manufacturing	$48,396	0.12	$13,416	$17,884
Ship building and repairing	$590,983	2.17	$201,462	$255,974
Wholesale trade	$3,088	0.01	$657	$1,526
Retail - Building material and garden equipment and supplies stores	$33,467	0.11	$11,854	$20,780
Air transportation	$30,172	0.15	$12,156	$16,580
Rail transportation	$62,651	0.04	$4,113	$57,799
Water transportation	$28,012	0.08	$8,452	$17,698
Truck transportation	$15,045	0.21	$25,900	$13,374
Pipeline transportation	$30,172	0.22	$11,966	$21,944
Insurance carriers	$2,786	0.01	$883	$1,933
Environmental and other technical consulting services	$6,223	0.02	$1,671	$3,045
Office administrative services	$3,918	0.00	$667	$1,307
Limited-service restaurants	$32,971	0.18	$14,385	$16,131
Commercial and industrial machinery and equipment repair and maintenance	$9,095	0.01	$9,379	$8,389
Employment and payroll of federal govt, non-military	$101,464	0.14	$18,414	$57,122
Private Labor	$56,080	0.48	$49,125	$41,781
Direct Impact	$391,169	5.05	$551,607	$217,267
Secondary Impact	$56,134	0.57	$18,595	$30,171
Total Impact	$954,363	5.53	$557,692	$672,040

*Jobs are presented in full-time equivalence (FTE)