PEASE DEVELOPMENT AUTHORITY

MARKET STREET MARINE TERMINAL MAIN WHARF EXPANSION

TIGER DISCRETIONARY GRANTS PROGRAM

BENEFIT-COST ANALYSIS TECHNICAL APPENDIX

OCTOBER 31, 2011

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1. Introduction

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

Section 2, Methodological Framework, introduces the conceptual framework used in the Benefit-Cost Analysis (BCA). Section 3, 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 rehabilitation and expansion of the main wharf at the Market Street Marine Terminal is expected to generate. Section 4, 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 5, Demand Projections. Specific data elements and assumptions pertaining to the long-term outcome selection criteria are presented in Section 6, 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 7, Summary of Findings and BCA Outcomes. Next, Section 8, BCA Sensitivity Analysis, provides the outcomes of the sensitivity analysis. Additional data tables are provided in Section 9, Supplementary Data Tables, including annual estimates of benefits and costs, as well as intermediate values to assist DOT in its review of the application.[1]

2. 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 TIGER 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 five long-term outcomes identified in the Notice of Funding Availability (NOFA)[2];
- 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.

3. Project Overview

The Pease Development Authority, Division of Ports and Harbors, is requesting TIGER grant funds for use toward the rehabilitation of the main wharf, as well as its expansion. 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 expand the wharf by 125 linear feet, and it will include a 24 square foot offshore mooring dolphin. The 29,000 square foot expansion will replace the deteriorating wharf access bridges by decking the area between the existing shoreline sheeting and the back of the current main wharf, as shown in the photograph of wharf design below. This will provide easy and direct access for the entire length of the main wharf, greatly enhancing its safety, functionality and operational efficiency.

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 and expansion as described in the Project Overview. The no-build scenario reflects no improvements in the main wharf and complete closure of the Market Street Marine Terminal by 2015.

Project Cost and Schedule[3]

For the build scenario, it is estimated that the project will require $15.75 million in capital expenditures. Maintenance after the improvement is estimated to cost $500,000 every ten

[2] U.S. Federal Register, Federal Register / Vol. 76, No. 156 / Friday, August 12, 2011 / Notices, Notice of Funding Availability for the Department of Transportation's National Infrastructure Investments under the Full-Year Continuing Appropriations, 2011; and Request for Comments.

[3] All cost estimates in this section are in millions of dollars of 2011.

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 2015, but prior to the port's closure, operating and maintenance costs would be incurred. The no-build scenario assumes $10,000 in maintenance expenditures in 2012 and an additional $5,000 per year in 2013 and 2014. After closure, no operating or maintenance expenditures are anticipated.

Effects on Long-Term Outcomes

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 and expansion of the Market Street Marine Terminal will ensure that the main wharf is in a state of good repair, which will support economic competitiveness, environmental sustainability, safety, and livability – important goals of the TIGER program. The table below presents the main benefit categories associated with the project as they relate to the five long-term outcome criteria set forth by the United States Department of Transportation.

Table 1: Expected Effects on Long Term Outcomes and Benefit Categories

Long-Term Outcomes	Benefit Categories	Description	Monetized	Qualitative
State of Good Repair	Pavement Maintenance	Port provides non-roadway option for transporting cargo, which reduces VMT and associated roadway maintenance expenses	X	
Economic Competitiveness	Shipper Cost Savings	Savings due to direct port shipments compared to longer-distance truck and rail	X	
	Productivity Benefit	Existing customers receive benefit for using port rather than reworking logistics and site location away from preferred site	X	
Livability	Congestion Reduction	Port provides non-roadway option for transporting cargo, which reduces congestion on highways	X	
	Efficient Harbor Operations	Port provides efficient and safe operations for commercial and non-commercial port users		X

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Long-Term Outcomes	Benefit Categories	Description	Monetized	Qualitative
Environmental Sustainability	Emissions Reduction	Reduction in VMT due to use of port rather than highways to transport goods	X	
Safety	Accident Reduction Benefits	Reduction in VMT due to use of port rather than highways to transport goods	X	
	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.		X

4. General Assumptions

The BCA measures benefits and costs for a period of analysis beginning at the start of construction through 30 years of operations.

The monetized benefits and costs are estimated in 2011 dollars with future dollars discounted in compliance with TIGER requirements using a 7 percent real discount 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 inflated to 2011 dollars;
- The period of analysis begins in 2012 and ends in 2043. It includes project development and construction years (2012-2013) and 30 years of operations (2014-2043)[4];
- 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.

[4] Shipping and receiving activity at the port will continue while the main wharf is being rehabilitated and expanded.

5. Demand Projections

In 2010, the Terminal handled 271,141 tons of bulk and break bulk cargo, primarily salt, scrap metal, and special projects for upstream and other businesses. Over the past four years, tonnage handled at the Terminal has increased by 10 percent.

5.1 Methodology and Assumptions

As part of the benefit-cost analysis, forecasts of tonnage shipped to and from the port were developed. These were based on historical and existing activity at the port, and expectations of tonnage increases if the main wharf is improved.

Scrap Metal Tonnage

For the no-build scenario, it is assumed that all scrap shipped by existing customers will increase in growth by 1.4 percent per year as the port heads toward closure. Because the port is expected to close, however, existing customers will begin to move their operations to other ports. The following details the transition due to anticipated port closure:

- 50 percent tonnage reduction in scrap metal by the second quarter of 2012.
- 100 percent tonnage reduction in scrap metal by the third quarter of 2012.

For the build scenario, the same rate of growth is assumed (1.4 percent) until the main wharf is rehabilitated and expanded. After the improvement, nearly twenty percent of tonnage will increase an average of approximately ten percent per year for the next ten years. This tonnage represents the share of scrap metal that will be shredded. Currently, a scrap metal customer is shredding 50 percent of the scrap that passes through the Port. The projected growth is due to planned expansion by this user.

Salt

For the no-build scenario, it is assumed that salt tonnage will increase by 1.4 percent per year until the port closes. Between today and full closure, it is assumed that salt operations at the Market Street Marine Terminal will phase-out in the following manner:

- 50 percent tonnage reduction by the second quarter of 2012.
- 75 percent tonnage reduction by the third quarter of 2012.
- 100 tonnage reduction in 2015 when the port closes.

The 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 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 1.4 percent per year.

Special Projects

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 improvements in the main wharf are expected to continue to support this growth.

For the no-build scenario, it is assumed that special project tonnage will increase 1.4 percent per year until the port closes. Between today and full closure, it is assumed that this tonnage at the Market Street Marine Terminal will be moved to other ports:

- 50 percent tonnage reduction by the second quarter of 2012.
- 75 percent tonnage reduction by the third quarter of 2012.
- 100 tonnage reduction in 2015 when the port closes.

For the build scenario, this "other" cargo will continue to grow 1.4 percent per year until the main wharf improvements are 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 and expanded. Based on recent activity, it is assumed that this category of freight will increase in tonnage by three percent per year after the wharf is improved.

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	1.4	Historic port activity data provided by PDA
Annual growth in Special Projects after improvement	Percent	3	Recent port activity data provided by PDA
Annual growth in non-shredded scrap metal and salt after improvement	Percent	1.4	Historic port data provided by PDA
Annual growth in shredded scrap metal after improvement	Percent	11% per year up to 5 times current volume	Port Director
Share of scrap metal that is shredded	Percent	50	Existing activity
Tonnage reduction by 2d quarter 2012 for all cargo	Percent	50	Port Director
Tonnage reduction by 3d quarter 2012 for non-scrap cargo	Percent	75	Port Director
Tonnage reduction by 3d quarter 2012 for scrap metal	Percent	100	Port Director
Tonnage reduction in 2015 when port closes for non-scrap cargo	Percent	100	Port Director

6. Benefits Measurement, Data and Assumptions

This section describes the measurement approach used for each benefit category estimated to achieve the TIGER program's long-term goals. It also provides an overview of the associated methodology, assumptions, and estimates.

6.1 Shipper Cost Savings

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 (compared to using other modes). Shipper cost savings associated with the project, due to direct port shipments compared to longer-distance truck, are estimated for the

analysis. The use of rail for a share of these shipments is also incorporated into the benefits, because some shredded scrap is currently transported via rail into the port.

6.1.1 Methodology and Assumptions

The primary benefit of the port improvement project is shipper cost savings. There are two ways that this project produces this benefit.

First, rehabilitation and expansion of the wharf means the port will not close and existing customers can continue to utilize the facility for shipping and receiving. If the port closes, these customers would use other ports located farther away, which would mean 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 are the Port of Portland in Maine for the scrap metal that is being shredded, and a division of other tonnage between the Port of Boston, Massachusetts, the Port of New Haven, Connecticut, the Port of Providence, Rhode Island, and the Port of Searsport, Maine. Since the destination of the freight is not the Port, 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 diversions since it will still need to be traveled to reach the final destination.

Second, 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 much more cargo than individual trucks.

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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
	Using Barge instead of Rail	$ per ton-mile	$0.02	Modal Experts
	Using Rail instead of Truck	$ per ton-mile	$0.04	Modal Experts
Tonnage Per Vehicle	Truck	Tons	25	Average based on truck movements at Port
	Rail	Tons	50	Rail Shipper Using the 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
Local Miles Transportation Factor	Truck	Miles	10	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 the scrap metal that all uses this Port.
	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
Share of Diverted Tonnage Moved by Rail	New Haven	Percent	20	HDR Assumption and Port Director input
	Portland	Percent	20	HDR Assumption and Port Director input
	Boston	Percent	0	HDR Assumption and Port Director input
	Providence	Percent	20	HDR Assumption and Port Director input
	Searsport	Percent	0	HDR Assumption and Port Director input

6.1.2 Benefit Estimates

With the main wharf rehabilitation and expansion, shipper cost savings of $65.22 million are estimated. This represents 72.6 percent of total project benefits.

Table 4: Estimates of Shipper Cost Savings, in Millions of 2011 Dollars

	In 2014	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Shipper Cost Savings – Removal of Trucks	$0.8	$55.6	$18.3
Shipper Cost Savings – Removal of Rail	$0.1	$9.6	$3.1
Total	**$0.9**	**$65.2**	**$21.4**

6.2 Productivity Benefit

Freight shippers have many options for transporting their cargo, and each business makes their location and logistics decisions based on a variety of factors. It is presumed that existing port customers are utilizing the Market Street Marine Terminal because it is operationally efficient for them to do so. As specifically stated by existing port customers, expansion of the port could allow them to expand operations and shipping volumes by using the low-cost rail connections and port facilities. If the port were to close, these businesses would either need to limit their expansion plans and/or find an alternative location. This shift would generate a loss in productivity for existing port customers who are forced to rework their logistics and site location away from their preferred site. Thus, maintaining and expanding the port results in estimated productivity benefits for users of the improved facility.

6.2.1 Methodology and Assumptions

To estimate the productivity benefit, it is assumed that the user of the Port earns more per ton of scrap metal than he pays to the Port to transport it. The revenue per ton for scrap metal to the Port is then used to gauge the productivity benefit of using the Port. It is assumed that the costs to the user would be greater at any other port, and thus he receives a productivity benefit of 50 percent of the additional cost per ton to move through this Port over other ports.

Table 5: Assumptions Used in the Estimation of Productivity Benefit

Variable Name	Unit	Value	Source
Revenue Per Ton of Scrap Metal	$	1.34	Port Vessel Activity for 2010

6.2.2 Benefit Estimates

The total productivity benefit associated with the main wharf improvement is estimated to be $2.8 million. This represents three percent of total benefits.

Table 6: Estimates of Productivity Benefits, in Millions of 2011 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Total	**$0.008**	**$2.8**	**$0.8**

6.3 Accident Reduction

If the port were to close, customers who use the facility today would be forced to use alternative ports and truck some, if not all, of their cargo. With the wharf improvement, some of these trucks would be removed from the highways, reducing congestion, vehicle miles traveled and the number of accidents.

6.3.1 Methodology and Assumptions

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 and expansion.

Table 7: Assumptions Used in the Estimation of Accident Reduction Benefits

Variable Name	Unit	Value	Source
Congestion Cost Per Vehicle Mile	$	0.058	Marginal External Cost, Addendum to the 1997 Federal Highway Cost Allocation Study Final Report, May 2000
Fatal Accidents	Per 100 Million VMT	1.1	2009 BTS Motor Vehicle Safety Data
Injury Accidents	Per 100 Million VMT	75.1	2009 BTS Motor Vehicle Safety Data
Property Damage Only Accidents	Per 100 Million VMT	186.4	2009 BTS Motor Vehicle Safety Data
Cost of Fatal Accident	$	6,200,000	Treatment of the Economic Value of a Statistical Life in Departmental Analyses – 2011 Interim Adjustment
Cost of Injury Accident	$	87,748	Treatment of the Economic Value of a Statistical Life in Departmental Analyses – 2011 Interim Adjustment
Cost of Property damage Only Accident	$	3,368	US DOT NOFA for TIGER 3

6.3.2 Benefit Estimates

With the main wharf rehabilitation and expansion, accident reduction benefits of $5.9 million are estimated. This represents 6.6 percent of total project benefits.

Table 8: Estimates of Accident Reduction Benefits, in Millions of 2011 Dollars

	In 2014	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Fatalities	$0.036	$3.0	$0.9
Injuries	$0.032	$2.7	$0.8
Property Damage Only	$0.003	$0.2	$0.08
Total	**$0.071**	**$5.9**	**$1.8**

6.4 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.

6.4.1 Methodology and Assumptions

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. It should be noted that based on US DOT guidance, carbon emissions (CO and CO2) are measured in grams per metric ton, whereas all other emissions are measured in grams per long ton. Additionally, 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. The assumptions used in the estimation of emissions benefits are summarized in the table below.

Table 9: Assumptions Used in the Estimation of Emissions Reduction Benefits

Mode	Variable Name	Unit	Value	Source
Truck	NOX	Grams Per Mile	8.55	MOVES, Long Haul Combination Truck 45 miles per hour, 2014*
	CO	Grams Per Mile	2.09	MOVES, Long Haul Combination Truck 45 miles per hour, 2014*
	PM	Grams Per Mile	0.31	MOVES, Long Haul Combination Truck 45 miles per hour, 2014*
	VOC(HC)	Grams Per Mile	0.33	MOVES, Long Haul Combination Truck 45 miles per hour, 2014*
	CO2	Grams Per Mile	1998.82	MOVES, Long Haul Combination Truck 45 miles per hour, 2014*
	SO2	Grams Per Mile	0.01	MOVES, Long Haul Combination Truck 45 miles per hour, 2014*
Rail	NOX	Grams Per Mile	0.328	EPA-420-F-09-025 – Emission Factors for Locomotives
	CO	Grams Per Mile	0.061	EPA-420-F-09-025 – Emission Factors for Locomotives
	PM	Grams Per Mile	0.008	EPA-420-F-09-025 – Emission Factors for Locomotives
	VOC(HC)	Grams Per Mile	0.015	EPA-420-F-09-025 – Emission Factors for Locomotives
	CO2	Grams Per Mile	23.43	EPA-420-F-09-025 – Emission Factors for Locomotives
	SO2	Grams Per Mile	0.00	EPA-420-F-09-025 – Emission Factors for Locomotives
Valuation	NOX	$ Per Long Ton	5,720	Final Regulatory Impact Analysis Corporate average Fuel Economy for MY 2012-MY2016 Passenger Cars and Light Trucks
	CO	$ Per Metric Ton	-	Victoria Transport Policy Institute, Air Pollution Costs Spreadsheet
	PM	$ Per Long Ton	312,740	Final Regulatory Impact Analysis Corporate average Fuel Economy for MY 2012-MY2016 Passenger Cars and Light Trucks
	VOC(HC)	$ Per Long Ton	1,400	Final Regulatory Impact Analysis Corporate average Fuel Economy for MY 2012-MY2016 Passenger Cars and Light Trucks
	CO2	$ Per Metric Ton	25.10	Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (February 2010), Value for 2014*
	SO2	$ Per Long Ton	33,430	Final Regulatory Impact Analysis Corporate average Fuel Economy for MY 2012-MY2016 Passenger Cars and Light Trucks

***Note that emissions rates vary annually based on the MOVES model, this is just a sample. Additionally, the cost of carbon emissions changes annually.*

6.4.2 Benefit Estimates

While emissions savings accounts for only 4.2 percent of benefits, the reduction in greenhouse gases is 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 benefits for emissions reductions.

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

Emission Type	Tonnage
NOX	97.6
CO	23.4
PM	2.0
VOC(HC)	3.1
CO2	74,129.3
SO2	0.5

Table 11: Estimates of Emission Reduction Benefits, in Millions of 2011 Dollars

	In 2014	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Non-Carbon Emissions	$0.078	$1.2	$0.7
Carbon Emissions	$0.027	$2.6	$1.5*
Total	**$0.105**	**$3.8**	**$2.1**

*Discounted at 3% per US DOT guidance.

6.5 Pavement Maintenance Savings

Pavement maintenance cost reduction is another benefit of reduced vehicle traffic and decreased congestion. With the wharf improvement, VMT is reduced and wear and tear on highways and the associated maintenance cost is decreased.

6.5.1 Methodology and Assumptions

Vehicles driving over roadways cause wear and tear, and these roads must be maintained and repaired. Reducing the usage of roadways decreases the frequency of this maintenance. Pavement maintenance savings are calculated based on the annual reduction in vehicle miles traveled multiplied by the cost of wear per truck vehicle mile.

Table 12: Assumptions Used in the Estimation of Pavement Maintenance Savings

Variable Name	Unit	Value	Source
Pavement Maintenance	Per Vehicle Mile	$0.122	Federal Highway Cost Allocation Study 1997 (inflated to 2011)

6.5.2 Benefit Estimates

Pavement maintenance savings account for five percent of total benefits, and are valued at $4.5 million over the study period.

6.6 Congestion Reduction

The removal of vehicles from the road results in an external benefit of a reductionin congestion for remaining roadway users.

6.6.1 Methodology and Assumptions

The average trip length for the diverted trucks was multiplied by the number of trucks removed from the road.

Table 13: Assumptions Used in the Estimation of Pavement Maintenance Savings

Variable Name	Unit	Value	Source
Congestion Cost Per Vehicle Mile	Per Vehicle Mile	$0.058	Marginal External Cost, Addendum to the 1997 Federal Highway Cost Allocation Study Final Report, May 2000 inflated to 2011 Dollars.

6.6.2 Benefit Estimates

Congestion reduction accounts for nearly 5 percent of benefits, totaling $4.2 million over the study period.

6.7 Residual Value

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

6.7.1 Methodology and Assumptions

To calculate the residual value, the amount of total benefits in the final year of analysis, $3.8 million in 2043, was weighted against the annual operating and maintenance costs of $1.1 million, and extended for the remaining 20 years of useful life. Each year, the net benefits were discounted at the appropriate 7 percent discount rate and the total net benefit was added to the other benefits.

Table 14: Assumptions Used in the Estimation of Residual Value

Variable Name	Unit	Value	Source
Total Benefits in 2043	$	3,815,235	Calculated in BCA
Total Costs in 2043	$	1,100,000	O&M Costs

6.7.2 Benefit Estimates

The total residual value associated with the main wharf improvement is estimated to be $3.3 million. This represents 3.7 percent of total benefits.

7. 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 2014. Benefits accrue during the full operation of the project.

Table 15: Overall Results of the Benefit Cost Analysis in Millions of 2011 Dollars

Project Evaluation Metric	7% Discount Rate	3% Discount Rate
Total Discounted Benefits	$32.4	$66.6
Total Discounted Costs	$26.3	$36.5
Net Present Value	$6.1	$30.2
Benefit / Cost Ratio	1.2	1.8
Internal Rate of Return (%)	7.6%	
Payback Period (years)	15	

Considering all monetized benefits and costs, the estimated internal rate of return of the project is 7.6 percent. With a 7 percent real discount rate, the $15.75 million investment would result in $32.4 million in total benefits and a benefit-cost ratio of approximately 1.2.

With a 3 percent real discount rate, the Net Present Value of the project would increase to $66.6 million, for a benefit-cost ratio of 1.8.

Table 16: Benefit Estimates by Long-Term Outcome for the Market Street Marine Terminal Main Wharf Rehabilitation and Expansion in Millions of 2011 Dollars

Long-Term Outcomes	Benefit Categories	7% Discount Rate	3% Discount Rate
State of Good Repair	Pavement Maintenance	$1.5	$2.7
	Residual Value	$3.3	$15.7
Economic Competitiveness	Shipper Cost Savings	$21.4	$38.4
	Productivity Benefit	$0.8	$1.6
Livability	Congestion Reduction	$1.4	$2.5
	Efficient and Safe Harbor Operations for commercial and non-commercial users	qualitative	qualitative
Environmental Sustainability	Emissions Reduction	$2.1	$2.4
Safety	Accident Reduction Benefits	$1.9	$3.4
	Harbor Safety and Security	qualitative	qualitative
Total Benefit Estimates		**$32.4**	**$66.6**

Table 17: Benefit Estimates by Category

Benefit Categories	7% Discount Rate	3% Discount Rate
Shipper Cost Savings	$21,392,042	$38,405,080
Productivity Benefits	$792,000	$1,558,260
Accident Reduction	$1,871,461	$3,429,032
Emissions Reduction	$2,143,876	$2,387,301
Pavement Maintenance Savings	$1,488,990	$2,663,319
Congestion Reduction	$1,393,725	$2,492,921
Residual Value	$3,300,556	$15,687,203
Total Benefit Estimates	**$32,382,651**	**$66,623,116**

8. 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 project 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 50 percent reduction in assumed tonnage growth represents a 76 percent decrease in NPV and a BCR of 1.1. Assuming that all tonnage is diverted to New Haven and Searsport after the Market Street Marine Terminal closes (the no-build scenario) results in a change in NPV of 138 percent and a BCR of 1.5. The following table presents the results of the sensitivity analyses that were conducted for this benefit-cost analysis.

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Table 18: Quantitative Assessment of Sensitivity, Summary (in Millions of 2011$)

Parameters	Change in Parameter Value	New NPV	Change in NPV	% Change in NPV	New B/C Ratio
Percent Growth in Tonnage	50% Reduction in Growth	$1.4	-$4.6	-76%	1.1
	50% Increase in Growth	$10.7	+$4.6	+76%	1.4
Share of Tonnage that is Rail	No Rail Diversion	$9.0	+2.9	+48%	1.3
	50% Tonnage Rail	$1.7	-$4.3	-72%	1.1
Diversion to Other Ports	All to Providence, Boston and Portland	-$8.3	-$14.4	-237%	0.7
	All to New Haven and Searsport	$14.4	+$8.4	+138%	1.5
Productivity Benefit	No Productivity Benefit	$5.1	-$0.9	-15%	1.2

9. Supplementary Data Tables

This section breaks down all benefits associated with the five long-term outcome criteria (State of Good Repair, Economic Competiveness, Livability, Sustainability, and Safety) in annual form for the Main Wharf expansion and rehabilitation project. Supplementary data tables are also provided for some specific benefit categories.

Annual Estimates of Total Project Benefits and Costs

Calendar Year	Total Benefits ($2011)	Total Costs ($2011)	Undiscounted Net Benefits ($2011)	Discounted Net Benefits at 7%	Discounted Net Benefits at 3%
2012	$432,344	$5,240,000	($4,807,656)	($4,172,458)	($4,519,451)
2013	$1,168,770	$11,585,000	($10,416,230)	($8,434,217)	($9,500,238)
2014	$1,229,903	$1,080,000	$149,903	$182,697	$165,970
2015	$1,958,058	$1,100,000	$858,058	$715,113	$790,839
2016	$2,018,557	$1,100,000	$918,557	$713,224	$819,992
2017	$2,079,403	$1,100,000	$979,403	$708,955	$847,067
2018	$2,140,620	$1,100,000	$1,040,620	$702,630	$872,170
2019	$2,206,765	$1,100,000	$1,106,765	$697,179	$898,982
2020	$2,273,534	$1,100,000	$1,173,534	$689,991	$923,971
2021	$2,340,998	$1,100,000	$1,240,998	$681,350	$947,259
2022	$2,412,995	$1,100,000	$1,312,995	$673,273	$971,681
2023	$2,485,873	$1,100,000	$1,385,873	$663,966	$994,495
2024	$2,559,650	$1,600,000	$959,650	$459,703	$685,208
2025	$2,637,010	$1,100,000	$1,537,010	$643,410	$1,037,326
2026	$2,715,457	$1,100,000	$1,615,457	$632,396	$1,057,465
2027	$2,795,029	$1,100,000	$1,695,029	$620,711	$1,076,251
2028	$2,877,832	$1,100,000	$1,777,832	$609,139	$1,095,002
2029	$2,927,883	$1,100,000	$1,827,883	$586,901	$1,092,508
2030	$2,979,257	$1,100,000	$1,879,257	$565,591	$1,089,985
2031	$3,033,036	$1,100,000	$1,933,036	$545,335	$1,088,014
2032	$3,088,245	$1,100,000	$1,988,245	$525,901	$1,086,002
2033	$3,144,928	$1,100,000	$2,044,928	$507,259	$1,083,954
2034	$3,203,902	$1,600,000	$1,603,902	$390,969	$836,297
2035	$3,264,462	$1,100,000	$2,164,462	$472,543	$1,080,533
2036	$3,326,663	$1,100,000	$2,226,663	$456,238	$1,078,769
2037	$3,390,993	$1,100,000	$2,290,993	$440,676	$1,077,177
2038	$3,457,074	$1,100,000	$2,357,074	$425,750	$1,075,552
2039	$3,524,976	$1,100,000	$2,424,976	$411,439	$1,073,904
2040	$3,595,000	$1,100,000	$2,495,000	$397,755	$1,072,340
2041	$3,666,435	$1,100,000	$2,566,435	$384,419	$1,070,537
2042	$3,739,818	$1,100,000	$2,639,818	$371,625	$1,068,709
2043	$3,815,235	$1,100,000	$2,715,235	$359,355	$1,066,868

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Annual Demand Projections (Tons)

Calendar Year	Existing Operations Continuation Projection (for Diversions)				Build Projections			
	Shredded Scrap Metal	Non-Shredded Scrap Metal	Salt	Remaining Tonnage	Shredded Scrap Metal	Non-Shredded Scrap Metal	Salt	Remaining Tonnage
2012	51,421	102,842	50,528	74,056	51,421	102,842	50,528	74,056
2013	52,146	104,293	51,241	75,100	52,146	104,293	51,241	75,100
2014	52,882	105,764	51,963	76,160	65,337	105,764	51,963	77,385
2015	53,628	107,256	52,697	77,235	78,527	107,256	52,697	79,739
2016	54,385	108,770	53,440	78,324	91,717	108,770	53,440	82,164
2017	55,152	110,304	54,194	79,429	104,907	110,304	54,194	84,663
2018	55,930	111,860	54,959	80,550	118,098	111,860	54,959	87,238
2019	56,719	113,439	55,734	81,686	131,288	113,439	55,734	89,892
2020	57,520	115,039	56,520	82,839	144,478	115,039	56,520	92,626
2021	58,331	116,662	57,318	84,008	157,668	116,662	57,318	95,443
2022	59,154	118,308	58,127	85,193	170,859	118,308	58,127	98,347
2023	59,989	119,977	58,947	86,395	184,049	119,977	58,947	101,338
2024	60,835	121,670	59,778	87,614	197,239	121,670	59,778	104,420
2025	61,693	123,387	60,622	88,850	210,429	123,387	60,622	107,597
2026	62,564	125,128	61,477	90,104	223,620	125,128	61,477	110,869
2027	63,447	126,893	62,344	91,375	236,810	126,893	62,344	114,242
2028	64,342	128,683	63,224	92,664	250,000	128,683	63,224	117,716
2029	65,249	130,499	64,116	93,971	250,000	130,499	64,116	121,297
2030	66,170	132,340	65,021	95,297	250,000	132,340	65,021	124,987
2031	67,104	134,207	65,938	96,642	250,000	134,207	65,938	128,788
2032	68,050	136,101	66,868	98,005	250,000	136,101	66,868	132,706
2033	69,011	138,021	67,812	99,388	250,000	138,021	67,812	136,742
2034	69,984	139,968	68,769	100,790	250,000	139,968	68,769	140,901
2035	70,972	141,943	69,739	102,212	250,000	141,943	69,739	145,187
2036	71,973	143,946	70,723	103,654	250,000	143,946	70,723	149,603
2037	72,988	145,977	71,721	105,117	250,000	145,977	71,721	154,154
2038	74,018	148,036	72,732	106,600	250,000	148,036	72,732	158,843
2039	75,062	150,125	73,759	108,104	250,000	150,125	73,759	163,674
2040	76,122	152,243	74,799	109,629	250,000	152,243	74,799	168,653
2041	77,195	154,391	75,855	111,176	250,000	154,391	75,855	173,783
2042	78,285	156,569	76,925	112,744	250,000	156,569	76,925	179,069
2043	79,389	158,778	78,010	114,335	250,000	158,778	78,010	184,515

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Annual Benefits

Calendar Year	Shipper Cost Savings	Productivity Benefit	Accident Reduction	Emissions Reduction	Pavement Maintenance Savings	Congestion Reduction	Total Benefits
2012	$327,873	$0	$23,640	$40,183	$20,995	$19,652	$432,344
2013	$866,654	$0	$71,008	$110,024	$62,543	$58,541	$1,168,770
2014	$915,947	$8,333	$74,691	$104,627	$65,240	$61,066	$1,229,903
2015	$1,459,700	$16,660	$122,513	$153,729	$106,123	$99,333	$1,958,058
2016	$1,510,288	$24,979	$126,796	$145,623	$108,920	$101,951	$2,018,557
2017	$1,561,550	$33,291	$131,204	$136,971	$111,769	$104,618	$2,079,403
2018	$1,613,504	$41,596	$135,740	$127,773	$114,672	$107,335	$2,140,620
2019	$1,666,168	$49,893	$140,409	$122,562	$117,630	$110,104	$2,206,765
2020	$1,719,561	$58,183	$145,215	$117,006	$120,644	$112,925	$2,273,534
2021	$1,773,704	$66,466	$150,162	$111,150	$123,715	$115,800	$2,340,998
2022	$1,828,616	$74,741	$155,256	$108,805	$126,847	$118,731	$2,412,995
2023	$1,884,318	$83,008	$160,500	$106,289	$130,039	$121,719	$2,485,873
2024	$1,940,831	$91,267	$165,900	$103,592	$133,294	$124,766	$2,559,650
2025	$1,998,178	$99,518	$171,461	$103,368	$136,613	$127,873	$2,637,010
2026	$2,056,381	$107,761	$177,187	$103,088	$139,998	$131,041	$2,715,457
2027	$2,115,462	$115,996	$183,085	$102,760	$143,452	$134,274	$2,795,029
2028	$2,175,447	$124,223	$189,160	$104,456	$146,975	$137,571	$2,877,832
2029	$2,213,672	$123,616	$194,584	$105,750	$149,927	$140,334	$2,927,883
2030	$2,252,851	$123,000	$200,183	$107,106	$152,952	$143,166	$2,979,257
2031	$2,293,008	$122,375	$205,962	$109,569	$156,053	$146,069	$3,033,036
2032	$2,334,171	$121,741	$211,929	$112,127	$159,232	$149,045	$3,088,245
2033	$2,376,367	$121,099	$218,089	$114,787	$162,491	$152,095	$3,144,928
2034	$2,419,625	$120,448	$224,450	$118,326	$165,832	$155,222	$3,203,902
2035	$2,463,974	$119,787	$231,018	$121,999	$169,256	$158,427	$3,264,462
2036	$2,509,444	$119,117	$237,801	$125,820	$172,768	$161,714	$3,326,663
2037	$2,556,065	$118,437	$244,806	$130,232	$176,368	$165,084	$3,390,993
2038	$2,603,870	$117,748	$252,040	$134,816	$180,060	$168,540	$3,457,074
2039	$2,652,890	$117,050	$259,513	$139,593	$183,846	$172,083	$3,524,976
2040	$2,703,161	$116,341	$267,232	$144,820	$187,728	$175,717	$3,595,000
2041	$2,754,716	$115,623	$275,207	$149,737	$191,709	$179,444	$3,666,435
2042	$2,807,591	$114,894	$283,445	$154,830	$195,793	$183,266	$3,739,818
2043	$2,861,823	$114,155	$291,957	$160,134	$199,981	$187,186	$3,815,235

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