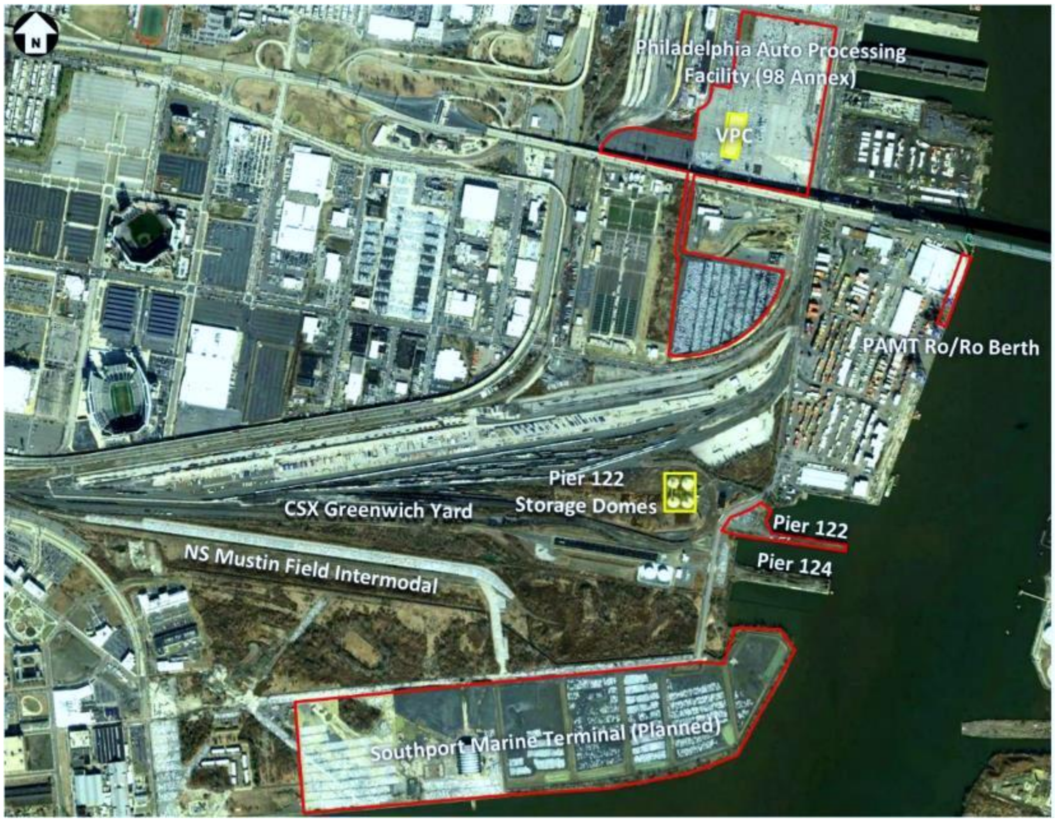
SOUTHPORT WHARF DEVELOPMENT AND PORT EXPANSION

BENEFIT-COST ANALYSIS SUPPLEMENTARY DOCUMENTATION



FY2019 INFRASTRUCTURE FOR REBUILDING AMERICA (INFRA) GRANT PROGRAM

PREPARED FOR: PHILAPORT
MARCH 1, 2019

EXECUTIVE SUMMARY

A benefit-cost analysis (BCA) was conducted for the Southport Wharf Development and Port Expansion project for submission to the U.S. Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the INFRA 2019 program. The analysis was conducted in accordance with the benefit-cost methodology outlined by U.S. DOT in the 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs. The period of analysis corresponds to 29 years and includes 5 years for project completion including design work already planned for 2019, and construction ending in 2023. After that is an analysis period of 24 years with benefits commencing after operations begin in 2024.

The project provides badly needed capacity to the Port of Philadelphia (PhilaPort) and significantly improves the efficiency of roll on/roll off (Ro/Ro) cargo handling at the port. Ro/Ro cargo are automobiles and other vehicles that are driven onto and off of vessels. The greatest quantified benefits result from 1) reduced automobile handling in the port, 2) reduced inland truck mileage due to Ro/Ro cargoes being delivered more efficiently from the Port of Philadelphia, 3) reduced inland truck mileage from containers being delivered more efficiently from the Port of Philadelphia. With the construction of a new two-vessel berth at Southport, PhilaPort will be able to make much more efficient use of the planned Southport vehicle processing center and associated vehicle storage areas (currently under construction). Seventy percent of cargo would proceed directly from ship to the new storage areas and vehicle processing center without passing over public roadways. The current operation is much less efficient, and the port's tenant reports that the company must spend at least $250,000 per month moving vehicles across public streets to the port's vehicle processing center at 98 Annex. This cost will grow with additional volumes of vehicles handled under current conditions. With the new terminal, this cost would be greatly reduced. Depreciation on autos and fuel costs will also be reduced as a result of the new more efficient operation.

Without the terminal, it will simply be impossible for PhilaPort to meet projected demand. While the Southport vehicle processing center is being constructed, vehicles are being diverted to Brunswick, GA. If the marine terminal is not built, a similar situation would likely occur in the short-term, so that the port's largest customer inefficiently diverts vehicles to Brunswick, GA. In the longer term, the most likely scenario is that Ro/Ro cargo would be handled by the Port of Baltimore instead of Philadelphia. PhilaPort's hinterland for Ro/Ro is the greater Northeast, including the area from Virginia to Maine. Were PhilaPort's market to be handled from Baltimore, this would add truck miles, since Baltimore is toward the southern end of the Northeast market area. In order to meet this demand, additional truck vehicle miles travelled will be generated as truckloads of vehicles are brought to the Northeast from Baltimore. This will not only generate additional costs for shippers, but will also generate additional risk of highway accidents, wear and tear on roadways, and truck emissions.

By consolidating Ro/Ro operations in the Southport terminal area and reducing the need for vehicles to pass between Packer Avenue Marine Terminal and 98 Annex, the project will also free up valuable space for the port to handle more containers, allowing the container handling capacity to increase by over 44,000 containers per year. Growth in container traffic at the port has been dramatic, increasing from less than 300,000 TEUs between 2007 and 2012 to nearly 600,000 TEUs in 2018. PhilaPort plays an important role in providing container service to the Philadelphia region. An analysis of a Port

Import/Export Reporting Service (PIERS) report from 2016 (using 2015 data) found that only 13 percent of the import/export container traffic to/from the 21-county region around Philadelphia was handled by the Port of Philadelphia. Most of the rest was handled by the ports of New York/New Jersey, Baltimore, or the Port of Virginia. Increasing container capacity at PhilaPort enables the port to serve its immediate hinterland and reduces truck mileage from these other ports.

The new terminal will also result in reduced vessel dwell times. Because Ro/Ro cargos will be offloaded more efficiently between the Southport Marine Terminal and the new Southport vehicle processing center, vessels will need to spend less time at port at lower cost to the vessel owners. Furthermore, without the new terminal, most Ro/Ro vessels would need to use Pier 122 which is inefficient because it is a "finger pier" so that vessels require additional time to be backed into the pier with the aid of tugboats. This will be a continual source of inefficiency. Each of these factors will cause vessels to spend unnecessary time at PhilaPort at a significant cost to owners. Furthermore, ocean vessels emit significant air pollution and would sit idle for longer periods in PhilaPort or the Delaware River. A map of the terminal area is included as Figure ES-1.

FIGURE ES-1: Philadelphia Marine Terminals and Vehicle Processing

COSTS

The capital cost for this Project is expected to be $95.9 million in undiscounted 2017 dollars, with construction ending in 2023. Costs have been deescalated using the U.S. Congressional Budget Office (CBO) forecast GDP Price Index.[1] At a seven percent real discount rate, these costs are $67.7 million. Operations and maintenance costs are projected to average $447,840 per year in the long term, which is associated with maintenance dredging. Over the entire 24-year post-construction analysis period these costs accumulate to $10.7 million in undiscounted 2017 dollars, or $3.4 million when discounted at 7 percent. Per U.S. DOT Guidance, operations and maintenance costs have been included in the numerator of the benefit/cost ratio calculation as an offset to benefits.

The new terminal is expected to have a service life of 50 years. At the end of the 24-year analysis period, the terminal retains 52 percent of its value, so $49.9 million in residual value. Discounted at 7 percent, the residual value is $6.6 million. When the discounted residual value is netted against the discounted project capital costs, the net result is $61.1 million. Project costs are summarized in Table ES-1.

TABLE ES-1: Project Costs in Millions of 2017 Dollars

Funding Source	Capital Costs	Operating and Maintenance Costs	Residual Value
Undiscounted	$95.9	$10.7	$49.9
Discounted	$67.7	$3.4	$6.6

Source: PhilaPort, WSP Analysis

BENEFITS

In 2017 dollars, the Project is expected to generate $116.4 million in discounted benefits using a 7 percent discount rate. Most of these benefits result from improved vehicle handling at the PhilaPort and the reduction of truck vehicle miles travelled. This leads to an overall project Net Present Value of $55.3 million and a Benefit Cost Ratio (BCR) of 1.90. The overall project benefit matrix can be seen in Table ES-2.

[1] January 2019 supplement to CBO's *The Budget and Economic Outlook: 2019 to 2029, www.cbo.gov/publication/54918.*

Table ES-2: Project Impacts and Benefits Summary, Monetary Values in Millions of $2017 Dollars

Current Status/Baseline & Problem to be Addressed	Change to Baseline/ Alternatives	Type of Impact	Population Affected by Impact	Economic Benefit	Summary of Results (at 7% discount rate)	Page Reference in BCA
Ro/Ro vehicles travel significant distances over public roadways to processing center	New terminal located adjacent to processing center minimizes handling costs	Reduction in vehicle handling costs	Port tenant and port tenant's customers	Reduced operating expense	$24.0	p. 9
Without the project, containers will need to be trucked from more distant ports to the Philadelphia area and vehicles will need to be trucked further to meet Northeast market demand	Capacity is added to PhilaPort to meet local demand	Reduction in truck miles	Vehicle shippers in the Philadelphia region	Reduced shipping costs	$66.9	p. 9
Operations at the port are such that vehicles are driven unnecessarily far to vehicle processing centers	New port terminal combined with new vehicle processing center will reduce distances vehicles are driven	Reduction in automobile miles	PhilaPort tenant and its customers	Reduced operating cost of vehicles, reduced fuel usage	$0.2	p. 13
Without the project autos and trucks must be driven unnecessary miles on public roadways	Project will result in reduced truck and auto miles	Reduction in truck, auto miles	Society at large, travelers on roadways in the Northeast	Reduced injuries, fatalities, property damage only accidents	$10.1	p. 14
Without the project autos and trucks must be driven unnecessary miles on public roadways	Project will result in reduced truck and auto miles	Reduction in truck, auto miles	Society at large, roadway owners	Reduced pavement damage	$5.1	p. 16
Without the project autos and trucks must be driven unnecessary miles on public roadways	Project will result in reduced truck and auto miles	Reduction in truck, auto miles	Society at large	Reduced emissions	$1.9	p. 16

Current Status/Baseline & Problem to be Addressed	Change to Baseline/ Alternatives	Type of Impact	Population Affected by Impact	Economic Benefit	Summary of Results (at 7% discount rate)	Page Reference in BCA
Without the project, vessels spend unnecessary time at berth, waiting for berth, maneuvering	More efficient vehicle handling and vessel handling reduces vessel operating time	Reduction in vessel hours of operating time	Vessel owners	Reduced operating expense	$9.8	p. 12
Without the project, vessels would be delayed unnecessarily, creating additional emissions	Vessel dwell, delay, and maneuvering are reduced which in turn reduces emissions	Reduction in vessel hours of operating time	Society at large	Reduced emissions	$1.8	p. 16

Source: WSP

The overall Project impacts can be seen in Table ES-3, which shows the magnitude of change and direction of the various impact categories.

Table ES-3: Project Impacts, Cumulative 2024-2047

Category	Unit	Quantity	Direction
Automobile handling cost	$2017	$73,601,915	▼
Truck shipping cost	$2017	$234,006,626	▼
Truck Vehicle-Miles Traveled	VMT	138,465,459	▼
Auto Vehicle-Miles Traveled	VMT	1,033,676	▼
Vessel Operating Hours	Hours	32,608	▼
Fatalities	#	2.6	▼
Injuries	#	63.5	▼
Property Damage Only (PDO)	#	171.1	▼
NO_X Emissions	tons	541.5	▼
PM^{10}	tons	15.7	▼
SO_X	tons	2.3	▼
VOC	tons	64.0	▼

Source: WSP, 2019

In addition to the monetized benefits presented in Table ES-2, PhilaPort has been in discussions with a potential customer to provide a domestic marine Ro/Ro service between Philadelphia and the Southeast if the terminal is built. This could save customers money and lower congestion, pavement damage, emissions, and improve safety relative to truck or rail transportation.

CONTENTS

LIST OF TABLES

1 INTRODUCTION

A benefit-cost analysis (BCA) was conducted for the Southport Auto Terminal Consolidation project for submission to the U.S. Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the INFRA 2019 program. The following section describes the BCA framework, evaluation metrics, and report contents.

1.1 BCA FRAMEWORK

A BCA is an evaluation framework to assess the economic advantages (benefits) and disadvantages (costs) of an investment alternative. Benefits and costs are broadly defined and are quantified in monetary terms to the extent possible. The overall goal of a BCA is to assess whether the expected benefits of a project justify the costs from a national perspective. A BCA framework attempts to capture the net welfare change created by a project, including cost savings and increases in welfare (benefits), as well as disbenefits where costs can be identified (e.g., project capital costs), and welfare reductions where some groups are expected to be made worse off as a result of the proposed project.

The BCA framework involves defining a Base Case or "No Build" Case, which is compared to the "Build" Case, where the grant request is awarded and the project is built as proposed. The BCA assesses the incremental difference between the Base Case and the Build Case, which represents the net change in welfare. BCAs are forward-looking exercises which seek to assess the incremental change in welfare over a project life-cycle. The value of future welfare changes are determined through discounting, which is meant to reflect both the opportunity cost of capital as well as the societal preference for the present.

The analysis was conducted in accordance with the benefit-cost methodology as recommended by the U.S. DOT in the December 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs. This methodology includes the following analytical assumptions:

- Defining existing and future conditions under a No Build base case as well as under the Build Case;
- Estimating benefits and costs during project construction and operation, as well as for 24 years of operations beyond the Project completion when benefits accrue;
- Using U.S. DOT recommended monetized values for reduced fatalities, injuries, property damage, travel time savings, and emissions, while relying on best practices for monetization of other benefits;
- Presenting dollar values in real 2017 dollars. In instances where cost estimates and benefit valuations are expressed in historical dollar years, using an appropriate Gross Domestic Product Implicit Price Deflator (GDP/IPD) to adjust the values;
- Discounting future benefits and costs with a real discount rate of 7 percent consistent with U.S. DOT guidance;

1.2 REPORT CONTENTS

- Section 2 provides a general overview of the project, the general assumptions behind the BCA
- Section 3 describes the details of the demand assumptions, benefits, and costs
- Section 4 summarizes the results and provides a sensitivity analysis

2 PROJECT OVERVIEW

2.1 DESCRIPTION

The $106.7 million (in year of expenditure dollars) development of a new marine terminal wharf at Southport will consist of the following major components

- Design and construction of a 1,600-foot long and 115-foot wide two-vessel berth
- Landside improvements and site access modifications to the wharf
- Dredging to approximately – 36-ft Mean Lower Low Water (MLLW) operational depth, and proper disposal of dredged material in a Confined Disposal Facility (CDF)
- Revetment and bulkhead rock and stonework

2.2 GENERAL ASSUMPTIONS

Costs include environmental, engineering, and design work scheduled to begin in 2019. Costs for professional services and construction are expected to continue through 2023. The project is forecast to become operational in 2024.

For project costs and benefits, dollar figures in this analysis are expressed in constant 2017 dollars. In instances where certain cost estimates or benefit valuations were expressed in dollar values in other (historical) years, these costs were adjusted to 2017 using the U.S. Bureau of Economic Analysis Implicit Price Deflators for Gross Domestic Product per U.S. DOT guidance for discretionary grant programs.[2]

A real discount rate of 7.0 percent was used, consistent with U.S. DOT guidance and OMB Circular A-4. Costs and benefits are discounted to 2017.

2.3 BASE CASE AND NO BUILD CASE

The BCA compares the benefits and costs that would accrue under a Build or No Build (Base Case) scenario. Under the Build scenario included in this BCA, the Southport Marine Terminal is constructed, including dredging and access road. The resulting capacity is added to the Port of Philadelphia (PhilaPort), bringing total Ro/Ro capacity at PhilaPort to 500,000 vehicles, and expanding container-handling capacity by more than 44,000 containers per year.

Under the No Build scenario, Southport Marine Terminal is not built, and the associated capacity is not added to the Port of Philadelphia. Under this scenario, volumes at the port increase until port's capacity is met at 200,000 vehicles per year. PhilaPort's largest customer, Hyundai Glovis Co., Ltd indicates that the company has been shipping vehicles destined for the Mid Atlantic through the Port of Brunswick, GA due to lack of storage capacity at PhilaPort, which has been inefficient and has required longer truck moves than if these vehicles were handled through PhilaPort. While the customer's immediate issues will be addressed through previously planned increases in the vehicle storage area near Southport, it is likely that similar issues will arise if the project is not completed.

[2] https://www.transportation.gov/sites/dot.gov/files/docs/mission/office-policy/transportation-policy/284031/benefit-cost-analysis-guidance-2018.pdf

Under the No Build scenario, vehicles that would otherwise be handled at Philadelphia are instead diverted to Brunswick, GA. To be reasonable, it is assumed that after five years, the customer makes alternate arrangements. However, the problem still remains that PhilaPort is unable to meet its demand. PhilaPort's primary hinterland is the greater Northeast. PhilaPort customers believe that the Port of New York/New Jersey is too land-constrained to add capacity if PhilaPort should be unable to meet demand, and that this capacity would instead be added to the Port of Baltimore. However, Baltimore is farther from most of the markets that PhilaPort serves. Under the No Build scenario, after PhilaPort's customer ceases to ship vehicles from Brunswick, GA after five years, PhilaPort traffic is then diverted to the Port of Baltimore, which adds truck miles because Baltimore is on average farther from PhilaPort's core markets in the Northeast.

As a result of the project, 70 percent of vehicles are processed through the Southport Marine Terminal and the Southport Vehicle Processing Center (VPC). In the No Build scenario, 70 percent of vehicles are processed at the Southport VPC, but are handled at Pier 122 instead of the new Southport Marine Terminal. Table 1 displays total vehicles by the marine terminal at which they are unloaded and vehicle processing center where they are driven.

Table 1: Build and No Build Demand Forecasts by Marine Terminal and Vehicle Processing Center

Year	Build			No Build	
	Packer Ave. Terminal to 98 Annex VPC	Pier 122 Terminal to 98 Annex VPC	Southport Terminal to Southport VPC	Packer Ave. Terminal to 98 Annex VPC	Pier 122 Terminal to Southport VPC
2024	12,000	28,000	232,500	70,000	130,000
2025	17,400	40,600	248,925	60,000	140,000
2026	19,923	46,487	261,371	60,000	140,000
2027	22,812	53,228	274,440	60,000	140,000
2028	26,120	60,946	288,162	60,000	140,000
2029	29,907	69,783	302,570	60,000	140,000
2030	34,243	79,901	317,698	60,000	140,000
2031	39,209	91,487	333,583	60,000	140,000
2032 - 2047	45,000	105,000	350,000	60,000	140,000

As a result of the project, there is less need for movements between 98 Annex and Packer Avenue Marine Terminal, which frees up areas of 98 Annex close to the Packer Avenue Marine Terminal for container operations. Twenty acres can be repurposed to support Packer Avenue Marine Terminal container operations, thus freeing additional space at Packer Avenue Marine Terminal. This area can be used for container and chassis storage. PhilaPort estimates that each acre enables the processing of 7,500 twenty foot equivalent units (TEUs) per year. However, because the space is across the street from Packer Avenue Marine Terminal at 98 Annex, it is assumed that the throughput savings would be less, conservatively estimated to be 50 percent less. Each container is approximately equivalent to 1.7 TEUs, so the area saved would be 7,500 TEUs x 20 acres x 50 percent reduction because separate from marine terminal ÷ 1.7 TEU's per container = 44,118 additional container capacity.

2.4 PROJECT COSTS

2.4.1 CAPITAL COSTS

Capital costs include those costs associated with constructing the Southport berth.

Table 2: Project Schedule and Costs, Millions of 2017 Dollars

Variable	Unit	Value
Construction Start	Year	2019
Construction End	Year	2023
Construction Duration	Years	5 years
Project Opening	Year	2024
Capital Cost – Construction	$ M	$93.1
Capital Cost – Professional Services	$ M	$2.8

Source: WSP

Costs have been adjusted from the engineering estimates which have been expressed in year of expenditure dollars, to constant $2017 using the U.S. Congressional Budget Office (CBO) forecast GDP Price Index.[3] This has had the effect of de-escalating engineering estimates to remove the impacts of nominal inflation.

2.4.2 OPERATIONS AND MAINTENANCE COSTS

The project includes dredging the area in front of the Southport terminal to provide 36-foot depth. However, over the years, the area will require maintenance dredging as silt accumulates in the dredged area. The cost of maintenance dredging is based on actual costs of maintenance dredging for the Packer Avenue Marine Terminal between 2011 and 2018, indexed to $2017. Because the area to be dredged is one third that of the Packer Avenue Marine Terminal, the cost of maintenance dredging at the Southport Marine Terminal was estimated to be one third that of dredging at Packer Avenue Marine Terminal. The total undiscounted cost is $447,840 per year. Per U.S. DOT BCA Guidance, operations and maintenance costs appear in the numerator of the benefit/cost ratio as an offset to benefits.

2.4.3 RESIDUAL VALUE

The project is estimated to have a 50-year service life. Assuming straight-line depreciation, the new marine terminal will still retain 52 percent of its original value at the end of the 24-year analysis period. Undiscounted residual value equals $49.9 million. Discounted at 7 percent from the close of the project analysis period, the residual value is $6.6 million.

2.5 PROJECT BENEFITS

The project will generate benefits in a number of ways:

[3] January 2019 supplement to CBO's *The Budget and Economic Outlook: 2019 to 2029, www.cbo.gov/publication/54918.*

1) Currently, autos unloaded from ships at PhilaPort must be driven over public streets to the vehicle processing center at 98 Annex. The port's tenant incurs at least $250,000 in additional costs per month as a result of transferring vehicles in this manner. With the new Southport Marine terminal located next to the soon to be constructed Southport vehicle processing center, much of this cost can be avoided.
2) Cargo volumes at PhilaPort have grown dramatically in recent years. Ro/Ro cargo is expected to continue to grow, outstripping PhilaPort's capacity by 2023. Without the project, Ro/Ro cargoes would shift to other ports, at first to Brunwick, GA, and then to Baltimore. These ports are farther from markets served by PhilaPort. Shifting RoRo cargoes to these ports would increase truck mileage and costs. By reducing truck mileage, the project also reduces the risk of highway accidents, damage to pavement, and truck emissions.
3) The project will free capacity in the area of 98 Annex next to Packer Avenue to support container operations, including container/chassis storage, moving these activities away from the Packer Avenue Marine Terminal. This will enable Packer Avenue Marine Terminal to increase capacity and allow the port to process more containers. Enabling this capacity at PhilaPort will reduce inland truck mileage as more of the import/export demand can flow through PhilaPort rather than the Baltimore, New York/New Jersey, and the Port of Virginia.
4) The project will reduce vessel delay and berth time at PhilaPort. Because autos can be unloaded faster, vessels need spend less time at PhilaPort berths. Pier 122 is a "finger pier" where vessels must be backed into this pier by a relatively inefficient process. Vessel owners will benefit from a more efficient berthing process at Southport. Maintenance dredging at Pier 122 can also be reduced as the PhilaPort is less dependent on Pier 122 for Ro/Ro cargoes. These reductions in vessel delays will also result in emissions reductions as ships no longer need to remain as long at port or outside of port using auxiliary power.
5) The project will reduce mileage of automobiles driven between vessels and vehicle processing centers, since the Southport Marine Terminal and Southport vehicle processing center will be adjacent. This will save fuel and vehicle operating costs, as well as roadway damage, risk of crashes, and emissions.

3 BENEFIT-COST ANALYSIS DATA AND ASSUMPTIONS

3.1 DEMAND PROJECTIONS

PhilaPort's Ro/Ro cargos grew by 240 percent between 2010 and 2017 with the port handling 164,901 vehicles in 2017. While 2018 volumes declined to 141,999 vehicles, the overall trend points to significant growth. The port expects market growth to increase to 325,000 by 2032 even if the port were to be no more efficient than it is today. Additional induced demand from efficiencies associated with the new terminal bring PhilaPort's volumes to its new capacity of 500,000 vehicles the same year. These projections are in part based on past growth rates and in part based on port staff communications with existing and potential customers. The resulting demand projections are presented in the following table for 2024 (the first year of operation) onward.

Table 3: Build and No Build Vehicle Forecasts

Year	No Build	Build		
		Market Growth	Induced Demand	Total Demand
2024	200,000	220,500	52,000	272,500
2025	200,000	231,525	75,400	306,925
2026	200,000	243,101	84,680	327,781
2027	200,000	255,256	95,223	350,479
2028	200,000	268,019	107,208	375,227
2029	200,000	281,420	120,839	402,260
2030	200,000	295,491	136,352	431,843
2031	200,000	310,266	154,013	464,279
2032 - 2047	200,000	325,000	175,000	500,000

Source: PhilaPort and WSP

In both the Build and No Build scenarios, a vehicle processing facility is constructed at Southport. In the Build scenario, the Southport Marine Terminal handles 70 percent of the Ro/Ro volume, while Pier 122 handles 21 percent and Packer Avenue handles 9 percent from 2032 onward. All autos handled by the Southport Marine Terminal are processed at the Southport vehicle processing center. All vehicles arriving at Pier 122 are processed at Southport VPC, while vehicles arriving at Packer Avenue Marine Terminal are processed at the existing vehicle processing center at 98 Annex.

In the No Build scenario, PhilaPort is only capable of handling 200,000 vehicles per year. Of these, 70 percent or 140,000 are unloaded at Pier 122 and processed at the Southport marine facility, while the other 60,000 or 30 percent are unloaded at the Packer Avenue Marine Terminal and processed at 98 Annex. The remaining overall market demand (as opposed to induced) which PhilaPort is unable to meet reaches 125,000 vehicles per year by 2030 and remains at this level for the remainder of the analysis period.

According to one of PhilaPort's largest customers, Hyundai Glovis Co, Ltd, the company is currently shipping vehicles through Brunswick, GA which are bound for the Mid Atlantic market. Although a considerably longer truck journey is required to ship these vehicles through Brunswick, GA, the company is forced to do so because

PhilaPort has not yet completed the Southport Vehicle Processing Center, and PhilaPort is unable to accommodate these vehicles. Were PhilaPort to be unable to accommodate vehicles due to lack of marine terminal capacity, a similar situation would likely occur. However, this customer would only be willing to endure this inconvenience for a finite amount of time before seeking different arrangements, estimated to be five years. At the end of those five years, PhilaPort would still be unable to meet demand. According to a port customer, the primary Ro/Ro market area for PhilaPort is the greater Northeast. According to the same customer, if PhilaPort were not able to meet demand, Ro/Ro cargoes would likely shift to the Port of Baltimore. Although the Port of New York/New Jersey serves the same market, it lacks enough land to expand significantly. Some of the customers would be closer to Baltimore, while some would be closer to Philadelphia, but the customer believes that on average a longer truck haul would be required to serve PhilaPort's existing market from Baltimore. Some key markets that could be accessed within a day from Philadelphia would be beyond truckers' hours of service for a single day, significantly adding costs.

As mentioned previously, the growth of container traffic at PhilaPort has been remarkable. In part due to a previous INFRA grant, PhilaPort is expanding its capacity to handle 900,000 twenty foot equivalent units (TEUs) or 529,412 containers assuming 1.7 TEUs per container. However, given current growth, this demand may be exceeded in the not too distant future. Table 4 below displays the estimated container traffic, capacity, volumes enable by the project.

Table 4: Forecast Container Demand, Capacity, Additional Container Traffic Enabled by Project

Year	Container Demand	Container Capacity	Added Container Traffic from Project
2018	341,809	529,412	0
2019	358,900	529,412	0
2020	376,845	529,412	0
2021	395,687	529,412	0
2022	441,176	529,412	0
2023	463,235	529,412	0
2024	486,397	529,412	0
2025	510,717	529,412	0
2026	536,253	529,412	6,841
2027	563,065	529,412	33,654
2028 - 2047	573,529	529,412	44,118

Source: PhilaPort and WSP analysis

3.2 ECONOMIC COMPETITIVENESS

This project would contribute to increasing the economic competitiveness of the Nation through improvements in the mobility of people and goods in the study area. The project will reduce the cost of transporting automobiles through several different ways:

— More efficient offloading vehicles at PhilaPort
— Reduced truck mileage
— Reduced operating costs of vessels at berth, maneuvering or waiting for a berth
— Reduced maintenance dredging at Pier 122
— Reduced automobile operating costs.

These benefits will accrue to port customers, port tenants, buyers of automobiles in the Philadelphia area.

Table 5: Economic Competitiveness Estimation of Benefits, 2017 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Lower automobile handling cost	$3,605,142	$2,245,101	$73,601,915	$24,010,355
Lower cost of truck shipping	$880,977	$548,977	$234,006,626	$66,869,996
Lower vessel operating cost due to lower dwell, delays, and handling	$1,434,245	$893,176	$22,877,041	$7,520,937
Reduced maintenance dredging of Pier 122	$300,000	$186,824	$7,200,000	$2,292,750
Lower automobile fuel and operating cost due to fewer miles driven in port	$49,125	$30,592	$404,936	$497,297

Source: WSP analysis

3.2.1 *LOWER AUTOMOBILE HANDLING COSTS*

Currently, autos handled at PhilaPort must travel unnecessarily long distances over public roadways to access vehicle processing centers. This creates cost in terms of the hiring of police to direct traffic, extra staffing of drivers to move vehicles from vessels to vehicle processing centers, van drivers to drive these individuals back to the ships. The port's tenant reports that the company incurs at least an extra $250,000 per month as a result of this operation, likely more. With the new Southport Marine Terminal located adjacent to the Southport vehicle storage facility, costs would be greatly reduced, since vehicles can be unloaded from ships almost directly to the vehicle processing center. If PhilaPort were to increase volumes from an estimated 169,848 vehicles in 2018 to 200,000 as is assumed in the No Build scenario, the $3 million ($250,000/month x 12 months) in annual costs increasing proportionately. In the Build scenario, this cost would be reduced by 70 percent, since the 70 percent of vehicles would move directly between the Southport Marine Terminal and the Southport vehicle processing center.

3.2.2 *AVOIDED TRUCKING COST*

If PhilaPort is unable to expand Ro/Ro capacity, it will not be able to meet forecast demand. Volumes handled at the port have grown rapidly in recent years and are expected to continue to grow rapidly. As the port reaches capacity, port operational performance may decline, but beyond a point, shippers will take their cargos elsewhere. As mentioned previously, the port's largest Ro/Ro customer has indicated that the company had had to ship vehicles through Brunswick, GA, and if PhilaPort cannot meet demand in the future, this is a likely short-term outcome. The company reports that it pays a $43 per vehicle premium ($2017) to ship these vehicles through Brunswick, GA.

Long-term, the company would likely make alternate arrangements, but PhilaPort would still not be able to meet market demand. PhilaPort's primary market area is the Northeast. Traffic that PhilaPort cannot handle would shift to the Port of Baltimore, which is farther from many of PhilaPort's primary markets. Reviewing the relative position of Baltimore and Philadelphia and weighting Northeast states by population, it is estimated that the weighted average additional mileage from Baltimore would be about 36 miles. Long-term, the costs of additional trucking are estimated to be $1.69 per mile. This is the American Transportation Research Institute's estimated operating cost of trucking. [4]

Avoided trucking cost for the first five years of the project is estimated by multiplying the number of vehicles PhilaPort would otherwise be unable to handle by $43 per vehicle. Associated vehicle miles traveled (VMT) are estimated to be $43/vehicle x 8 vehicles per truck ÷ $1.69/truck VMT = 203 miles per diverted truck. Avoided truck vehicle miles travelled beyond the first five years are estimated to be diverted vehicles ÷ 8 vehicles per truck x 36 miles x 100 percent empty return ratio. Avoided truck costs are truck VMT x $1.69 per truck VMT.

Table 6: Summary of Avoided Trucking Cost for Ro/Ro Shipments

Year	Demand	No Build Unfulfilled Demand	Truck Vehicle Miles Traveled	Undiscounted Benefit
2024	220,500	20,500	521,288	$880,977
2025	231,525	31,525	801,640	$1,354,771
2026	243,101	43,101	1,096,009	$1,852,255
2027	255,256	55,256	1,405,096	$2,374,612
2028	268,019	68,019	1,729,638	$2,923,088
2029	281,420	81,420	730,745	$1,234,959
2030	295,491	95,491	857,033	$1,448,385
2031	310,266	110,266	989,634	$1,672,482
2032 - 2047	325,000	125,000	1,121,875	$1,895,969

Source: PhilaPort, WSP analysis

Is mentioned previously, PhilaPort's container volumes have grown dramatically in recent years from below 300,000 TEUs in 2007 – 2012 to nearly 600,000 TEUs in 2017 and 2018. By the time the project is expected to be completed, PhilaPort will have sufficient capacity to handle 900,000 TEUs per year. However, because container volumes are growing rapidly, it is expected that demand will exceed the 900,000 TEUs in 2026. The project will enable PhilaPort to handle an additional 75,000 TEUs or 44,118 containers.

An analysis of PIERS data for a previous INFRA grant application found that only 13 percent of container traffic headed to or from the 21 counties around Philadelphia were handled by PhilaPort in 2015. This suggested a significant demand for container handling capacity in the Philadelphia region, which has been borne out by rapid increases in the number of containers handled at the port.

[4] American Transportation Research Institute, *An Analysis of the Operating Costs of Trucking: 2018 Update,* October 2018, https://atri-online.org/wp-content/uploads/2018/10/ATRI-Operational-Costs-of-Trucking-2018.pdf.

Table 7: 2015 County Container Units for 21 counties

		US NORTHEAST PORT OF ORIGIN				
DESTINATION COUNTY	**TOTAL**	**PHILADELPHIA**	**NY/NJ**	**BALTIMORE**	**VIRGINIA**	**TOTAL NON-PHILADELPHIA**
Atlantic	850	123	693	0	34	727
Berks	13,611	865	9,757	1,417	1,573	12,746
Bucks	10,086	170	8,294	211	1,410	9,916
Burlington	21,508	10,731	9,998	648	130	10,777
Camden	4,375	675	3,201	360	140	3,701
Cape May	441	67	363	11	0	374
Chester	12,146	366	3,454	1,980	6,346	11,780
Cumberland	10,619	431	4,973	3,615	1,600	10,188
Delaware	10,056	709	7,004	975	1,367	9,346
Gloucester	8,977	1,639	6,984	37	317	7,338
Kent	671	22	426	120	103	649
Lancaster	7,494	453	3,613	2,478	951	7,041
Lebanon	1,443	173	1,057	125	88	1,270
Lehigh	8,890	266	7,290	359	975	8,624
Montgomery	18,300	2,502	11,943	1,694	2,162	15,798
New Castle	2,309	254	1,468	215	373	2,056
Northampton	9,737	1,461	8,181	73	22	8,276
Philadelphia	24,862	2,861	17,369	1,113	3,520	22,001
Salem	814	164	509	12	129	651
Schuylkill	7,862	15	7,673	162	11	7,847
Sussex	3,659	2	1,296	974	1,387	3,657
VOLUME BOUND FOR PHILADELPHIA REGION	**178,712**	**23,949**	**115,546**	**16,581**	**22,636**	**154,763**
PCT BY PORT OF ORIGIN	**100%**	**13%**	**65%**	**9%**	**13%**	**87%**

Source: FY2017 INFRA Grant Application Analysis using PIERS data

If PhilaPort is unable to meet demand due to capacity constraints, it is likely that this freight will revert back to these other more distant ports. The same PIERS analysis found that if freight handled by these other ports were instead handled by PhilaPort, average trucking hauls would be 121.78 miles less. The 121.78 miles per container was multiplied by the containers that PhilaPort would be unable to accommodate without the project to derive avoided vehicle miles traveled. These were then multiplied by $1.69 per mile to estimate avoided trucking costs. Table 8 displays the estimation of container truck costs avoided.

Table 8: Summary of Avoided Truck Cost for Container Shipments

Year	Demand	Current Capacity	Added Capacity	Truck Mileage Avoided	Truck VMT Avoided	Undiscounted Truck Cost Avoided
2024	486,397	529,412	0	121.78	0	$0
2025	510,717	529,412	0	121.78	0	$0
2026	536,253	529,412	6,841	121.78	833,096	$1,407,932
2027	563,065	529,412	33,654	121.78	4,098,339	$6,926,193
2028 - 2047	573,529	529,412	44,118	121.78	5,372,647	$9,079,774

Source: PhilaPort, WSP analysis

3.2.3 *AVOIDED VESSEL OPERATING COSTS*

Without the project, vessels will be delayed in several ways:

- With the project, vessels can be unloaded quickly, since the Southport Marine Terminal would be next to the Southport vehicle processing center and storage area. Without the project, crews will require a longer period of time to load and unload vessels. Vessel owners will need to pay additional vessel operating costs as the vessels wait at berth. The difference in vessel unloading times is estimated in Table 9 below. As can be seen, unloading of vessels between Southport Marine Terminal and the Southport vehicle processing center would be twice as fast as unloading between Packer Avenue Marine Terminal and 98 Annex today. The unload times of Table 9 are based on 2,500 vehicles per call. Under the No Build scenario, it is unknown the unload time of the vessels that PhilaPort is unable to accommodate. Therefore, the unloading times of the Build scenario have been adjusted to include only the same number of vehicles handled as the No Build scenario.
- PhilaPort will need to make greater use of Pier 122 in the No Build scenario than in the Build scenario. For vessels to berth at Pier 122 requires more handling because it is a “finger pier” and vessels must be backed into the pier. This additional time is estimated to be one hour per vessel. Usage of Pier 122 also requires additional assistance by tugboats above that which would be necessary at Southport Marine Terminal. The additional cost of tugboats has not been quantified here.

Table 9: Comparison of Time to Unload Vessel (Includes only Driving/Van Time)

	PAMT to 98 Annex	P122 to 98 Annex	P122 to Southport	Southport
Vessel Time (hrs)	**20.8**	**50**	**41.7**	**10.4**

Source: WSP analysis

Ship operating costs per hour have been estimated using the U.S. Army Corps of Engineers Economic Guidance for Deep Draft Vessels, 2002, indexed to $2017.[5] Costs are those of a 20,000 deadweight tonne foreign flag general cargo vessel at port. Vessel operating cost per hour is estimated to equal $702.

[5] The U.S. Army Corps of Engineers has produced more updated estimates of vessel operating costs, but recent estimates are proprietary.

The number of vessels calling on terminals is equal to the number of vehicles shown in Table 3 divided by an average of 2,500 vehicles per vessel.

Table 10: Vessel Operating Hours Avoided and Savings

Year	Faster Unloading	Avoided Berthing Time at Pier 122	Total Vessel Time Savings	Total Savings in $2017
2024	1,555	62	1,617	$1,134,245
2025	1,534	63	1,597	$1,120,132
2026	1,500	60	1,561	$1,094,886
2027	1,465	58	1,523	$1,068,155
2028	1,428	37	1,465	$1,027,592
2029	1,389	35	1,424	$999,171
2030	1,348	34	1,382	$969,475
2031	1,306	34	1,339	$939,739
2032 - 2047	1,260	34	1,294	$907,728

3.2.4 *AVOIDED PIER 122 MAINTENANCE DREDGING COSTS*

Under the No Build scenario, 70 percent of PhilaPort's Ro/Ro freight would be handled by Pier 122. Under the Build scenario, PhilaPort's dependence on Pier 122 would not be quite as high. While maintenance dredging will still be necessary for Pier 122, it is not anticipated to be quite as high in the Build scenario. An analysis of PhilaPort maintenance dredging between 2011 and 2018 suggests that maintenance dredging for Pier 122 has averaged about $900,000 per year. The project could reduce the required maintenance dredging by $300,000 per year.

3.2.5 *AVOIDED AUTOMOBILE OPERATING AND FUEL COSTS*

The $250,000 per month handling cost above included the external costs of moving automobiles, but the existing operation also introduces costs to vehicles including fuel and maintenance. By driving vehicles an unnecessarily long distance between the marine terminal and vehicle processing center, current operations impose wear and tear on vehicles, reducing the number of miles until they will require maintenance. With the new Southport Marine Terminal adjacent to the Southport vehicle processing center, this vehicle operating cost will be minimized.

Vehicle miles travelled between marine terminals and vehicle processing centers under the Build and No Build scenarios were compared. Mileages were multiplied by the vehicles shown in Table 3. Mileage for each marine terminal – vehicle processing center pair were estimated to be:

— Packer Avenue Marine Terminal – 98 Annex vehicle processing center: 0.5 miles
— Pier 122 Marine Terminal – Southport vehicle processing center: 1.0 miles
— Pier 122 Marine Terminal – 98 Annex vehicle processing center: 1.5 miles
— Southport Marine Terminal – Southport vehicle processing center: 0 miles

It was considered appropriate to compare Build scenario mileage to only that mileage in the No Build scenario which would remain at PhilaPort. This would include the first 200,000 vehicles in the Build scenario, since it is unknown how far vehicles diverting to other ports in the No Build scenario must be driven between vessels and vehicle processing centers at these other ports. Therefore, vehicle miles in the Build scenario were reduced to a level as if only 200,000 vehicles were being handled, since these additional vehicles were unaccounted for in the No Build scenario. Vehicle operating expense was $0.39 per vehicle mile traveled (VMT) per U.S. DOT 2018 BCA guidance.

Table 11: Automotive VMT Savings and Vehicle Operating Benefits

Year	VMT Savings	Vehicle Operating and Maintenance
2022	125,400	48,906
2023	112,580	43,906
2024	104,254	40,659
2025	94,721	36,941
2026	83,805	32,684
2027	71,307	27,810
2028	56,997	22,229
2029	40,611	15,838
2030	21,500	8,385
2031	125,400	48,906
2032 - 2047	112,580	43,906

3.3 SAFETY

The safety benefits assessed in this analysis include a reduction in fatalities and injuries, as well as a reduction in property-damage-only crash costs resulting from the project. Reduction in auto processing VMTs yield benefits, but the reduction of truck VMTs are a much larger source of benefits. Safety benefits impact the general traveling public.

Table 12: Safety Estimation of Benefits, 2017 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Reduced truck crash fatalities	$89,578	$55,785	$23,793,904	$6,799,373
Reduced truck crash injuries	$39,638	$24,684	$10,528,637	$3,008,675
Reduced truck property damage only crashes	$2,679	$1,668	$711,505	$203,320
Reduced auto crash fatalities	$13,756	$8,567	$121,951	$48,062
Reduced auto crash injuries	$13,997	$8,716	$115,372	$48,900
Reduced auto property damage only crashes	Not quantified	Not quantified	Not quantified	Not quantified

Source: WSP analysis

The analysis assumes constant accident rates for the "Build" and "No Build" scenarios. As a result, any changes in the number of accidents will be a result of changes in VMT, not of structural changes to the safety conditions on the roadway network. The assumptions used in the estimation of safety benefits are presented in the following table. The rate of accidents per VMT was multiplied by the VMT reduction and then multiplied by the value per avoided fatality, injury, or property damage only accident. National statistics for truck accidents were considered more appropriate than Pennsylvania statistics, since much of the truck VMT would be outside of the state.

Table 13: Safety Benefits Assumptions and Sources

Variable	Unit	Value	Source
Truck fatalities per 100 million VMT	#/100M VMT	1.79	Federal Motor Carrier Safety Administration, *Large Truck and Bus Crash Facts 2016*
Truck injuries per 100 million VMT	#/100M VMT	43.7	Federal Motor Carrier Safety Administration, *Large Truck and Bus Crash Facts 2016*
Truck property damage only accidents per VMT	#/100M VMT	119.5	Federal Motor Carrier Safety Administration, *Large Truck and Bus Crash Facts 2016*
Automobile fatalities	#/100M VMT	1.14	Pennsylvania Department of Transportation, *2017 Pennsylvania Crash Facts and Statistics*
Automobile serious injuries per 100 million VMT	#/100M VMT	4.25	Pennsylvania Department of Transportation, *2017 Pennsylvania Crash Facts and Statistics*
Automobile minor injuries per 100 million VMT	#/100M VMT	27.37	Pennsylvania Department of Transportation, *2017 Pennsylvania Crash Facts and Statistics*
Automobile possible injuries per 100 million VMT	#/100M VMT	22.74	Pennsylvania Department of Transportation, *2017 Pennsylvania Crash Facts and Statistics*
Automobile injury severity unknown per 100 million VMT	#/100M VMT	26.65	Pennsylvania Department of Transportation, *2017 Pennsylvania Crash Facts and Statistics*
Value of fatality avoided	$2017	$9,600,000	U.S. DOT 2018 BCA Guidance, indexed to $2018
Value of a serious injury avoided	$2017	$1,008,000	U.S. DOT 2018 BCA Guidance, indexed to $2018
Value of injury accident avoided, severity unknown	$2017	$174,000	U.S. DOT 2018 BCA Guidance, indexed to $2018
Value of minor injury avoided	$2017	$28,800	U.S. DOT 2018 BCA Guidance, indexed to $2018
Value of possible injury avoided	$2017	$63,900	U.S. DOT 2018 BCA Guidance, indexed to $2018
Value of property damage only accident avoided	$2017	$4,300	U.S. DOT 2018 BCA Guidance, indexed to $2018

3.4 STATE OF GOOD REPAIR

The state of good repair benefits assessed in this analysis include maintenance and repair savings, deferral of replacement cost savings, as well as reduced VMT which leads to less road and pavement damage. State of good repair impacts government entities, toll authorities, and taxpayers that pay to improve roadways. Roadway maintenance savings have been quantified for both automobile and truck VMT. Savings associated with automobile VMT reductions are minimal and have been excluded from this analysis. The source of pavement impacts is the FHWA *Addendum to the 1997 Federal Highway Cost Allocation Study Final Report*, May 2000, indexed to $2017. This study provides different values for avoided pavement damage depending upon the weight of truck and whether roadways are urban or rural. The average gross weight per truck was assumed to be 60,000 pounds. For the truck diversion analysis, the region is primarily urban. An analysis was performed which used Interstate 95 as a proxy for urban/rural mileage for regional truck moves. This analysis suggested that about 85 percent of the mileage in the area around Philadelphia and between Baltimore and Philadelphia would be urban and 15 percent rural. Weighting a value of $0.149 per VMT for urban roadway sections and $0.047 per VMT for rural roadway sections yields a weighted value of $0.134 per mile. For movements that would otherwise divert to Brunswick, GA during the first five years of the analysis period, the ratio of urban to rural highways is assumed to be reversed, so 85 percent rural and 15 percent urban. Weighted pavement damage is $0.62 per mile.

Table 14: State of Good Repair Estimation of Benefits, 2017 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Avoided truck pavement damage	$32,473	$20,223	$18,152,974	$5,091,623

3.5 ENVIRONMENTAL SUSTAINABILITY

This project will create environmental and sustainability benefits relating to reduction in air pollution associated with decreased automobile and commercial truck travel. Five forms of emissions were identified, measured and monetized, including: nitrous oxide, particulate matter, sulfur dioxide, volatile organic compounds, and carbon dioxide. Emissions of vessels at harbor were also quantified. Because vessel emission factors are only available for particulate matter, volatile organic compounds and nitrous oxides, only these pollutants were quantified for vessel emissions.

For vehicle emissions, the emission rate or factor in grams per VMT is multiplied by VMT savings. The resulting savings in grams are converted to metric tons and then multiplied by the value per metric ton of avoided emissions. For vessel emissions, estimated fuel consumption per hour while the vessel is at port is multiplied by vessel hour savings. For trucks, emissions were estimated assuming average speeds of a long-distance haul. For vehicle fuel emissions, vehicles were assumed to be travelling below 15 miles per hour between vessel, location of first rest, and vehicle processing center. The resulting metric tonnage of fuel consumed is multiplied by kilograms of emissions per metric ton of fuel. Kilograms of emissions are converted to metric tons and then multiplied by the value of emissions reduction per metric ton.

Table 15: Environmental Sustainability Estimation of Benefits, 2017 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Truck VOC emission savings	$659	$410	$126,194	$37,304
Truck NOx emission savings	$21,132	$13,160	$3,246,963	$986,766
Truck SOx emission savings	$458	$285	$121,068	$34,597
Truck PM emission savings	$28,635	$17,832	$2,484,079	$840,188
Auto VOC emission savings	$116	$72	$528	$273
Auto NOx emission savings	$10,050	$6,259	$47,918	$24,298
Auto SOx emission savings	$159	$99	$1,266	$541
Auto PM emission savings	$4,723	$2,941	$21,357	$11,037
Vessel NOx emission savings	$76,982	$47,941	$1,552,690	$510,454
Vessel VOC emission savings	$505	$314	$10,177	$3,346
Vessel PM emission savings	$196,229	$122,202	$3,957,826	$1,301,154

The assumptions used in the estimation of environmental sustainability benefits are presented in the following table. Truck emissions factors rely on an analysis using the U.S. EPA MOVES model. Auto emissions factors rely on an analysis using the California Air Resources Board EMFAC model. Vessel emissions are based on a paper by Techne Consulting, Inc.[6] Vessel fuel consumption rate is based upon U.S. Army Corps of Engineers estimate for vehicles at port on auxiliary power.

The value per ton of reducing emissions are from U.S. DOT 2018 guidance.

Table 16: Environmental Sustainability Benefits Assumptions and Sources

Variable	Unit	Value	Source
Truck VOC emission factor 2023	g/VMT	0.61	EPA Moves 2016
Truck NOx emission factor 2023	g/VMT	4.86	EPA Moves 2016
Truck SOx emission factor 2023	g/VMT	0.02	EPA Moves 2016
Truck PM10 emission factor 2023	g/VMT	0.175	EPA Moves 2016
Truck CO2 emission factor 2023	g/VMT	1,559.33	EPA Moves 2016
Truck VOC emission factor 2047	g/VMT	0.39	EPA Moves 2016
Truck NOx emission factor 2047	g/VMT	2.23	EPA Moves 2016
Truck SOx emission factor 2047	g/VMT	0.02	EPA Moves 2016
Truck PM10 emission factor 2047	g/VMT	0.03	EPA Moves 2016
Truck CO2 emission factor 2047	g/VMT	1,353.19	EPA Moves 2016
Auto NOx emission factor 2023	g/VMT	9.44	CARB EMFAC 2017
Auto PM10 emission factor 2023	g/VMT	0.10	CARB EMFAC 2017
Auto SOx emission factor 2023	g/VMT	0.02	CARB EMFAC 2017
Auto VOC emission factor 2023	g/VMT	0.45	CARB EMFAC 2017
Auto CO2 emission factor 2023	g/VMT	1,032.37	CARB EMFAC 2017
Auto NOx emission factor 2047	g/VMT	0.39	CARB EMFAC 2017
Auto PM10 emission factor 2047	g/VMT	0.003	CARB EMFAC 2017

[6] Carlo Trozzi, Techne Consulting, Inc., "Emission Estimate Methodology for Maritime Navigation," https://www3.epa.gov/ttnchie1/conference/ei19/session10/trozzi.pdf.

Variable	Unit	Value	Source
Auto SOx emission factor 2047	g/VMT	0.02	CARB EMFAC 2017
Auto VOC emission factor 2047	g/VMT	0.04	CARB EMFAC 2017
Auto CO2 emission factor 2047	g/VMT	946.2	CARB EMFAC 2017
Vessel fuel consumption rate	MT/Hr	0.083	USACE Economic Guidance
Vessel NOx emission factor	Kg/MT	62.5	Carlo Trozzi, Techne Consulting, Inc.
Vessel VOC emission factor	Kg/MT	1.7	Carlo Trozzi, Techne Consulting, Inc.
Vessel PM emission factor	Kg/MT	3.5	Carlo Trozzi, Techne Consulting, Inc.
Cost per ton of NOX	$2017	$9,142	2018 U.S. DOT Guidance
Cost per ton of PM10	$2017	$416,147	2018 U.S. DOT Guidance
Cost per ton of SOX	$2017	$53,863	2018 U.S. DOT Guidance
Cost per ton of VOC	$2017	$2,203	2018 U.S. DOT Guidance

4 SUMMARY OF RESULTS

4.1 EVALUATION MEASURES

The benefit-cost analysis converts potential gains (benefits) and losses (costs) from the Project into monetary units and compares them. The following common benefit-cost evaluation measures are included in this BCA:

- Net Present Value (NPV): NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.
- Benefit Cost Ratio (BCR): The evaluation also estimates the benefit-cost ratio; the present value of incremental benefits is divided by the present value of incremental costs to yield the benefit-cost ratio. The BCR expresses the relation of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of the costs.
- Internal Rate of Return (IRR): The IRR is the discount rate which makes the NPV from the Project equal to zero. In other words, it is the discount rate at which the Project breaks even. Generally, the greater the IRR, the more desirable the Project.
- Payback Period: The payback period refers to the period of time required to recover the funds expended on a Project. When calculating the payback period, the time value of money (discounting) is not taken into account.

4.2 BCA RESULTS

The table below presents the evaluation results for the project. Results are presented in undiscounted, discounted at 7 percent as prescribed by the U.S. DOT. All benefits and costs were estimated in constant 2017 dollars over an evaluation period extending 24 years beyond system completion in 2023.

The project creates $392.3 million in undiscounted benefits over the 24-year project analysis period. When discounted to 2017 at 7 percent, benefits are $116.4 million. Undiscounted costs are $95.9 million excluding the residual value of the project at the end of the analysis period. When residual value is netted against costs, undiscounted costs are $46.0 million. Including the residual value, discounted costs are $61.1 million. The ratio of benefits over costs at a 7 percent is 1.90. The net present value (discounted benefits minus discounted costs) is $55.3 million. The project has an internal rate of return of 12.9 percent. The project pays for itself in 8 years from going into service.

Table 17: Benefit Cost Analysis Results, Millions of 2017 Dollars

BCA Metric	Project Lifecycle	
	Undiscounted	Discounted (7%)
Total Benefits	$392.3	$116.4
Total Costs	$46.0	$61.1
Net Present Value (NPV)	$346.3	$55.3
Benefit Cost Ratio (BCR)	8.52	1.90
Internal Rate of Return (IRR)	12.9	
Payback Period (Years)	8	

Source: WSP analysis

The benefits over the project lifecycle are presented in the table below by U.S. DOT long-term outcome category.

Table 18: Benefits by Long-Term Outcome, Millions of 2017 Dollars

Long-Term Outcome	Project Lifecycle	
	Undiscounted	Discounted (7%)
Economic Competitiveness	$338.1	$100.9
Safety	$35.3	$10.1
State of Good Repair	$18.2	$5.1
Environmental Sustainability	$11.6	$3.7
Additional O&M	-$10.7	-$3.4

Source: WSP analysis

4.3 SENSITIVITY TESTING

A sensitivity analysis is used to help identify which variables have the greatest impact on the BCA results. This analysis can be used to estimate how changes to key variables from their preferred value affect the final results and how sensitive the final results are to these changes. This sensitivity testing investigates key assumptions of the BCA and assesses impact of changes to those assumptions.

- The project is assumed to add overall capacity to PhilaPort by consolidating Ro/Ro operations in Southport and reducing need for automobiles to travel between Packer Avenue Marine Terminal and 98 Annex. The project will not only increase Ro/Ro capacity, but also container capacity. If the projects impacts were limited to Ro/Ro cargoes, discounted benefits would fall to $49.6 million. The new benefit/cost ratio would be 0.81.
- Many of the benefits of the project related to additional capacity that the project provides. The project enables PhilaPort to continue to serve markets for which it is most efficiently situated. If capacity was not available, freight would move to other ports and travel farther to markets served. Benefit assumptions rely on demand forecasts, which estimate the point at which PhilaPort without the project would not be able to meet demand. If PhilaPort demand forecasts with a simple assumption of four percent growth rate, benefits decline to $101.0 million and the new benefit/cost ratio becomes 1.65. If the assumed growth rate is reduced to three percent, benefits decline to $84.1 million and the benefit/cost ratio becomes 1.38.

The table below summarizes the key variables which have been tested for sensitivity and the results of this analysis.

Table 19: Benefit Cost Analysis Sensitivity Analysis

Sensitivity Variable	New BCR	New NPV (Million $2017)
Project has no impact on container capacity	0.81	$-11.4
Forecast growth in demand decreased to 4 percent per year	1.64	$39.9
Forecast growth in demand decreased to 3 percent per year	1.38	$23.0

Source: WSP analysis