Cost-Effectiveness Analysis Supplementary Documentation

FASTLANE Discretionary Grant Program

Market Street Marine Terminal

Main Wharf Rehabilitation

Pease Development Authority

December 15, 2016

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Cost Effectiveness Analysis Supplementary Documentation

1. Executive Summary

The Pease Development Authority, Division of Ports and Harbors, is requesting FASTLANE grant funds for use toward the rehabilitation of the Main Wharf at the Market Street Marine Terminal in Portsmouth, New Hampshire. The project will improve the structural integrity of the existing wharf and facilitate current operations, bringing it to a state of good repair. It is also designed to increase operational opportunities and extend the useful working life of the berth at the terminal. The improved wharf will support heavier cargo and improve operational efficiency on both the water and land sides as well as providing easy and direct access to the Main Wharf, greatly enhancing safety, functionality and operational efficiency. Table ES-1 summarizes the Main Wharf rehabilitation and associated economic benefits. Without the necessary improvements, the Port must turn away users, placing additional strain on the regional transportation infrastructure.

Table ES-1: Summary of Infrastructure Improvements and Associated Benefits

Current Status or Baseline & Problems to be Addressed	Changes to Baseline / Alternative	Type of Impacts	Population Affected by Impact	Economic Benefit	Summary of Results (Millions of $2015)	Page Ref.
Main Wharf in need of rehabilitation to accommodate existing freight at port	Rehabilitate Main Wharf	Reduce truck vehicle miles traveled	Vehicle drivers	Monetized value of accident reduction	$4.1	p. 18-19
				Monetized value of reduced roadway congestion	$1.7	p. 16-18
			Government	Monetized value of pavement maintenance savings	$1.2	p. 16-18
Main Wharf in need of rehabilitation to accommodate freight growth at port		Reduce pollutant emissions	Local, state, region, and national population	Monetized value of emission reductions	$3.1	p. 19-21
		Remaining value of infrastructure after 30 years of wharf use	Port of NH, Pease Development Authority, and State of NH	Monetized residual value of improved Wharf	$0.3	p. 16-18
		Decrease shipper costs	Shippers who utilize the port	Savings due to direct port shipments compared to longer-distance truck and rail	$18.7	p. 15-16

The period of analysis used in the estimation of benefits and costs corresponds to 33 years, including just over 2 years of construction and 30 years of operation plus a residual value after the final year. Operations at the port will not be disrupted during the construction period; as a result, no disruption costs are included in the analysis. The total project costs are $12.5 million dollars and are expected to be financed by Federal and State sources according to the distribution shown in Table ES-2. The Pease Development Authority Division of Ports and Harbors is committed to funding $5 million, or 40 percent, or the project cost.

Table ES-2: Summary of Project Costs and Anticipated Funding Sources, in Millions of Dollars of 2015

Funding Source	Capital Costs	Percent of Total Cost Financed by Source
Federal	$7.5	60%
State	$5.0	40%
TOTAL	**$12.5**	**100%**

A summary of the relevant data and calculations used to derive the benefits and costs of the project are shown in Table ES-3 (in dollars of 2015). Based on the analysis presented in the rest of this document, the project is expected to generate $29.2 million in discounted benefits and $20.9 million in discounted costs, using a 7 percent real discount rate. Therefore, the project is expected to generate a Net Present Value of $8.3 million and a Benefit/Cost Ratio of 1.4.

Table ES-3: Summary of Pertinent Data, Quantifiable Benefits and Costs

Calendar Year	Total Benefits ($2015)	Total Costs ($2015)	Undiscounted Net Benefits ($2015)	Discounted Net Benefits at 7%	Discounted Net Benefits at 3%
2016	$0	$0	$0	$0	$0
2017	$0	$3,515,617	($3,515,617)	($3,070,676)	($3,313,806)
2018	$0	$4,687,490	($4,687,490)	($3,826,388)	($4,289,717)
2019	$216,881	$4,296,866	($4,079,985)	($3,111,470)	($3,625,013)
2020	$2,670,009	$1,100,000	$1,570,009	$1,136,402	$1,354,303
2021	$2,736,765	$1,100,000	$1,636,765	$1,110,673	$1,370,765
2022	$2,816,382	$1,100,000	$1,716,382	$1,092,784	$1,395,575
2023	$2,895,773	$1,100,000	$1,795,773	$1,072,523	$1,417,600
2024	$2,909,052	$1,100,000	$1,809,052	$1,014,124	$1,386,488
2025	$2,909,783	$1,100,000	$1,809,783	$952,549	$1,346,649
2026	$2,910,557	$1,100,000	$1,810,557	$894,991	$1,307,985
2027	$2,911,375	$1,100,000	$1,811,375	$841,183	$1,270,462
2028	$2,915,111	$1,100,000	$1,815,111	$792,067	$1,236,002
2029	$2,916,235	$1,600,000	$1,316,235	$550,394	$870,187
2030	$2,922,719	$1,100,000	$1,822,719	$702,958	$1,169,934
2031	$2,928,430	$1,100,000	$1,828,430	$663,197	$1,139,417
2032	$2,934,188	$1,100,000	$1,834,188	$625,894	$1,109,714
2033	$2,939,994	$1,100,000	$1,839,994	$590,892	$1,080,803
2034	$2,946,799	$1,100,000	$1,846,799	$558,307	$1,053,204
2035	$2,953,654	$1,100,000	$1,853,654	$527,705	$1,026,323
2036	$2,960,557	$1,100,000	$1,860,557	$498,959	$1,000,141
2037	$2,968,000	$1,100,000	$1,868,000	$472,063	$974,895
2038	$2,978,154	$1,100,000	$1,878,154	$448,131	$951,645
2039	$2,985,698	$1,600,000	$1,385,698	$325,751	$681,672
2040	$2,993,577	$1,100,000	$1,893,577	$401,991	$904,383
2041	$3,001,508	$1,100,000	$1,901,508	$380,981	$881,719
2042	$3,006,829	$1,100,000	$1,906,829	$360,015	$858,434
2043	$3,014,881	$1,100,000	$1,914,881	$341,449	$836,950
2044	$3,022,986	$1,100,000	$1,922,986	$323,974	$816,012
2045	$3,031,146	$1,100,000	$1,931,146	$307,522	$795,606
2046	$3,039,362	$1,100,000	$1,939,362	$292,029	$775,720
2047	$3,026,619	$1,100,000	$1,926,619	$263,318	$748,177
2048	$3,034,336	$1,100,000	$1,934,336	$249,659	$729,296
2049	$5,999,601	$1,600,000	$4,399,601	$479,577	$1,610,451
Total	$91,496,962	$46,999,973	$44,496,989	$8,263,528	$20,871,975

In addition to the monetized benefits presented in Table ES-3, the project would generate benefits that are difficult to quantify. A brief description of those benefits is provided below.

Economic Outcomes

- The port provides ship handling for numerous companies.
- Both port and rail services are available at the Market Street Terminal, and the combination is critical to the cost competitiveness of multiple regional businesses. An improved wharf will position the port to increase the exports and imports of current customers, be more productive, and expand existing operations.
- The port supports upstream businesses by providing special cargo handling services and a staging area for construction and maintenance of other facilities located along the Piscataqua River.
- Provides a facility that meets the needs of new shippers, facilitating an increase in exports.

Mobility Outcomes

- Rehabilitation of the Main Wharf improves the efficiency of the port and the harbor. This is beneficial to recreational boat users on the Piscataqua River. It also benefits other commercial vessels that are traveling up the Piscataqua to the private facilities north of the Market Street Terminal.

Safety Outcomes

- The Market Street Marine Terminal coordinates with all agencies involved with security of the port, including the U.S. Coast Guard, NH Marine Patrol, the U.S. Customs, the FBI, the U.S. Navy, NCIS and the Department of Transportation. Specifically, the Terminal provides these entities access to its state-of-the-art camera system, which allows them the ability to reconnoiter or otherwise observe land based facilities, ships in port, and vessels transiting the area between the I-95 and Memorial Bridge. If the port were to close, there would not be sufficient revenue generated to support the staff required to operate this equipment.
- The port hosts advanced shipboard fire fighting training. The terminal is also used for oil spill training drills and, in the unlikely event of a spill, for staging response equipment.
- Security at the Portsmouth Naval Shipyard is elevated at all times. When there is a nuclear submarine docked, the Terminal is utilized to load and unload cargo from foreign flag vessels. This practice maintains some separation of the foreign vessels from the Naval Shipyard for security reasons. In the absence of the Main Wharf, it is not clear how the Shipyard would maintain this distance and security precaution.

Community and Environmental Outcomes

- The Main Wharf project includes the rehabilitation of a section of the wharf, rather than completely replacing it. In addition, the wharf project is designed with concrete containing recycled fly ash, and the deck is supported with steel caissons that provide large spans that limit impact to the Piscataqua riverbed.

Cost Effectiveness

Provide information related to the BCR, as well as highlight the important benefits that should weigh into the consideration of whether the monetized, quantified, and qualitative benefits are significant enough to warrant the investment.

2. Introduction

This document provides detailed technical information on the economic analyses conducted in support of the FASTLANE Grant Application for the Market Street Marine Terminal Main Wharf Rehabilitation project.

Section 3, Methodological Framework, introduces the conceptual framework used in the Benefit-Cost Analysis (BCA). Section 4, Project Overview, provides an overview of the project, including a brief description of existing conditions and proposed alternatives; a summary of cost estimates and schedule; and a description of the types of effects that the Market Street Terminal Main Wharf Rehabilitation is expected to generate. Section 5, General Assumptions, discusses the general assumptions used in the estimation of project costs and benefits, while estimates of travel demand and traffic growth can be found in Section 6, Demand Projections. Specific data elements and assumptions pertaining to the selection merit criteria are presented in Section 7, Benefits Measurement, Data and Assumptions, along with associated benefit estimates. Estimates of the project's Net Present Value (NPV), its Benefit/Cost ratio (BCR) and other project evaluation metrics are introduced in Section 8, Summary of Findings and BCA Outcomes. Next, Section 9, BCA Sensitivity Analysis, provides the outcomes of the sensitivity analysis. Additional data tables are provided in Section 10, Supplementary Data Tables, including annual estimates of benefits and costs, as well as intermediate values to assist US DOT in its review of the application.[1]

3. Methodological Framework

Benefit-Cost Analysis (BCA) is a conceptual framework that quantifies in monetary terms as many of the costs and benefits of a project as possible. Benefits are broadly defined. They represent the extent to which people impacted by the project are made better-off, as measured by their own willingness-to-pay. In other words, central to BCA is the idea that people are best able to judge what is "good" for them, what improves their well-being or welfare.

BCA also adopts the view that a net increase in welfare (as measured by the summation of individual welfare changes) is a good thing, even if some groups within society are made worse-off. A project or proposal would be rated positively if the benefits to some are large enough to compensate the losses of others.

Finally, BCA is typically a forward-looking exercise, seeking to anticipate the welfare impacts of a project or proposal over its entire life-cycle. Future welfare changes are weighted against today's changes through discounting, which is meant to reflect society's general preference for the present, as well as broader inter-generational concerns.

[1] While the models and software themselves do not accompany this appendix, greater detail can be provided, including spreadsheets presenting additional interim calculations and discussions on model mechanics and coding, if requested.

The specific methodology developed for this application was developed using the above BCA principles and is consistent with the FASTLANE guidelines. In particular, the methodology involves:

- Establishing existing and future conditions under the build and no-build scenarios;
- Assessing benefits with respect to each of the four merit criteria identified in the FASTLANE BCA guidance;
- Measuring benefits in dollar terms, whenever possible, and expressing benefits and costs in a common unit of measurement;
- Using DOT guidance for the valuation of travel time savings, safety benefits and reductions in air emissions, while relying on industry best practice for the valuation of other effects;
- Discounting future benefits and costs with the real discount rates recommended by the DOT (7 percent, and 3 percent for sensitivity analysis); and
- Conducting a sensitivity analysis to assess the impacts of changes in key estimating assumptions.

4. Project Overview

The Pease Development Authority, Division of Ports and Harbors, is requesting FASTLANE discretionary funds for use toward the rehabilitation of the Main Wharf. The project will improve the structural integrity of the existing wharf and facilitate current operations. It is also designed to increase operational opportunities and extend the useful working life of the berth at the terminal.

The project will consist of a 17,500 square foot deck rehabilitation that will replace the deteriorating wharf access bridges (one of which has collapsed) by decking the open water area between the existing shoreline sheeting and the back of the current Main Wharf. This will provide easy and direct access for the entire length of the Main Wharf, assuring continued use for ocean commerce and greatly enhancing its safety, functionality and operational efficiency.

4.1 Base Case and Alternatives

Two alternatives were compared in the benefit-cost analysis, a build and no-build scenario. The build scenario represents the Main Wharf rehabilitation as described in the Project Overview, with the continuation of service for project cargoes, salt, and several other confidential users. The no-build scenario reflects no improvements in the Main Wharf and complete closure of the Market Street Marine Terminal by the end of 2017.

There is interest on the part of several potential shippers to operate through the Market Street Marine Terminal. Specifically, this shipper estimates that an improved main wharf would enable the business to move its operation to the Port of New Hampshire, resulting in 6,000 containers per year utilizing the port. These containers are currently being handled by the Ports of Baltimore, New York and Montreal. While this would represent a diversion from other ports, there would be multiple societal benefits, including emissions, congestion and pavement maintenance savings generated from this shift.

In addition, it is expected that the number of containers using the Main Wharf would grow once the container operation had been relocated. This is due, in part, to industry demand but also because the Port of New Hampshire offers some locational and other advantages to this prospective shipper, as compared to other ports. The timing and likely share of this growth associated with the Port of New Hampshire specifically, rather than overall industry demand, are uncertain. As a result, the container service is ***not*** included in the primary build analysis. A separate analysis was conducted on this scenario with results presented later in this document. Overall, the incorporation of the new container service results in a benefit-cost ratio of 2.5.

4.2 Project Cost and Schedule

For the build scenario, it is estimated that the project will require $12.5 million in capital expenditures with construction commencing in April 2017 and completion anticipated in November 2019. Maintenance after the improvement is estimated to cost $500,000 every ten years. Operating costs are currently $1.1 million annually and anticipated to remain at this level after the wharf is improved.

The no-build scenario is predicated on complete closure of the Market Street Marine Terminal by the end of 2017 with no large maintenance expenditures before the closure.

4.3 Disruptions Due to Construction

No significant disruptions due to construction are anticipated.

4.4 FASTLANE Merit Criteria

A strong multimodal transportation system promotes economic viability, vitality and ultimately more livable communities that utilize the system. Transportation projects have the dual benefit of directly supporting jobs during construction and supporting the local, regional and national economies through the improved movement of goods, services and people.

Deficient links in a transportation system restrict travel and can significantly impact economic growth and safety. Ensuring that transportation is in a state of good repair is a critical element in providing opportunities for economic competitiveness and viable economic growth. Rehabilitation of the Market Street Marine Terminal will ensure that the Main Wharf is in a state of good repair, which will support economic, mobility, safety, and community and environmental outcomes – all important criteria for the FASTLANE program. The table below presents the main benefit categories associated with the project as they relate to the four merit criteria set forth by the United States Department of Transportation.

Table 1: Expected Effects on Merit Criteria and Benefit Categories

Merit Criteria	Benefit or Impact Categories	Description	Monetized	Qualitative
Economic Outcomes	Shipper Cost Savings	Savings due to direct port shipments compared to longer-distance truck and rail	Yes	No
Mobility Outcomes	Pavement Maintenance	Port provides non-roadway option for transporting cargo, which reduces VMT and associated roadway maintenance expenses	Yes	No
	Congestion Reduction	Port provides non-roadway option for transporting cargo, which reduces congestion on highways	Yes	No
Safety Outcomes	Accident Reduction Benefits	Reduction in VMT due to use of port rather than highways to transport goods reduces accidents on the roadway network.	Yes	No
	Harbor Safety and Security	Location of fire and oil spill response staging; operation of harbor security equipment; support of Portsmouth Naval Shipyard when foreign flag vessels are in the harbor and/or maintenance at Shipyard requires staging	No	Yes
Community & Environmental Outcomes	Emissions Reduction	Reduction in VMT due to use of port rather than highways to transport goods reduces overall pollutant emissions	Yes	No
	Efficient Harbor Operations	Port provides efficient and safe operations for commercial and non-commercial port users	No	Yes

5. General Assumptions

The BCA measures benefits against costs throughout a period of analysis beginning at the start of construction and including 30 years of operations.

The monetized benefits and costs are estimated in 2015 dollars with future dollars discounted in compliance with FASTLANE requirements using a 7 percent real rate, and sensitivity testing at 3 percent.

The methodology makes several important assumptions and seeks to avoid overestimation of benefits and underestimation of costs. Specifically:

- Input prices are expressed in 2015 dollars;
- The period of analysis begins in 2017 and ends in 2049. It includes project development and construction years (2017-2019) and 30 years of operations (2020-2049);
- A constant 7 percent real discount rate is assumed throughout the period of analysis. A 3 percent real discount rate is used for sensitivity analysis;
- Opening year demand is an input to the BCA and is assumed to be fully realized in Year 1 (no ramp-up); and
- Unless specified otherwise, the results shown in this document correspond to the effects of the Full Build alternative, rehabilitation of the Market Street Marine Terminal.

6. Demand Projections

In 2012, the Terminal handled a recent high-volume of 381,800 tons of bulk and break bulk cargo, primarily salt, scrap metal, gypsum and special projects for upstream and other businesses. From 2008 to 2012, tonnage handled at the terminal increased by approximately 10 percent. Due to the deteriorating condition of the wharf, annual volumes have been declining ever since, reaching a historic low of 91,934 in 2015. Despite this decline in recent years, extensive interest in using the terminal remains should the repairs be completed. The deterioration of the terminal is accelerating the loss of business and the wear and tear on the other infrastructure in the area, as the destination of the shipments remains the same and they can no longer use this particular port.

Current operations are sustained by various components of project cargo using the port. These include construction components related to the Sarah Mildred Long Bridge and the maintenance of some historic cargo and other special projects. The terminal no longer serves scrap metal, though the potential for its return does exist.

6.1 Methodology

As part of the benefit-cost analysis, forecasts of tonnage shipped to and from the port were developed. These forecasts were based on historical and existing activity at the port, and expectations of tonnage increases upon completion of the Main Wharf rehabilitation.

Salt

For the no-build scenario, it is assumed that salt tonnage will remain at its 2015 volume until the port closes. Salt is being shipped to the area for use on local roads, and if the port closes, the salt will be diverted elsewhere in the Portsmouth area. Thus, the salt is excluded from

diversions in the no-build scenario. For the build scenario, it is assumed that salt tonnage will increase 0.5 percent per year.

Special Projects and Other Cargo

Numerous special projects are handled at the port. Most frequently, the cargo shipped and received is heavy machinery and equipment. The tonnage associated with these special projects has been increasing recently, and rehabilitation of the Main Wharf is expected to continue to support this growth.

For the no-build scenario, it is assumed that special project tonnage will remain consistent with the 2014 volumes until the port closes due to contractual agreements.

For the build scenario, this "other" cargo will continue to grow 0.5 percent per year until the Main Wharf rehabilitation is complete. At that point, the port will be equipped to handle more special projects, and all indications are that the demand for those shipping and receiving services will increase after the wharf is rehabilitated. Based on recent activity, it is assumed that this category of freight will conservatively increase in tonnage up to 250,000 tons in 2024 after the wharf rehabilitation.

New Container Service

A shipper has approached the port regarding container transport at the Market Street Marine Terminal. Specifically, they have 12,000 containers that they would like to move through Portsmouth once the Main Wharf is rehabilitated. Approximately half of these containers are being shipped through other ports today and half would be completely new containers.

By moving this container traffic to the Port of New Hampshire from these other ports, vehicle miles traveled will be reduced resulting in decreased emissions costs, congestion, and other benefits as well as reduced costs to shippers from increasing distance shipped via sea rather than on trucks. The remaining 6,000 containers are estimated to be new business. The following details how this potential new growth in containers was treated in the benefit-cost analysis of the Main Wharf rehabilitation.

The no-build scenario includes no container traffic, and the primary build scenario does ***not*** include container business at the port.

Because indications are that container service could be re-initiated with the wharf improvement, however, a second scenario for sensitivity analysis was considered. The following assumptions are made for the analysis that incorporates container growth at the port:

- 6,000 containers are currently being handled by the Ports of New York, Baltimore, and Montreal and would be moved to Portsmouth.
    - Forty percent of containers are handled by New York, 40 percent by Baltimore, and the remaining 20 percent are handled in Montreal.
    - Eighty-five percent of these containers arrive to the ports via truck from New England and are exported. The remaining 15 percent are shipped by rail and then exported.

In addition, it is expected that the number of containers shipped through Market Street Marine Terminal will continue to grow once the container operation has been relocated. This is due, in

part, to industry demand but also because the Port of New Hampshire offers some locational and other advantages to this prospective shipper, as compared to other ports. It is expected that 6,000 new containers will be exported once the Main Wharf is improved. Once 12,000 containers are serviced at the port, it is assumed that container traffic would continue to grow for approximately five years to a maximum annual volume of 15,000. As mentioned previously, this container business is not incorporated in the primary build scenario. While the magnitude of the benefit is difficult to quantify, however, it is reasonable to assume (and corroborated by the prospective shipper) that a significant share of the potential growth in container exports is attributable to the Port of New Hampshire specifically, and not just overall industry demand. As a result, the second analysis incorporating containers was conducted for comparison purposes.

6.2 Assumptions

The following table presents the assumptions utilized in the base (no container service) and alternative (container service) benefit-cost analyses. Demand values can be found in the Supplementary Data.

Table 2: Assumptions Used in the Estimation of Demand

Variable Name	Unit	Value	Source
Annual growth for all cargo in no-build scenario until port closes	Percent	0%	Recent port activity data provided by PDA
Annual growth in Special Projects after improvement	Percent	0.5%	Recent port activity data provided by PDA
Annual growth in project cargo and salt after improvement	Percent	0.5%	Recent port activity data provided by PDA
Tonnage reduction in 2017 when port closes	Percent	100%	Port Director
Truck trips per container	Number	0.9	HDR Assumption based on share of containers that will be on single vs. combination trucks

7. Benefits Measurement, Data and Assumptions

This section describes the measurement approach used for each benefit or impact category estimated to achieve the FASTLANE program's merit criteria. It also provides an overview of the associated methodology, assumptions, and estimates.

Merit Criteria

ECONOMIC OUTCOMES

The proposed project would contribute to enhancing the economic competitiveness of the Nation through improvements in the mobility of people and goods within and across the study area. In this analysis, economic competitiveness is represented by a cost savings to shippers.

Between the project's maintenance of existing port activity and its ability to facilitate growth in waterborne cargo, the region's freight shippers and receivers will directly benefit through lower shipping costs when compared to using other modes. Shipper cost savings associated with the project, due to direct port shipments compared to longer-distance truck hauls, are estimated for this analysis.

Methodology

To quantify the anticipated economic outcomes of the rehabilitation of the Main Wharf, shipper cost savings were estimated.

Rehabilitation of the wharf means that the port will not close, and existing customers will be able to continue utilizing the facility for shipping and receiving. If the port closes, these customers would use other ports located farther away, which would result in increased costs to ship cargo due to the increased miles associated with its transport. Based on discussions with the Port director, the likely alternative ports for current users are the Port of Boston, Massachusetts, the Port of New Haven, Connecticut, the Port of Providence, Rhode Island, and the Ports of Portland or Searsport, Maine. Since the final destination of the freight is not the Port where it enters, it is assumed that there is an average "last-mile" distance of 10 miles for all movements. This has been netted out of the increased distance for diversion as it will still need to be traveled to reach the final destination if the freight is diverted away from the Market Street Marine Terminal.

The second component of shipper cost savings relates to relative costs. The costs to shippers of transporting goods on the highway are relatively higher than the costs for shipping goods on marine vessels. This is partially due to the size of ships and their ability to handle more cargo per movement than individual trucks.

Assumptions

The assumptions used in the estimation of travel time savings are summarized in the table below.

Table 3: Assumptions Used in the Estimation of Shipper Cost Savings

Variable Name	Mode	Unit	Value	Source
Per Ton-Mile Savings	Using Barge instead of Truck	$ per ton-mile	$0.06	Modal Experts
Tonnage Per Vehicle	Truck	Tons	25	Average based on truck movements at Port
Distance to Other Ports	New Haven	Miles	188	Google Maps
	Portland	Miles	50	Google Maps
	Boston	Miles	64	Google Maps
	Providence	Miles	109	Google Maps
	Searsport	Miles	160	Google Maps
	New York	Miles	281	Google Maps
	Baltimore	Miles	401	Google Maps
	Montreal	Miles	300	Google Maps
Local Miles Transportation Factor	Truck	Miles	10	HDR Assumption
Local Miles for Container Shipments	Truck	Miles	45	HDR Assumption
Share of Diversion by Port	New Haven	Percent	28	HDR Assumptions based on Port Size and Army Corps of Engineers information regarding port freight
	Portland	Percent	5	HDR Assumptions based on Port Size and Army Corps of Engineers information regarding port freight. This excludes scrap metal.
	Boston	Percent	10	HDR Assumptions based on Port Size and Army Corps of Engineers information regarding port freight
	Providence	Percent	28	HDR Assumptions based on Port Size and Army Corps of Engineers information regarding port freight
	Searsport	Percent	28	HDR Assumptions based on Port Size and Army Corps of Engineers information regarding port freight

Benefit Estimates

With the Main Wharf rehabilitation, non-discounted shipper cost savings would total $34.5 million. This represents 52 percent of total benefits.

Table 4: Estimates Shipper Cost Savings, Millions of 2015 Dollars

	In First Full Year of Operation (2020)	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Shipper Cost Savings – Removal of Trucks	$1.8	$34.5	$18.7
Total Economic Benefit	**$1.8**	**$34.5**	**$18.7**

MOBILITY OUTCOMES

By rehabilitating the Market Street Marine Terminal Main Wharf, the wharf will remain operational beyond 2017. The associated cargo laydown space will allow the port to meet future demand and capture users who have already shown an interest in the facility.

If the wharf is not rehabilitated, all cargo that currently comes in via the wharf will move to other ports after closure by the end of 2017. Rehabilitating the wharf will keep cargo from being shipped to other ports and ultimately traveling longer routes by truck. Two components of benefits contribute to state of good repair – pavement maintenance and residual value.

In addition, the removal of vehicles from the road results in an external benefit by reducing congestion on the highways for remaining roadway users. This improves user mobility as they are able to reach their destinations in a timely manner.

Methodology

In the no-build scenario, the wharf will close by the end of 2017.

Closure of the port will result in trucks taking longer, circuitous routes that will increase vehicle miles traveled and wear and tear on the pavement. To estimate pavement maintenance cost savings associated with the wharf rehabilitation, the pavement maintenance cost is applied to the increase in truck VMT that is attributed to the truck diversions.

The second component of mobility benefits is residual value. For the purpose of this analysis, benefits were estimated for a period of 30 years after the completion of construction on the port. However, the useful life of the project is actually 50 years. In order to capture the un-used value of the investment, a residual value has been calculated.

To generate congestion impacts, the average trip length for the diverted trucks in the build scenario was multiplied by the quantity of trucks removed from the road.

Assumptions

The assumptions used in the estimation of pavement maintenance, residual value, and user mobility benefits are summarized in the table below.

Table 5: Assumptions Used in the Estimation of Mobility Benefits

Variable Name	Unit	Value	Source
Pavement Maintenance	Per Vehicle Mile	$0.095	Federal Highway Cost Allocation Study 1997 (inflated to 2015)
Capital Costs with longer useful life	$	$8,027,500	Based on components of construction cost estimate that have a useful life longer than 30 years
Useful Life	Years	50	Industry knowledge of construction components
Congestion Cost	Per Vehicle Mile	$0.139	Marginal External Cost, Addendum to the 1997 Federal Highway Cost Allocation Study Final Report, May 2000 inflated to 2015 Dollars; value for combination trucks

Benefit Estimates

The pavement maintenance savings associated with the reduction in truck diversion due to the rehabilitation of the wharf leads to a non-discounted pavement maintenance savings of $3.8 million over the 30 year study period. This accounts for more than five percent of total benefits.

The residual value, discounted at $0.3 million, accounts for more than four percent of total benefits.

Congestion reduction accounts for $5.5 million in non-discounted benefits, eight percent of total benefits.

Table 6: Estimates of Mobility Benefits, Millions of 2015 Dollars

	In First Full Year of Operation (2020)	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Pavement Maintenance Savings	$0.1	$3.8	$1.2
Residual Value	$--	$3.2	$0.3
Congestion Cost Reduction – Removal of Trucks	$0.2	$5.5	$1.7
Total Mobility Benefits	**$0.3**	**$12.5**	**$3.2**

SAFETY OUTCOMES

If the port were to close, customers who currently use the facility would be forced to use alternative ports and truck some, if not all, of their cargo. With the wharf rehabilitation, some of these trucks would be removed from the highways, reducing the number of accidents associated with additional VMT.

Methodology

The reduction of accident costs, like other variable costs, is dependent on the reduction of vehicle-miles. With the improved wharf, some vehicles will be removed from the roadways as shippers opt to use marine transportation instead of trucks to transport their freight. The reduction in vehicles on the road is combined with a multiplier, which is a weighted average of fatal, injury, and property damage only (PDO) accidents. This calculation provides an estimate of the accident reduction benefits associated with the Main Wharf rehabilitation.

Assumptions

The assumptions used in the estimation of safety benefits are summarized in the table below.

Table 7: Assumptions Used in the Estimation of Safety Benefits

Variable Name	Unit	Value	Source
Fatal Accidents	Per 100 million VMT	1.291	BTS Table 2-17: Motor Vehicle Safety Data (updated July 2014); Rates are for 10-year average from 2003-2012
Injury Accidents	Per 100 million VMT	83.582	BTS Table 2-17: Motor Vehicle Safety Data (updated July 2014); Rates are for 10-year average from 2003-2012
Property Damage Only Accidents	Per 100 million VMT	196.446	BTS Table 2-17: Motor Vehicle Safety Data (updated July 2014); Rates are for 10-year average from 2003-2012
Cost of Fatality	$	$9,600,000	US DOT, Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses (2015)
Cost of Injury	$	$174,030	US DOT, Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses (2015)
Property Damage Costs	$	$4,198	US DOT, Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses (2015)
Annual Increase in Accident Related Costs	%	1.0%	US DOT, Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses (2015)

Benefit Estimates

With the Main Wharf rehabilitation, discounted accident reduction benefits of $4.2 million are expected. This represents 20 percent of total project benefits.

Table 8: Estimates of Safety Benefits, Millions of 2015 Dollars

	In First Full Year of Operation (2020)	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Accident Reduction Benefits	$0.4	$13.7	$4.1
Total Safety Benefits	**$0.4**	**$13.7**	**$4.1**

COMMUNITY AND ENVIRONMENTAL OUTCOMES

The primary benefit associated with community and environmental outcomes is emissions reduction. Emissions reductions are generated by reduced VMT. Emissions are further reduced because transporting cargo by marine vessel results in lower emissions than transporting that same cargo by truck. When the wharf work is completed, reduced VMT will lead to emission savings. Emissions measured include VOC (HC), CO, CO2, NOX, SO2, and PM, varying by auto and truck.

Methodology

Using the MOVES model for emissions in the northeast and assuming an average speed of 45 miles per hour, emissions rates for VOC(HC), NOX, SO2, PM2.5, CO, and CO2 were measured. These rates were then converted from grams per mile to calculate the reduction in tonnage of emissions due to the diversion from trucks and rail to marine transportation. Each pollutant was then converted to metric tons. The cost of carbon dioxide emissions increases annually and values for these emissions are to be discounted at a value of 3 percent rather than

the 7 percent recommendation for all other values. Emissions rates for 2020 were used to estimate benefits.

Assumptions

The assumptions used in the estimation of environmental benefits are summarized in the table below.

Table 9: Assumptions Used in the Estimation Emissions Reduction Benefits

Mode	Variable Name	Unit	Value	Source
Truck	NOX	Grams Per Mile	4.14	MOVES, Long Haul Combination Truck 45 miles per hour, 2020*
	CO	Grams Per Mile	0.99	MOVES, Long Haul Combination Truck 45 miles per hour, 2020*
	PM	Grams Per Mile	0.12	MOVES, Long Haul Combination Truck 45 miles per hour, 2020*
	VOC	Grams Per Mile	0.15	MOVES, Long Haul Combination Truck 45 miles per hour, 2020*
	CO2	Grams Per Mile	1998.83	MOVES, Long Haul Combination Truck 45 miles per hour, 2020*
	SO2	Grams Per Mile	0.01	MOVES, Long Haul Combination Truck 45 miles per hour, 2020*
Valuation	NOX	$ Per Metric Ton	$8,010	Final Regulatory Impact Analysis Corporate average Fuel Economy for MY 2017-MY2025 Passenger Cars and Light Trucks
	CO	$ Per Metric Ton	-	Victoria Transport Policy Institute, Air Pollution Costs Spreadsheet
	PM	$ Per Metric Ton	$366,414	Final Regulatory Impact Analysis Corporate average Fuel Economy for MY 2017-MY2025 Passenger Cars and Light Trucks
	VOC	$ Per Metric Ton	$2,032	Final Regulatory Impact Analysis Corporate average Fuel Economy for MY 2017-MY2025 Passenger Cars and Light Trucks
	CO2	$ Per Metric Ton	$47.00	Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (May 2015); Value for 2020*
	SO2	$ Per Metric Ton	$47,341	Final Regulatory Impact Analysis Corporate average Fuel Economy for MY 2017-MY2025 Passenger Cars and Light Trucks

*Varies over time.

Benefit Estimates

While emissions savings account for only 9 percent of total benefits, or $5.8 million, the reduction in greenhouse gases are an important environmental benefit that should not be understated. The table below shows the total reduction in tons of emissions by type. The table beneath it summarizes the monetized benefits for emissions reductions.

Table 10: Estimates of Emissions Reduction over Project Life, in Metric Tons

Emission Type	Tonnage
NOX	70.98
CO	16.53
PM	1.11
VOC	2.61
CO2	77,288.90
SO2	0.64

Table 11: Estimates of Emissions Reduction Benefits, Millions of 2015 Dollars

	In First Full Year of Operation (2020)	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Emissions Reduction Benefit	$0.2	$5.8	$3.1
Total Community & Environmental Benefit	**$0.2**	**$5.8**	**$3.1**

Note that carbon emissions are discounted at 3% per US DOT guidance on valuing the social cost of carbon.

Cost-Effectiveness

For the analysis, quantifiable benefits for the four merit criteria were measured; economic, mobility, safety, and community and environmental. These monetized benefits include shipper cost savings, pavement maintenance, congestion reduction, accident reduction benefits, and emission reductions. Though the above mentioned benefits are important when considering the viability of this project, other non-monetized benefits should also be included in determining the cost-effectiveness of the project. These qualitative benefits include harbor safety and security, and efficient harbor operations.

This benefit cost analysis compares the monetized benefits listed above to the overall project cost. It was found that an investment of $20.9 million results in $29.2 million in total benefit (discounted at 7%) and yield a Benefit/Cost ratio of approximately 1.4.

8. Summary of Findings and BCA Outcomes

The tables below summarize the BCA findings. Annual costs and benefits are computed over the lifecycle of the project (30 years). As stated earlier, construction is expected to be completed by the end of 2019. Benefits accrue during the full operation of the project.

Table 12: Overall Results of the Benefit Cost Analysis, Millions of 2015 Dollars*

Project Evaluation Metric	7% Discount Rate	3% Discount Rate
Total Discounted Benefits	$29.2	$52.2
Total Discounted Costs	$20.9	$31.3
Net Present Value	$8.3	$20.9
Benefit / Cost Ratio	1.4	1.7
Internal Rate of Return (%)	12.3%	
Payback Period (years)	11	

** Unless Specified Otherwise*

Considering all monetized benefits and costs, the estimated internal rate of return of the project is 13.2 percent. With a 7 percent real discount rate, the $20.9 million investment would result in $29.2 million in total benefits and a Benefit/Cost ratio of approximately 1.4.

With a 3 percent real discount rate, the Net Present Value of the project would increase to $52.2 million, for a Benefit/Cost ratio of 1.7.

Table 13: Benefit Estimates by Merit Criteria for the Full Build Alternative (Millions of 2015 Dollars)

Merit Criteria	Benefit Categories	7% Discount Rate	3% Discount Rate
Economic Outcomes	Shipper Cost Savings	$18.7	$34.5
Mobility Outcomes	Pavement Maintenance	$1.2	$2.2
	Residual Value	$0.3	$1.2
	Congestion Reduction	$1.7	$3.2
Safety Outcomes	Accident Reduction Benefits	$4.1	$7.8
	Harbor Safety and Security	Qualitative	Qualitative
Community and Environmental Outcomes	Emissions Reduction	$3.1	$3.3
	Efficient and Safe Harbor Operations for commercial and non-commercial users	Qualitative	Qualitative
Total Benefit Estimates		**$29.2**	**$52.2**

As discussed previously, if the Port is repaired, there has been extensive interest from a container shipper to move a portion of his operations to the Market Street Marine Terminal. This movement is expected to bring an additional 12,000 containers by 2024 and up to 15,000 containers by 2028. Of these containers, approximately half would be diverted from other Ports, and 20 percent of these (approximately 1,200 in 2025) would come from Montreal. The other half of the containers would be new business that would result from the level of service provided by the Port and the ability of the shipper to expand his business due to increased efficiencies. Following the same methodology as the base analysis, when these new containers are accounted for, the Net Present Value of the project at a 7 percent discount rate increases to $30.5 million, resulting in a BCR of 2.5 and an internal rate of return of approximately 21.6 percent. The presence of these containers would reduce congestion on the roads due to the diversion, as well as generate new business and exports for the region and the United States.

9. BCA Sensitivity Analysis

The BCA outcomes presented in the previous sections rely on a large number of assumptions and long-term projections; both of which are subject to considerable uncertainty.

The primary purpose of the sensitivity analysis is to help identify the variables and model parameters whose variations have the greatest impact on the BCA outcomes: the "critical variables."

The sensitivity analysis can also be used to:

- Evaluate the impact of changes in individual critical variables – how much the final results would vary with reasonable departures from the "preferred" or most likely value for the variable; and
- Assess the robustness of the BCA and evaluate, in particular, whether the conclusions reached under the "preferred" set of input values are significantly altered by reasonable departures from those values.

The outcomes of the quantitative analysis for the Market Street Marine Terminal Rehabilitation, using a 7 percent discount rate are summarized in the table below. The table provides the percentage changes in project NPV associated with variations in variables or parameters (listed in row), as indicated in the column headers.

For example, a 25 percent reduction in capital cost estimate represents a 62 percent increase in NPV and a BCR of 1.6. The following table presents the results of the sensitivity analyses that were conducted for this benefit-cost analysis.

Table 14: Quantitative Assessment of Sensitivity, Summary

Parameters	Change in Parameter Value	New NPV	Change in NPV	% Change in NPV	New B/C Ratio
Change in Terminal Demand	Lower than anticipated (0.25% Annual Growth)	$8.2	-$0.4	-1%	1.4
	Higher than anticipated (3% Annual Growth)	$8.7	$0.5	11%	1.4
Capital Cost Estimate	25% Reduction	$10.8	$2.5	62%	1.6
Annual O&M Cost Estimate	25% Reduction	$11.0	$2.7	66%	1.6

10. Supplementary Data Tables

This section breaks down all benefits associated with the four merit criteria (Economic Outcomes, Mobility Outcomes, Safety Outcomes, and Community and Environmental Outcomes) in annual form for the Market Street Marine Terminal Main Wharf Rehabilitation. Supplementary data tables are also provided for some specific benefit categories. For example, tables providing estimates of annual emission reductions (in tons) are provided under Environmental Sustainability.

Table 15: Annual Estimates of Total Project Benefits and Costs

Calendar Year	Total Benefits ($2015)	Total Costs ($2015)	Undiscounted Net Benefits ($2015)	Discounted Net Benefits at 7%	Discounted Net Benefits at 3%
2016	$0	$0	$0	$0	$0
2017	$0	$3,515,617	($3,515,617)	($3,070,676)	($3,313,806)
2018	$0	$4,687,490	($4,687,490)	($3,826,388)	($4,289,717)
2019	$216,881	$4,296,866	($4,079,985)	($3,111,470)	($3,625,013)
2020	$2,670,009	$1,100,000	$1,570,009	$1,136,402	$1,354,303
2021	$2,736,765	$1,100,000	$1,636,765	$1,110,673	$1,370,765
2022	$2,816,382	$1,100,000	$1,716,382	$1,092,784	$1,395,575
2023	$2,895,773	$1,100,000	$1,795,773	$1,072,523	$1,417,600
2024	$2,909,052	$1,100,000	$1,809,052	$1,014,124	$1,386,488
2025	$2,909,783	$1,100,000	$1,809,783	$952,549	$1,346,649
2026	$2,910,557	$1,100,000	$1,810,557	$894,991	$1,307,985
2027	$2,911,375	$1,100,000	$1,811,375	$841,183	$1,270,462
2028	$2,915,111	$1,100,000	$1,815,111	$792,067	$1,236,002
2029	$2,916,235	$1,600,000	$1,316,235	$550,394	$870,187
2030	$2,922,719	$1,100,000	$1,822,719	$702,958	$1,169,934
2031	$2,928,430	$1,100,000	$1,828,430	$663,197	$1,139,417
2032	$2,934,188	$1,100,000	$1,834,188	$625,894	$1,109,714
2033	$2,939,994	$1,100,000	$1,839,994	$590,892	$1,080,803
2034	$2,946,799	$1,100,000	$1,846,799	$558,307	$1,053,204
2035	$2,953,654	$1,100,000	$1,853,654	$527,705	$1,026,323
2036	$2,960,557	$1,100,000	$1,860,557	$498,959	$1,000,141
2037	$2,968,000	$1,100,000	$1,868,000	$472,063	$974,895
2038	$2,978,154	$1,100,000	$1,878,154	$448,131	$951,645
2039	$2,985,698	$1,600,000	$1,385,698	$325,751	$681,672
2040	$2,993,577	$1,100,000	$1,893,577	$401,991	$904,383
2041	$3,001,508	$1,100,000	$1,901,508	$380,981	$881,719
2042	$3,006,829	$1,100,000	$1,906,829	$360,015	$858,434
2043	$3,014,881	$1,100,000	$1,914,881	$341,449	$836,950
2044	$3,022,986	$1,100,000	$1,922,986	$323,974	$816,012
2045	$3,031,146	$1,100,000	$1,931,146	$307,522	$795,606
2046	$3,039,362	$1,100,000	$1,939,362	$292,029	$775,720
2047	$3,026,619	$1,100,000	$1,926,619	$263,318	$748,177
2048	$3,034,336	$1,100,000	$1,934,336	$249,659	$729,296
2049	$5,999,601	$1,600,000	$4,399,601	$479,577	$1,610,451
Total	$91,496,962	$46,999,973	$44,496,989	$8,263,528	$20,871,975

Table 16: Annual Benefits by Category

Calendar Year	Shipper Cost Savings	Productivity Benefit	Accident Reduction	Emissions Reduction	Pavement Maintenance Savings	Congestion Reduction	Residual Value	Total Benefits
2019	$146,919	$0	$29,096	$17,901	$9,302	$13,663	$0	$216,881
2020	$1,814,968	$0	$362,930	$208,406	$114,914	$168,790	$0	$2,670,009
2021	$1,868,482	$0	$377,264	$198,949	$118,302	$173,767	$0	$2,736,765
2022	$1,923,615	$0	$392,174	$199,905	$121,793	$178,894	$0	$2,816,382
2023	$1,980,414	$0	$407,683	$198,110	$125,389	$184,177	$0	$2,895,773
2024	$1,992,062	$0	$414,072	$191,531	$126,127	$185,260	$0	$2,909,052
2025	$1,992,396	$0	$418,173	$187,775	$126,148	$185,291	$0	$2,909,783
2026	$1,992,732	$0	$422,317	$184,017	$126,169	$185,322	$0	$2,910,557
2027	$1,993,070	$0	$426,503	$180,258	$126,191	$185,354	$0	$2,911,375
2028	$1,993,410	$0	$430,731	$179,372	$126,212	$185,385	$0	$2,915,111
2029	$1,993,751	$0	$435,004	$175,830	$126,234	$185,417	$0	$2,916,235
2030	$1,994,094	$0	$439,320	$177,601	$126,255	$185,449	$0	$2,922,719
2031	$1,994,439	$0	$443,680	$178,553	$126,277	$185,481	$0	$2,928,430
2032	$1,994,785	$0	$448,085	$179,506	$126,299	$185,513	$0	$2,934,188
2033	$1,995,133	$0	$452,535	$180,459	$126,321	$185,546	$0	$2,939,994
2034	$1,995,483	$0	$457,031	$182,364	$126,343	$185,578	$0	$2,946,799
2035	$1,995,835	$0	$461,573	$184,270	$126,366	$185,611	$0	$2,953,654
2036	$1,996,188	$0	$466,161	$186,176	$126,388	$185,644	$0	$2,960,557
2037	$1,996,544	$0	$470,797	$188,572	$126,410	$185,677	$0	$2,968,000
2038	$1,996,901	$0	$475,480	$193,630	$126,433	$185,710	$0	$2,978,154
2039	$1,997,260	$0	$480,211	$196,028	$126,456	$185,743	$0	$2,985,698
2040	$1,997,620	$0	$484,991	$198,710	$126,479	$185,777	$0	$2,993,577
2041	$1,997,983	$0	$489,820	$201,393	$126,502	$185,811	$0	$3,001,508
2042	$1,998,347	$0	$494,699	$201,414	$126,525	$185,845	$0	$3,006,829
2043	$1,998,713	$0	$499,627	$204,114	$126,548	$185,879	$0	$3,014,881
2044	$1,999,081	$0	$504,607	$206,814	$126,571	$185,913	$0	$3,022,986
2045	$1,999,451	$0	$509,637	$209,516	$126,595	$185,947	$0	$3,031,146
2046	$1,999,823	$0	$514,719	$212,220	$126,618	$185,982	$0	$3,039,362
2047	$2,000,196	$0	$519,853	$193,911	$126,642	$186,016	$0	$3,026,619
2048	$2,000,572	$0	$525,041	$196,007	$126,665	$186,051	$0	$3,034,336
2049	$1,834,203	$0	$486,091	$181,595	$116,132	$170,579	$3,211,000	$5,999,601
Total	**$59,474,471**	**$0**	**$13,739,902**	**$5,774,910**	**$3,765,605**	**$5,531,074**	**$3,211,000**	**$91,496,962**

Table 17: Annual Demand Projections (Tons)

Calendar Year	Existing Operations Continuation Projection (for Diversions)			Build Projections			Alternative	
	Bulk Cargo	Salt	Remaining Tonnage	Bulk Cargo	Salt	Remaining Tonnage	Diverted Containers	New Containers
2015	0	83,665	8,269	0	83,665	8,269	0	0
2016	0	83,665	8,269	0	83,665	8,269	0	0
2017	0	84,087	8,311	0	84,087	8,311	0	0
2018	0	84,511	8,353	0	84,511	8,353	0	0
2019	0	84,937	8,395	220,480	84,937	8,395	0	0
2020	0	85,366	8,437	227,181	85,366	8,437	250	250
2021	0	85,796	8,480	234,086	85,796	8,480	750	750
2022	0	86,229	8,522	241,200	86,229	8,522	1,500	1,500
2023	0	86,664	8,565	248,531	86,664	8,565	3,000	3,000
2024	0	87,101	8,609	250,000	87,101	8,609	6,000	6,000
2025	0	87,540	8,652	250,000	87,540	8,652	6,375	6,375
2026	0	87,982	8,696	250,000	87,982	8,696	6,750	6,750
2027	0	88,425	8,739	250,000	88,425	8,739	7,125	7,125
2028	0	88,871	8,784	250,000	88,871	8,784	7,500	7,500
2029	0	89,320	8,828	250,000	89,320	8,828	7,500	7,500
2030	0	89,770	8,872	250,000	89,770	8,872	7,500	7,500
2031	0	90,223	8,917	250,000	90,223	8,917	7,500	7,500
2032	0	90,678	8,962	250,000	90,678	8,962	7,500	7,500
2033	0	91,135	9,007	250,000	91,135	9,007	7,500	7,500
2034	0	91,595	9,053	250,000	91,595	9,053	7,500	7,500
2035	0	92,057	9,098	250,000	92,057	9,098	7,500	7,500
2036	0	92,521	9,144	250,000	92,521	9,144	7,500	7,500
2037	0	92,988	9,190	250,000	92,988	9,190	7,500	7,500
2038	0	93,457	9,237	250,000	93,457	9,237	7,500	7,500
2039	0	93,928	9,283	250,000	93,928	9,283	7,500	7,500
2040	0	94,402	9,330	250,000	94,402	9,330	7,500	7,500
2041	0	94,878	9,377	250,000	94,878	9,377	7,500	7,500
2042	0	95,356	9,425	250,000	95,356	9,425	7,500	7,500
2043	0	95,837	9,472	250,000	95,837	9,472	7,500	7,500
2044	0	96,321	9,520	250,000	96,321	9,520	7,500	7,500
2045	0	96,806	9,568	250,000	96,806	9,568	7,500	7,500
2046	0	97,295	9,616	250,000	97,295	9,616	7,500	7,500
2047	0	97,295	9,665	250,000	97,785	9,665	7,500	7,500
2048	0	97,785	9,713	250,000	98,278	9,713	7,500	7,500
2049	0	98,774	9,762	250,000	98,774	9,762	7,500	7,500
Total	**-**	**3,177,257**	**314,120**	**7,671,479**	**3,178,240**	**314,120**	**196,750**	**196,750**

Table 18: Environmental Benefits – Annual Emissions Reduction Estimates (Metric Tons)

Year	Nitrogen Oxide	Carbon Monoxide	Particulate Matter	Volatile Organic Compounds	Carbon Dioxide	Sulfur Dioxide	Total Tonnage Reduction
2020	5.01	1.20	0.15	0.18	2418.54	0.02	**2425.10**
2021	4.50	1.08	0.12	0.16	2489.85	0.02	**2495.73**
2022	4.22	1.00	0.11	0.14	2563.32	0.02	**2568.81**
2023	3.92	0.93	0.09	0.13	2639.01	0.02	**2644.09**
2024	3.51	0.83	0.07	0.11	2654.53	0.02	**2659.07**
2025	3.25	0.76	0.06	0.10	2654.97	0.02	**2659.16**
2026	2.98	0.70	0.05	0.09	2655.42	0.02	**2659.25**
2027	2.72	0.63	0.04	0.08	2655.87	0.02	**2659.35**
2028	2.57	0.59	0.03	0.07	2656.32	0.02	**2659.60**
2029	2.42	0.55	0.03	0.06	2656.78	0.02	**2659.86**
2030	2.27	0.52	0.02	0.06	2657.24	0.02	**2660.12**
2031	2.20	0.50	0.02	0.05	2657.69	0.02	**2660.47**
2032	2.13	0.48	0.01	0.05	2658.15	0.02	**2660.83**
2033	2.05	0.46	0.01	0.05	2658.61	0.02	**2661.20**
2034	2.03	0.45	0.01	0.05	2659.08	0.02	**2661.63**
2035	2.00	0.45	0.01	0.04	2659.55	0.02	**2662.07**
2036	1.97	0.44	0.01	0.04	2660.03	0.02	**2662.51**
2037	1.96	0.44	0.00	0.04	2660.50	0.02	**2662.96**
2038	1.95	0.44	0.00	0.04	2660.97	0.02	**2663.42**
2039	1.94	0.43	0.00	0.04	2661.44	0.02	**2663.88**
2040	1.94	0.43	0.00	0.04	2661.92	0.02	**2664.36**
2041	1.94	0.43	0.00	0.04	2662.41	0.02	**2664.84**
2042	1.93	0.43	0.00	0.04	2662.89	0.02	**2665.32**
2043	1.93	0.43	0.00	0.04	2663.38	0.02	**2665.81**
2044	1.93	0.43	0.00	0.04	2663.88	0.02	**2666.31**
2045	1.93	0.43	0.00	0.04	2664.38	0.02	**2666.81**
2046	1.94	0.43	0.00	0.04	2664.87	0.02	**2667.30**
2047	0.63	0.21	0.09	0.25	2059.27	0.06	**2060.51**
2048	0.63	0.21	0.09	0.25	2059.66	0.06	**2060.90**
2049	0.58	0.20	0.08	0.23	1888.37	0.05	**1889.51**
Total	**70.98**	**16.53**	**1.11**	**2.61**	**77,288.90**	**0.64**	