Portsmouth/Kittery Memorial Bridge Replacement Project Benefit-Cost Analysis

Portsmouth, New Hampshire

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for the New Hampshire Department of Transportation

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1. INTRODUCTION

1.1 Background and Purpose

The Memorial Bridge carries US Route 1 over the Piscataqua River and links the downtown areas of Portsmouth, New Hampshire, and Kittery, Maine. At its opening in 1923, this vertical lift movable steel truss bridge was dedicated as the official state memorial to World War I servicemen. At that time, it served as the only local connection between the downtown areas of Portsmouth and Kittery. Today it is the only river crossing for pedestrians and bicyclists in the region.

The Memorial Bridge is eligible for listing in the National Register of Historic Places and contributes greatly to the cultural and historic fabric of the seacoast region. The safe and dependable operation of this complex structure is critical to the efficient movement of marine traffic to and from numerous active ports along the Piscataqua River, while also providing connectivity for the regional transportation system between the States of New Hampshire and Maine and the seacoast communities of Portsmouth and Kittery.

The Memorial Bridge is in Serious condition (per NBIS condition rating guidelines) and currently has a load posting of 3 tons. There is advanced section loss on structural steel members throughout the structure, and corrosion holes on many members. The bridge deck is in generally Poor condition (per NBIS condition rating guidelines), with spalling in the concrete deck and section loss in numerous reinforcement bars. Interim inspections of Fracture Critical Members are being performed every 6 months. This application requests TIGER II Discretionary Grant program funds to replace the existing bridge structure. The replacement of this structure is anticipated to cost $90 million.

The Benefit-Cost Analysis described in the following sections estimates the benefits and costs associated with the proposed infrastructure improvement. The project is evaluated as compared to the current system, which is considered the baseline, and a future scenario without major capital improvements. It is anticipated that if no major improvement is made to Memorial Bridge, it will be closed. The bridge's closure would increase vehicular traffic on the alternative bridges in the region, as well as completely eliminate a pedestrian and bicyclist river crossing in the Portsmouth and Kittery area.

1.2 Summary of Benefit-Cost Results

Using the TIGER guidance recommended discount rate of 7 percent, the replacement of the Memorial Bridge will result in:

- Total benefits of $67.5 million in present value terms;
- Total costs of $89.2 million in present value terms;

- Total net present value of ($21.8) million, with a benefit-cost ratio of 0.8 at a 7 percent discount rate, and a net present value of $73.7 million and a benefit-cost ratio of 1.6 and a 3 percent discount rate.

A benefit-cost ratio (BCR) of 0.8 at a 7 percent discount rate indicates that the anticipated capital and operations and maintenance costs outweigh the measurable benefits. For comparison purposes, the BCR was also calculated at a 3 percent discount rate, resulting in a BCR of 1.6 for the bridge replacement. Thus, the benefits do outweigh costs if future benefits are not discounted as severely as the 7 percent real discount rate. Measurable benefits are estimated to outweigh costs up to a 5.45 percent discount factor.

1.3 Organization of the Report

This report provides the framework of the benefit-cost analysis in Section 2. Information related to the traffic estimation utilized in the analysis is provided in Section 3. Benefits and costs are detailed in Section 4, and Section 5 presents the results with a conclusion evaluating the findings of the study. Figures and tables are provided throughout the report to better illustrate the analysis.

2. FRAMEWORK OF THE ANALYSIS

A comparison of the benefits and costs of a project can give an indication of whether or not a project is worthwhile. To be deemed economically feasible, projects must pass one or more value benchmarks: the total benefits must exceed the total costs on a present value basis; and/or the rate of return on the funds invested should exceed the cost of raising capital, often defined as the long-term treasury rate or the social discount rate. A fundamental tenet of the benefit-cost analysis approach is that only those incremental benefits directly attributable to the construction and operation of the project are included in the estimation of benefits and costs.

For this analysis, the cost to build and operate represents the foregone value of an alternative investment. The benefits of the project refer to the improvement in the social well-being delivered by the project.

2.1 Benefit-Cost Analysis

In the Memorial Bridge Replacement Project benefit-cost analysis, benefits are estimated for current and future users on an incremental basis; that is, the change in welfare that consumers and, more generally, society derive from access to the replacement bridge, as compared to the current situation. As with most transportation projects, the benefits derived from the implementation of infrastructure projects are actually a reduction in the costs associated with transportation activities. For example, the reduction of costs due to the replacement of Memorial Bridge affects users differently, depending on their preferences and the way the project changes their individual transportation costs.

The benefits of a project are the cost reductions that may result from the project's implementation. These cost reductions may come in the form of average time saved by users, reductions in the operating expenses, reduction of pollution or, more generally, a combination of these effects.

2.1.1 Principles

The Benefit-Cost Analysis was conducted by HDR| Decision Economics using methods and parameters consistent with the US Department of Transportation and the Transportation Investment Generating Economic Recovery (TIGER) and TIGER II Discretionary Grants guidance. The following principles guide the estimation of benefits and costs in the analysis:

- Only incremental benefits and costs are measured.
    - Incremental benefits of the project include transportation cost savings for the users of the bridge. Users of Memorial Bridge include pedestrians, bicyclists, automobile drivers, and truck drivers. Health benefits to society associated with individuals who choose to walk or bike, instead of drive, were also incorporated.

- Incremental costs of implementation of the project include initial and recurring costs. Initial costs refer to capital costs incurred for design and construction of the bridge replacement. Recurring costs include incremental operating costs and maintenance expenses. Only additions in costs to the current operations and planned investments are considered in the analysis.

- Benefits and costs are valued at their opportunity costs.

    - The benefits stemming from the implementation of the Memorial Bridge replacement are those above and beyond the benefits that could be obtained from the best transportation alternative.

2.1.2 Measurement Data and Assumptions

As part of the TIGER II Grant application process, which was the impetus behind this analysis, benefits and costs associated with specific long term outcomes criteria were estimated. Table 1 presents the benefits measured in this project application as they relate to the five long term outcomes identified in the TIGER II grant guidance: State of Good Repair; Economic Competitiveness; Livability; Sustainability; and, Safety.

Table 1: Benefits and Description of Evaluation Criteria Identified in Long Term Outcomes

Criteria	Benefit(s)	Description
State of Good Repair	Pavement Maintenance Savings	Pavement maintenance savings due to new bridge
	Maintenance and Operating Cost Savings	Savings in costs associated with longer term maintenance and operation of infrastructure
Economic Competitiveness	Long Term Employment	Value of long-term jobs and whether they will be created in areas of economic distress
Livability	Travel Time Savings	Door-to-door trip time savings to transportation users
	Pedestrian and Health Benefits	Health benefits accruing to society as a result of pedestrian and bicycle use, instead of motorized vehicle use

Sustainability	Emissions Reductions	Reductions in pollutants and green house gases due to auto and truck use reductions
Safety	Accident Reduction	Reductions in property losses and injuries and deaths due to improved bridge
Job Creation and Economic Stimulus	Short Term Employment	Value of new short-term jobs created

2.1.3 Valuation

The valuation of benefits makes use of a number of assumptions that are required to produce monetized values for non-pecuniary benefits. For instance, the different components of time are monetized by using a “value of time” that is assumed to be equivalent to the user’s willingness to pay for time savings in transit. United States Department of Transportation (USDOT) valuation guidance on the preparation of TIGER II applications was used in the analysis. Where USDOT has not provided valuation guidance or a reference to guidance, standard industry practice has been applied.

All benefits and costs are estimated in 2010 dollars in the analysis, and annual costs and benefits are computed over a long-run planning horizon and summarized through a lifecycle cost analysis. The Memorial Bridge replacement project is assumed to have a useful life of 50 years.

2.1.4 The Opportunity Cost of Capital

The opportunity cost associated with the delayed consumption of benefits and the alternative uses of the capital for the implementation of the project is measured by the discount rate. All benefits and costs are discounted to reflect the opportunity costs of committing resources to the project. Calculated real discount rates are applied to all future costs and benefits as a representation of how the public sector evaluates investments. A 7 percent real discount rate is used in the analysis, with a sensitivity test at 3 percent.

2.1.5 Model Structure

When conducting a benefit-cost analysis, a baseline scenario is compared to an alternative. For this study, the current Memorial Bridge condition is considered the baseline condition. The replacement of the Memorial Bridge is the alternative. Data from numerous sources are combined using a variety of relationships and TIGER II guidance to develop benefit and cost estimates.

3. TRAFFIC ESTIMATION

3.1 Estimating Travel Data and Travel Time Savings

The following section provides information about the traffic estimates that were utilized for the Benefit-Cost Analysis. These estimates provided the basis for the estimation of benefits and costs associated with the replacement of Memorial Bridge.

The State of New Hampshire and the State of Maine signed a Cooperative Agreement to complete a study evaluating the transportation needs and connections between Portsmouth, New Hampshire and Kittery, Maine. *The Connections Study* is ongoing, but the traffic data developed as part of that study were available for the Benefit-Cost Analysis. Traffic analysis data, including estimates of changes to vehicle miles and hours of travel for trucks and autos, was thus provided by the HNTB consulting team and their sub consultant, Kevin Hooper Associates.

3.1.1 Estimating Travel Data and Travel Time Savings

The travel data was developed for two specific scenarios: a "no build" scenario and a "build" scenario. The "no build" scenario assumes the Memorial Bridge closes in 2012. The "build" scenario assumes the Memorial Bridge will be reopen after replacement in October 2014 and maintain a direct access between Portsmouth and Kittery.

The travel data included weekday peak estimates of Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT) for both truck and auto. These weekday peak hour estimates were converted to daily volumes and then annual estimates, with an anticipated annual growth in traffic of 0.8%[1]. The traffic analysis estimates that peak volumes are approximately 9 percent of daily volumes. Daily travel impacts were annualized using a factor of 336 that reflects the number of working weekdays and the relatively high ratio of weekend travel in the area compared to weekday travel (reflecting high tourism volumes).

The travel data suggests that if the Memorial Bridge were to close, total traffic would increase for both truck and autos. The increase in trip length is a result of trucks and autos taking a longer more circuitous route to cross the Piscataqua River. Table 2 below shows the 2009 baseline daily traffic.

Table 2: 2009 Daily Traffic

	VMT	VHT
Total Traffic	979,544	25,460

[1] According to growth forecasts provided by the Rockingham Planning Commission, the Portsmouth area's metropolitan planning organization.

Auto Traffic	915,874	23,805
Truck Traffic	63,670	1,655

Source: Kevin Hooper Associates, 2009

The following table, Table 3, provides traffic forecasts for both the "build" and "no-build" scenarios for the year 2035. As shown below, VMT in the "no-build" scenario is higher, reflecting the fact that Memorial Bridge would be closed and not an available option to cross the river, necessitating longer trips to cross the river. As a result, VHT would also increase because of congestion and the longer route for some travelers who previously relied on the Memorial Bridge to cross the Piscataqua.

Table 3: 2035 Daily Traffic

	2035 Build		2035 No Build		2035 Difference	
	VMT	VHT	VMT	VHT	VMT	VHT
Total Traffic	1,358,700	40,620	1,382,859	41,480	18,878	860
Auto Traffic	1,270,385	37,980	1,293,316	38,784	17,651	804
Truck Traffic	88,316	2,640	89,543	2,696	1,227	56

Note: the "no build" scenario assumes that Memorial Bridge is completely closed.

Many of the benefits estimated in the Benefit-Cost Analysis are due to reduced auto and truck VMT and VHT that result from maintaining a direct route over the Piscataqua River. The reduction in VMT due to the project relieves congestion and results in reduced travel time (VHT). These reductions reflect the difference in traffic between the "build" and "no build" scenarios.

Using these VMT and VHT data, as well as other information provided by the TIGER II Grant guidelines and other sources, estimation of benefits for the analysis was completed. A full description of these benefits measures is provided later in the report.

4. BENEFITS AND COSTS ASSOCIATED WITH MEMORIAL BRIDGE REPLACEMENT

The benefit-cost analysis was conducted using methods and parameters consistent with US Department of Transportation guidance.

4.1 Benefits

Six categories of benefits were measured for this analysis: 1) travel time savings; 2) vehicle operating cost savings; 3) accident reduction benefits; 4) emission reduction benefits; 5) pavement maintenance benefits; and 6) walking and biking health benefits. Costs include capital construction costs and operating and maintenance (O&M) costs for the Memorial Bridge. A description of the benefits associated with the Memorial Bridge replacement is provided in the following subsections.

4.1.1 Travel Time Savings

Once the Memorial Bridge is replaced and traffic crossing the bridge resumes, travel time will be reduced as both autos and trucks will have better mobility options than in the baseline. These travel time savings, due to the replacement of the bridge, were quantified as part of the Connections Study in terms of VHT for autos and trucks. Benefits are estimated using value of time parameters from the US DOT, escalated to 2010 dollars. They account for a mix of personal (85%) and business (15%) auto trips, as well as truck impacts. It is also worth noting that travel time is likely to increase for highway vehicles while the bridge is closed during construction. Those drivers will choose alternate bridges to cross the Piscataqua while construction is underway, and those impacts are accounted for in the calculations.

4.1.2 Vehicle Operating Cost Savings

In addition to the overall savings in time travel, the reduction in VMT also generates savings in the costs associated with the operation and maintenance of automobiles and trucks. In the analysis, vehicle operating costs include fuel, oil, depreciation, tire wear, and maintenance and repair. The vehicle operating cost savings are part of the overall calculation of benefits attributable to the project improvement.

The Memorial Bridge is currently the only reasonable way for pedestrians and bicyclists to cross the Piscataqua between Portsmouth and Kittery. When the bridge is closed, it is assumed that individuals who commute to work via walking and biking will divert to traveling by automobile. Once the Memorial Bridge is replaced, those pedestrians and bicyclists will resume commuting by foot and bike. Trip cost reductions will accrue to users who divert from personal automobiles to walking and biking across the bridge. These benefits are included in the analysis.

4.1.3 Accident Reduction Benefits

The reduction of accident costs, like other variable costs, is dependent on the reduction of vehicle-miles. 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 replaced Memorial Bridge.

4.1.4 Emissions Reduction Benefits

Emissions reduction benefits are due to reduced auto and truck VMT, based on estimates of traffic in the Portsmouth-Kittery region before, during, and after the bridge replacement. When the bridge 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. The Memorial Bridge replacement will result in emissions benefits.

4.1.5 Pavement Maintenance Savings

Pavement maintenance cost reduction is another benefit of reduced vehicle traffic. In addition to the costs that individual drivers incur for auto and truck trips, there are costs in terms of damage to the road surface. Pavement maintenance savings result from reduced auto and truck VMT. Because VMT decrease when the bridge repair is complete, there are savings in pavement maintenance costs associated with the project completion.

4.1.6 Pedestrian and Bicyclist Health Benefits

In addition to the reduction in vehicle operating costs and travel time savings that accrue when an individual chooses to walk or bike, rather than drive their vehicle, there are health benefits associated with these non-motorized options. These benefits accrue both to the individual and to society as a whole. Health benefits due to active transportation are measured in this Benefit-Cost Analysis.

4.2 Construction and Operating and Maintenance Costs

The Memorial Bridge is projected to be unsafe for vehicular traffic and be forced to close in one to three years, if necessary repairs are not made. When permanently closed, the lift span will need to be removed to comply with US Coast Guard navigational requirements at an estimated cost of $1 million. While operations and maintenance costs would be significantly lower if the bridge were closed, they would not be eliminated. Furthermore, the region will lose the only reasonable means to cross the Piscataqua River for pedestrians and bicyclists.

The costs of the project consist of initial construction costs associated with Memorial Bridge replacement, as well as operation and maintenance (O&M) costs. Replacement of the bridge is expected to cost $90 million. Operating and maintenance costs for the bridge are estimated to total $106.5 million over its lifespan.

5. BENEFITS AND COSTS ESTIMATION

5.1 Estimation of Benefits and Costs – Bridge and Highway Related Benefits

The following section provides detail on the benefits and costs to existing pedestrians, bicyclists, automobile and truck travelers. For the purpose of estimating the costs and benefits, it is assumed that the construction to the Memorial Bridge will begin in 2012 and be completed by the end of October 2014, allowing for two months of operation in 2014. Operating and maintenance costs occur annually, while construction costs are only incurred in the relevant construction period. Benefits increase annually as well.

5.1.1 Travel Time Savings

For the analysis, the values of time are drawn directly from the US DOT's guidance on travel time, inflated to 2010 dollars. The auto value of time for business travel (assumed to be 6% of all auto trips is $29.93 while the value of time for personal travel is $13.24. When adding additional factors, as recommended by Federal Highway Administration's (FHWA's) Highway Economic Requirements System (HERS) model (inventory cost, truck depreciation cost, etc.) to the truck wage of $24.23, the full value of truck travel time is $36.15.

In the analysis, cumulative travel time savings are estimated to be $265.0 million.

5.1.2 Vehicle Operating Cost Savings

Vehicle operating costs (VOC) are an integral element of the generalized cost of traveling. These costs are typically the most recognized of user costs because they usually include some out-of-pocket expenses associated with owning, operating, and maintaining a vehicle. The cost components of VOC measured in this analysis include: fuel and oil consumption, maintenance and repairs, tire wear, and vehicle depreciation.

The estimation of VOC is based on consumption and depreciation rate tables from the FHWA's HERS, and the individual cost components vary by auto and truck. The benefits directly stem from reduced VMT because the replacement of Memorial Bridge offers more direct routes, greater pedestrian and bicycle mobility, and fewer trips by automobile.

Cumulative vehicle operating cost savings were estimated to be $192.6 million for Memorial Bridge replacement.

5.1.3 Accident Reduction Benefits

Reduced vehicle traffic will also decrease the likelihood and cost of accidents. The National Highway Traffic Safety Administration (NHTSA) provides guidance on the rates per 100 million VMT for accidents and fatalities. These accident rates were applied to the annual VMT estimates to determine the number of accidents by category: injury, fatality, and property damage only. Estimates for the cost of each type of accident from US Department of Transportation were then applied to the number of accidents by type to monetize the benefits associated with fewer accidents.

The reduction of accident costs, like other variable costs, is dependent upon the reduction of vehicle-miles. In the Benefit-Cost Analysis conducted for this application, cumulative accident reduction benefits are estimated to be $68.7 million.

5.1.4 Emissions Savings

Congestion reduction benefits are due to reduced auto and truck VMT, based on estimates of traffic in the Portsmouth-Kittery region before, during, and after the bridge is replaced. When the bridge work is completed, congestion will be reduced in the region. In addition to reducing travel time, the decreased congestion will result in emission savings produced from the reduction in auto and truck VMT.

Emissions benefits are calculated as the change before and after the implementation of the project for autos and trucks. The Environmental Protection Agency's values of grams per mile of emission from Mobile6 were used to estimate the change in emissions from reduced VMT and were monetized using estimates of dollars per ton of emission from FHWA's HERS and the Victoria Transport Policy Institute. Emissions measured include VOC (HC), CO, CO2, NOX, SO2, and PM, varying by auto and truck. The investment in the Memorial Bridge will result in total emissions benefits of $47.3 million.

5.1.5 Pavement Maintenance Savings

In addition to the costs that individual drivers incur for auto and truck trips, there are costs in terms of damage to the road surface. A pavement maintenance cost reduction is another benefit of reduced vehicular traffic.

Because VMT decrease when the bridge repairs are complete, there are savings in pavement maintenance costs associated with the project completion. Based on the Federal Cost Allocation study of 1997, a pavement maintenance cost of $0.001 (in 2010 dollars) was used for autos and $0.119 per mile for trucks. A reduction in traffic leads directly to a reduction in these maintenance costs.

Total pavement maintenance cost savings are estimated to be $2.4 million for the replacement of Memorial Bridge.

5.1.6 Pedestrian and Bicyclist Benefits

The Memorial Bridge provides pedestrian and bicycle access to downtown Portsmouth. If the bridge closes, which is the assumption under the "no build" scenario, this access would be eliminated. This would mean that the pedestrians and bicyclists that cross the bridge as part of their commute would be forced to switch to another mode of transportation, likely auto. In addition to the added congestion that will be incurred on the road due to these additional vehicles, the pedestrians and bicyclists will also lose the health benefit that they received from walking or bicycling to work.

In the "no build" scenario, the bridge will close permanently in 2012, and these individuals will be transferred from walking/biking to driving. In the "build" scenario, the bridge would be closed from 2012 to the end of 2014 during the bridge replacement period, and these people would be forced to find an alternative means of transportation until the bridge reopens. It is assumed that they will drive until the bridge replacement is complete, at which point they will resume walking or biking across the Memorial Bridge.

Because pedestrians and bicyclists will divert from walking to driving, the associated increase in emissions, accidents, and operating costs is captured in the analysis. In addition to these vehicle related costs, there is a health benefit that is lost when these individuals stop walking and biking to work. According to the Victoria Transport Policy Institute, the benefit to cycling is $0.20 per mile in 2010 dollars, and the benefit of walking is $0.50 per mile in 2010 dollars. It is assumed that the maximum pedestrian commute is 2 miles and the maximum bike commute is 10 miles, but the average biker only rides 6 miles.

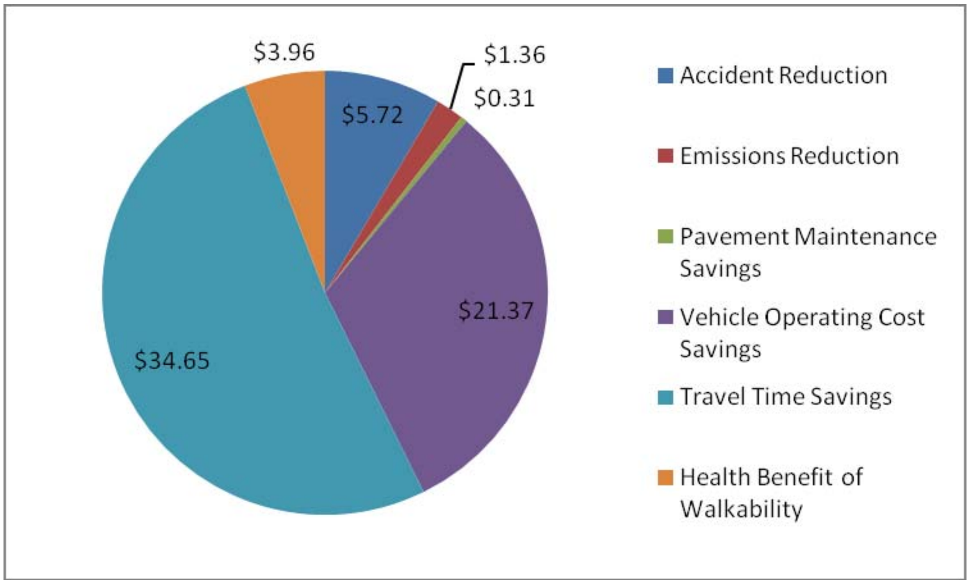
The benefit of the reduction in VMT associated with these individuals was incorporated in the difference between base and build scenarios; it was not calculated separately in the analysis. The total health benefit of the access to the Memorial Bridge amounts to $19.8 million over the 50 year useful life of the project.

5.2 Summary of Benefit-Cost Results

The replacement of the Memorial Bridge will result in total benefits of $67.5 million, when discounted by 7 percent. The present value of total costs associated with this project is $89.2 million, and the net present value is ($21.8) million. The BCR is 0.8 at 7 percent and 1.6 at a 3 percent discount rate. As shown in

Figure 1, replacement of the Memorial Bridge will have the most significant impact on travel time savings for users of the bridge (51%). Reduced vehicle operating costs also represent a significant portion of the benefits, 32%.

Figure 1: Total Present Value of Benefits of Memorial Bridge Replacement Project, 7% Discount Rate



A summary table of the benefits and costs associated with the Memorial Bridge replacement is provided in Table 4.

Table 4: Summary Table of Benefits and Costs for Memorial Bridge

7% Discount Rate		
BENEFITS	Millions of 2010$	
Accident Reduction	$	47.3
Emissions Reduction	$	13.3
Pavement Maintenance Savings	$	2.4
Vehicle Operating Cost Savings	$	192.6
Travel Time Savings	$	265.0
Health Benefit of Walkability	$	19.8
TOTAL BENEFITS	$	540.34
PV of Total Benefits	$	67.47
COSTS		
Maintenance Costs	$	106.50
Capital Costs	$	90.40
TOTAL COSTS	$	196.90
PV of Total Costs	$	89.24
Net Present Value (NPV)	$	(21.77)

3% Discount Rate		
BENEFITS	Millions of 2010$	
Accident Reduction	$	47.3
Emissions Reduction	$	13.3
Pavement Maintenance Savings	$	2.4
Vehicle Operating Cost Savings	$	192.6
Travel Time Savings	$	265.0
Health Benefit of Walkability	$	19.8
TOTAL BENEFITS	$	540.34
PV of Total Benefits	$	199.04
COSTS		
Maintenance Costs	$	106.50
Capital Costs	$	90.40
TOTAL COSTS	$	196.90
PV of Total Costs	$	125.35
Net Present Value (NPV)	$	73.68

Benefit-Cost Ratio (BCR)	0.8	**Benefit-Cost Ratio (BCR)**	1.6