Benefit-Cost Analysis Supplementary Documentation

BUILD Grant Program

US-281 Bridgeport Bridge over South Canadian River

Oklahoma Department of Transportation

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Benefit-Cost Analysis Supplementary Documentation

1. Executive Summary

The Benefit-Cost Analysis (BCA) conducted for this BUILD grant application compares the societal benefits associated with the proposed investment to the cost of the project. To the extent possible, benefits have been monetized. A qualitative discussion is also provided when a benefit is anticipated to be generated but is not easily monetized or quantified.

The project for which this BCA is conducted is for the replacement of the Bridgeport Bridge located on US-281 spanning the South Canadian River in Caddo and Canadian Counties, Oklahoma, immediately west of Oklahoma City.

The bridge was constructed in 1933 and is a contributing element to a National Register of Historic Places (NRHP) - listed segment of Route 66. It is a key feature of the Oklahoma Route 66 National Scenic Byway and, together with the adjacent roadway segments, forms an iconic historical feature important to the regional tourism economy.

Currently, the US-281 Bridgeport Bridge is a 2-lane undivided bridge assessed by the Oklahoma Department of Transportation (ODOT) as structurally deficient. The bridge is already load posted to heavy traffic, and in October 2018, the load restrictions were further increased from 15 tons to 9 tons after inspection revealed rapidly deteriorating condition of gusset plates and other superstructure elements. It is anticipated that if no action is taken, the bridge would be closed to all traffic beginning in 2021 and all traffic would be required to take a detour route of approximately 11.5 miles.

A table summarizing the changes expected from the project, and the associated quantified benefits, is provided below.

Table ES- 1. Summary of Project Infrastructure Improvements and Associated Quantified Benefits

Current Status or Baseline & Problems to be Addressed	Changes to Baseline / Alternatives	Type of Impacts	Population Affected by Impacts	Economic Benefit/Impact	Summary of Results
Bridgeport Bridge over the South Canadian River is one of the most historically significant bridges in Oklahoma and a key feature of the Oklahoma Route 66 National Scenic Byway. Currently Bridgeport Bridge is a structurally deficient 2-lane undivided bridge. If no action is taken, the bridge will be closed to all traffic in 2021. All travelers will be forced to take a lengthy detour.	Full bridge replacement preserving historical aesthetic appeal	Safety: reduction in number of crashes due to avoidance of traffic detours	Auto Users, Truck Operators	Reductions in fatalities, injuries, and property losses, reduction in accident costs on highway segment	$11.2 million in accident cost savings to auto users and truck operators.
		Economic Competitiveness: impact on travel times due to avoidance of traffic detours	Auto Users, Truck Operators	Travel time savings to highway users	$21.7 million in travel time savings to auto users.
		Economic Competitiveness: impacts on vehicle operating costs due to avoidance of detours	Auto Users, Truck Operators	Vehicle operating cost impacts to highway users	$21.0 million in vehicle operating costs
		Environmental Sustainability: impacts on vehicle emissions due to avoidance of traffic detours	Citizens of Canadian and Caddo Counties	Vehicle emissions cost savings	$0.2 million in vehicle emission

Note: All monetary values in the table above are in millions of 2017 dollars discounted using a real discount rate of 7 percent.

The analysis period used in the estimation of benefits and costs spans 22 years, including 1.6 years of construction and 20 years of operation. Total project construction costs are estimated at $22.2 million in 2019 dollars. For the purpose of this BCA, costs were de-escalated to 2017 dollars using the GDP deflator. The total (undiscounted) project costs are estimated at $21.5 million with operations and maintenance costs estimated at $2.7 million.

All relevant data and calculations used to derive the benefits and costs of the project are shown in the BCA model that accompany this grant application. Based on the analysis presented in the remainder of this document, the project is expected to generate $54.1 million in discounted benefits, and $16.3 million in discounted costs, using a 7 percent real discount rate. Therefore, the project is expected to generate a Net Present Value of $36.9 million and a Benefit/Cost Ratio of 3.3 as shown in Table ES- 2.

Table ES- 2: Summary of BCA Outcomes, in Millions of Dollars of 2017*

Project Evaluation Metric	Undiscounted	Present Value at 7% Discount Rate	Present Value at 3% Discount Rate
Total Benefits	$143.4	$54.1	$92.1
Total O&M Costs	$2.7	$0.9	$1.7
Total Construction Costs	$21.5	$16.3	$19.1
Net Present Value	$119.1	$36.9	$71.3
Benefit / Cost Ratio	6.5	3.3	4.7
Internal Rate of Return (%)	26.3%		

**Unless indicated otherwise*

In addition to the monetized benefits, the project would generate benefits that are difficult to quantify in monetary terms. A brief description of such benefits is provided below.

<u>Economic Competitiveness</u>

- Contribution to local economic development and growth - The Bridgeport Bridge is a part of the Bridgeport Hill-Hydro NRHP-listed Route 66 Segment. The historic bridge is arguably one of the most important elements of Route 66, and also has individual historic significance. By replacing the existing structure in a manner that preserves the historic aesthetics, the project will enhance the growing economic potential of Route 66 as a tourist destination and preserve the route for tourist-driven economic development. .

<u>Quality of Life</u>

- Enjoyment of the bridge as a tourist attraction - The project will provide a modern, safe structure while preserving its historical status as a tourist attraction. The project will provide an alternative for those that wish to experience Route 66, as opposed to bypassing the scenic and culturally historic area by using I-40.

2. Introduction

This document provides detailed technical information on the economic analyses conducted in support of the grant application for the US-281 Bridgeport Bridge over South Canadian River project. The remainder of this document is organized as follows:

Section 3: Methodological Framework, introduces the conceptual framework used in the BCA:

Section 4: Project Overview, provides an overview of the project, including a brief description of existing conditions and the proposed alternative; a summary of cost estimates and schedule; and a description of the types of effects that the project is expected to generate;

Section 5: General Assumptions, discusses the general assumptions used in the estimation of project costs and benefits;

Section 6: Demand Projections, provides estimates of travel demand and traffic growth;

Section 7: Benefits Measurement, Data and Assumptions, presents specific data elements and assumptions pertaining to the long-term outcome selection criteria along with associated benefits estimates;

Section 8: Summary of Findings and BCA Outcomes, provides estimates of the project's Net Present Value (NPV), its Benefit/Cost Ratio (BCR) and other project evaluation metrics;

Section 9: BCA Sensitivity Analysis, provides the results of the sensitivity analysis in terms of changes to NPV and BCR.

Additional data tables are provided within the BCA model including annual estimates of benefits and costs to assist the U.S. Department of Transportation (USDOT) in its review of the application.[1]

3. Methodological Framework

The BCA conducted for this project includes the monetized benefits and costs measured using USDOT guidance, as well as the quantitative and qualitative merits of the project. A BCA provides estimates of the benefits that are expected to accrue from a project over a specified period and compares them to the anticipated costs of the project. Costs include both the resources required to develop the project and the costs of maintaining the new or improved asset over time. Estimated benefits are based on the projected impacts of the project on both users and non-users of the facility, valued in monetary terms.[2]

While BCA is just one of many tools that can be used in making decisions about infrastructure investments, USDOT believes that it provides a useful benchmark from which to evaluate and compare potential transportation investments.[3]

[1] While the models and software themselves do not accompany this appendix, they are provided separately as part of the application.
[2] USDOT, Benefit-Cost Analysis Guidance for Discretionary Grant Programs, December 2018.
[3] Ibid.

The specific methodology adopted for this application is based on the BCA guidance developed by USDOT and is consistent with the BUILD program guidelines. In particular, the methodology involves:

- Establishing existing and future conditions under the build and no-build scenarios;
- Assessing benefits with respect to selection criteria identified in the Notice of Funding Opportunity (NOFO);
- Measuring benefits in dollar terms, whenever possible, and expressing benefits and costs in a common unit of measurement;
- Using USDOT 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 USDOT (7 percent, and 3 percent for sensitivity analysis); and
- Conducting a sensitivity analysis to assess the impacts of changes in key input assumptions.

4. Project Overview

The Bridgeport Bridge is located on US-281 spanning the South Canadian River in Caddo and Canadian Counties, Oklahoma. The bridge is a historically significant structure on the original path of Historic Route 66 and a key feature of the Oklahoma Route 66 National Scenic Byway that is integral to regional and national tourism economies.

The Route 66 corridor continues to grow in popularity as a nostalgic road trip adventure and is certain to surge in popularity with the upcoming 2026 Centennial Celebration. The Bridgeport Bridge is not only an essential historic link in the Route 66 story, it is also essential key physical link, connecting nearby Route 66 tourist attractions both east and west, from Robert's Grill (since 1926) in El Reno, OK, to the Cherokee Trading post in Calumet, OK. Just west of the bridge is Lucille's Service Station (built in 1929) in Hydro, OK, and the Route 66 Museum down the road in Clinton, OK. Route 66 travelers spend a significant amount of money during their trip contributing to the local economies.

The bridge is currently assessed by ODOT as structurally deficient and in critical need of replacement. The bridge is already load posted to heavy traffic, and in October 2018, the load restrictions were further increased from 15 tons to 9 tons after inspection revealed rapidly deteriorating condition of gusset plates and other superstructure elements. It is anticipated that if no action is taken, the bridge will be closed to all traffic beginning in 2021, forcing all traffic to take a lenghty detour of 11.5 miles.

The US-281 Bridgeport Bridge Project will replace the existing 2-lane bridge with a new deck and superstructure that maintains the same width. The historic trusses will be put back into place on the outside of the new structure to preserve its historic aesthetic appeal. The majority of the substructure elements will be retained, with new pier caps provided to support the new superstructure and trusses. The replacement of the deficient bridge will eliminate the implications of its impending closure.

The project will enhance the growing economic potential of Route 66 as a tourist destination by maintaining the aesthetics of this historically significant bridge and preserving the route for similar tourist driven economic development. The replacement will provide the opportunity for tourists and locals alike to enjoy the scenic bridge for years to come. Finally, the project will also increase efficiency of the movement of people and goods by avoiding bridge closure, avoiding lengthy detours and improving local transportation connectivity.

4.1 No-Build and Build Scenarios

The No-Build scenario reflects the continuation of current conditions. The bridge is currently in poor condition, posted for load restrictions (at 9 tons), and it is anticipated that it will be closed to all traffic at the beginning of 2021. Operations and maintenance will continue until the date of closure with no major infrastructure improvements.

Upon closure, traffic traversing this bridge will be forced to use an alternative route, which is approximately 6 miles longer. This will result in additional travel time, travel costs, vehicle emissions, and the potential for additional road collisions.

The Build scenario assumes that the Bridgeport Bridge will be replaced as planned, avoiding its impending closure and related traffic impacts.

4.2 Types of Impacts

The replacement of the US-281 Bridgeport Bridge will prevent its long term closure, allowing vehicles to continue using the bridge, avoiding lengthy detour routes. Replacement of the structurally deficient bridge can then be expected to generete significant travel time savings benefits as well as corresponding impacts on vehicle operating costs and environmental emissions. The new bridge will maintain its original appearance thus continuing to draw tourists and related expenditures to the region.

4.3 Project Cost and Schedule[4]

Total project construction costs are estimated at $22.2 million in 2019 dollars. For the purpose of this BCA, the costs were de-escalated to 2017 dollars using the GDP deflator.[5] The adjusted cost amounts to $21.5 million in 2017 undiscounted dollars and $16.3 million discounted at 7 percent. The environmental assessment effort began in 2015 with an alternatives analysis and series of stakeholder meetings, and is planned for completion in January 2021. The design process is currently underway, with an anticipated completion date of June 2021. Construction will start at

[4] All cost estimates in this section are in millions of dollars of 2017, discounted to 2018 using a 7 percent real discount rate.

[5] The adjustment amounted to dividing 2019 costs by the deflator index of 1.0327 based on the GDP deflator for the years 2017 - 2019 (Office of Management and Budget of the White House, Table 10.1, https://www.whitehouse.gov/omb/historical-tables/)

the beginning of 2022 and be completed by late July 2023. Over the project life cycle, total operations and maintenance costs are estimated at $0.9 million discounted at 7 percent.

Table 1. Summary of Costs, Millions of 2017 Dollars

	Over the Project Lifecycle		
	In Constant Dollars	Discounted at 7 Percent	Discounted at 3 Percent
Construction & Development Costs	$21.5	$16.3	$19.1
Operations and Maintenance	$2.7	$0.9	$1.7
Total	**$24.3**	**$17.2**	**$20.8**

4.4 Effects on Selection Criteria

Table 2 provides main benefit categories associated with the project mapped into the selection criteria set forth by USDOT in the Notice of Funding Opportunity (NOFO).

Table 2. Benefit Categories and Expected Effects on Selection Criteria

Selection Criteria	Benefit or Impact Categories	Description	Monetized	Qualitative
Safety	Reduction in number of traffic crashes, fatalities and injuries	Reduction in property losses, injuries, and deaths due to reduction in detours/out-of-direction miles traveled	Yes	
Economic Competitiveness	Reduction in travel times due to avoidance of detours/out-of-direction travel	Travel time savings for roadway users due to avoided detours/out-of-direction travel when bridge is closed.	Yes	
	Impacts on vehicle operating costs due to avoidance of detours/out-of-direction travel	Reduction in monetary costs to drivers due to avoided detours/out-of-direction miles traveled	Yes	
	Contribution to local economic development and growth	The bridge is part of the scenic Bridgeport Hill-Hydro Route 66 Segment Historic District. The new bridge will continue serving tourists and area businesses.		Yes
Quality of Life	Enjoyment of bridge as a tourist attraction	The project will replace the bridge while preserving its historical status as a tourist attraction.		Yes
Environmental Protection	Impacts on vehicle emissions	Reduction in air pollutants due to reduction in detours/out-of-direction travel.	Yes	
	Minimization of impacts to South Canadian River and critical species habitat.	Preservation of the existing substructure elements will minimize in-water work and impacts to the critical habitat of the Arkansas River Shiner.		Yes

5. General Assumptions

The BCA measures benefits against costs throughout a period of analysis beginning at the start of the bridge closure and includes 20 years of operations.

The monetized benefits and costs are estimated in 2017 dollars with future dollars discounted in compliance with BUILD requirements, using a 7 percent real rate with a sensitivity test 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 2017 dollars;
- The period of analysis begins in 2019 and ends in 2042. It includes project development and construction years (2019 – 2023) and 20 years of operations (August 2023 – December 2042);
- 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 and benefits are inputs to the BCA and are assumed to be fully realized after construction is finished in 2023 (no ramp-up); and,
- Unless specified otherwise, the results shown in this document correspond to the effects of the Full Build alternative, replacement of the Bridgeport Bridge.

6. Demand Projections

The traffic forecast is a critical component of the benefit-cost analysis, as most of the benefits depend on the change in vehicle miles of travel between the No-Build and Build scenarios.

Current 2018 traffic volumes crossing the evaluated bridge, including the share of truck traffic, as well as estimates of future (for year 2060) traffic were provided by the Collision Analysis and Safety Branch of Oklahoma Department of Transportation (ODOT). Annual traffic volumes were then interpolated from these two figures using the implied average annual rate of growth. The assumptions are presented in **Error! Reference source not found.** below. Resulting traffic estimates for key years (applicable to both No-Build and Build scenarios) are presented in Table 4.

Table 3. Assumptions Used in the Estimation of Traffic

Variable Name	Unit	Value	Source
Current Traffic Crossing Bridge (2018)	ADT	1,800	ODOT's Collision Analysis and Safety Branch
Future Traffic (2060)	ADT	4,100	ODOT's Collision Analysis and Safety Branch
Average Annual Rate of Growth	Percent	1.98%	Calculated from traffic inputs above.
Truck Share	Percent	21%	ODOT's Collision Analysis and Safety Branch

Table 4. Traffic Projections

Year	Total ADT
2018	1,800
2019	1,836
2020 (Construction Start)	1,872
2023 (Project Completion, First Year of Benefits)	1,985
2025	2,065
….	….
2041	2,825
2042	2,881

7. Benefits Measurement, Data and Assumptions

7.1 Safety Benefits Impacts

Safety criteria for BUILD grants include impacts such as improving safety outcomes within the project area or wider transportation network including how the project will reduce the number, rate and consequences of transportation-related accidents, serious injuries, and fatalities. With the closure of the Bridgeport Bridge, traffic will be rerouted adding some 6 miles of travel. The additional vehicle miles travelled (VMT) may increase the number of vehicle crashes. Replacement of the bridge avoids additional VMT and associated crashes.

7.1.1 METHODLOGY

Crash rates and crash statistics on the bridge and detour route were provided by ODOT's Collision Analysis and Safety Branch. The distribution of crashes by accident type (fatal, injury, property damage only) was assumed based on these crash statistics.

Safety benefits impacts were monetized based upon the difference in the estimated on the number of accidents, by severity, under No-Build and Build scenarios using the social values of accident costs as recommended by USDOT.

7.1.2 ASSUMPTIONS

The assumptions used in the estimation of safety benefits are summarized in Table 5.

Table 5. Assumptions Used in Safety Benefits

Variable Name	Unit	Value	Source
Fatality	$/Victim	$9,600,000	US DOT, Benefit-Cost Analysis Guidance for Discretionary Grants Program, December 2018.
Injury	$/Victim	$174,000	US DOT, Benefit-Cost Analysis Guidance for Discretionary Grants Program, December 2018.
No Injury/ PDO	$/Vehicle	$4,300	US DOT, Benefit-Cost Analysis Guidance for Discretionary Grants Program, December 2018.
Accident rate, current	rate, number per million VMT	122.5	ODOT - Collision Analysis and Safety Branch. Crash rate for the bridge over period 2013-2018.
Fatality	rate, number per million VMT	0	Calculated from ODOT collision data for the bridge over period 2013-2018.
Injury Accidents	rate, number per million VMT	18	Calculated from ODOT collision data for the bridge over period 2013-2018.
No injury/ PDO	rate, number per million VMT	105	Calculated from ODOT collision data for the bridge over period 2013-2018.
Accident rate, detour route	rate, number per million VMT	66.4	ODOT- Collision Analysis and Safety Branch. Crash rate for the detour route over period 2013-2018.
Fatality	rate, number per million VMT	1.2	Calculated from ODOT collision data for the detour route over period 2013-2018.
Injury Accidents	rate, number per million VMT	20.2	Calculated from ODOT collision data for the detour route over period 2013-2018.
No injury/ PDO	rate, number per million VMT	44.9	Calculated from ODOT collision data for the detour route over period 2013-2018.
Number of injured per injury crash on bridge	Number per Crash	1.00	Calculated from bridge crash statistics 2013 to 2018.
Number of injured per injury crash on detour	Number per Crash	1.40	Calculated from detour crash statistics 2013 to 2018.
Damaged vehicles per PDO crash	Number per Crash	1.31	ODOT - Collision Analysis and Safety Branch. Number of damaged vehicles per PDO crash over period 2013-2018.

7.1.3 BENEFIT ESTIMATES

Table 6 shows that the proposed project will result in a safety benefit of $11.2 million discounted at 7 percent, or $29.6 million in undiscounted dollars.

Table 6. Estimates of Safety Benefits, Millions of 2017 Dollars

	In Constant Dollars	Discounted at 7 Percent	Discounted at 3 Percent
Monetary Value of Safety Benefits	$29.6	$11.2	$19.1

7.2 Economic Competitiveness

Economic Competitiveness criteria for BUILD grants include impacts of the project on the movement of good and people. These impacts include how the project increases the efficiency of movement and thereby reduces the costs of doing business, improves local and regional freight connectivity and reduces the burden of commuting improving overall well-being.

The replacement of the Bridgeport Bridge is expected to have significant economic competitiveness effects. Specifically, they can be grouped under two categories of impacts:

(1) Travel Time Saving, and

(2) Vehicle operating costs savings.

The first category captures the reduced travel time for automobiles and trucks due to avoided detours after bridge closure. The avoided detours also save vehicle operating costs, which represent the second category of benefits.

7.2.1 METHODOLOGY

Travel Time Savings

Estimation of travel time savings due to avoidance of detours requires determination of a travel route that vehicles are currently taking when crossing the bridge and that they would likely take when the bridge eventually closes.

The travel routes (and their associated length) were assessed using a planning level approach (Google maps) by considering the next best and suitable travel path in the local area.

Total travel times were calculated as a product of route travel time and the volume of vehicles. The detour route under the No-Build scenario is expected to be longer than the typical route under the Build scenario. The difference in total travel time between the detour route and the typical route represents travel time savings. Travel time savings were calculated separately for auto and trucks and monetized using the value of time as recommended by USDOT.

Vehicle Operating Costs Impacts

Vehicle operating cost savings were calculated for incremental vehicle miles of travel due to detours as the product of the vehicle miles and the out-of-pocket travel cost for items such as fuel and maintenance. This cost was measured in terms of dollars per mile, recommended by USDOT, and was assumed to be constant over the analysis period.

7.2.2 ASSUMPTIONS

The specific assumptions used in the estimation of travel time savings and out-of-pocket travel cost are summarized in Table 7.

Table 7. Assumptions Used in the Estimation of Economic Competitiveness Benefits

Data Item	Unit	Value	Source and Comments
Typical route			
Route length	Miles	5	Calculated based on Google maps.
Travel time	Minutes	5	Calculated based on Google maps.
Detour			
Full detour route length	Miles	11.5	Calculated based on Google maps.
Full detour travel time	Minutes	13	Calculation based on posted speed and detour length.
Auto Traffic that would take detour	%	100%	Known due to bridge closure.
Truck Traffic that would be detoured	%	100%	Known due to bridge closure.
Date when bridge would be closed to traffic under no-build	-	1/1/2021	Engineering assessment.
Vehicle Operating Costs			
Passenger Vehicles	$ per mile	$0.39	US DOT, Benefit-Cost Analysis Guidance for Discretionary Grants Program, December 2018.
Trucks	$ per mile	$0.90	US DOT, Benefit-Cost Analysis Guidance for Discretionary Grants Program, December 2018.

7.2.3 BENEFIT ESTIMATES

The estimated benefits of economic outcomes are shown in Table 8. Total economic outcomes benefit over the analysis period amount to $113.3 million in constant 2017 dollars or $42.7 million in dollars discounted at 7 percent. The benefits are approximately equally distributed between travel time savings and vehicle operating cost savings.

Table 8. Estimates of Economic Competitiveness Benefits, Millions of 2017 Dollars

	In Constant Dollars	Discounted at 7 Percent	Discounted at 3 Percent
Monetary Value of Travel Time Saving	$57.9	$21.7	$37.1
Monetary Value of Vehicle Operating Cost Savings	$55.4	$21.0	$35.6
Total	**$113.3**	**$42.7**	**$72.7**

7.3 Environmental Sustainability

Environmental Sustainability criteria for BUILD grants include impacts such as reduced energy consumption, reduced stormwater runoff or achieving other benefits for the environment such as brownfield redevelopment. The replacement of the US-281 Bridgeport Bridge is expected to have an impact on vehicle emissions and emissions costs due to the avoidance of additional vehicle miles of travel associated with the longer detour route. This section presents the methodology and assumptions.

7.3.1 METHODOLOGY

Emissions impacts were calculated for the incremental vehicle miles of travel due to detours as the product of these vehicle miles of travel and the social cost of vehicle emissions (dollars per mile). That cost was calculated using vehicle emissions rates (grams of emission per mile) and social cost of emission for various categories of air pollutants (dollars per ton of emissions) recommended by USDOT. Auto and truck emission rates were adopted from Cal-B/C, a nationally recognized sketch-planning model for benefit-cost analysis of transportation infrastructure projects (developed by the California Department of Transportation). The rates used in most recent version of Cal-B/C are based on fuel consumption rates and emission factors from EMFAC 2014 model. This analysis focuses on Criteria Air Contaminant (CAC) emissions (NOx, VOC, SOx, and PM2.5). The speed assumed for the calculations is 65 mph. The BCA spreadsheet model provided with this application contains full details of the calculation of cost per mile, including the specific emission factors assumed for each pollutant.

7.3.2 ASSUMPTIONS

Table 9 presents the assumptions regarding social costs of vehicle emissions and resulting cost of emissions per VMT.

Table 9. Assumptions Used in the Estimation of Environmental Benefits

Variable Name	Unit	Value	Source
Nitrogen Oxides (NOx)	$ per metric ton	$8,300	US DOT, Benefit-Cost Analysis Guidance for Discretionary Grants Program, December 2018.
Fine Particulate Matter (PM2.5)	$ per metric ton	$377,800	US DOT, Benefit-Cost Analysis Guidance for Discretionary Grants Program, December 2018.
Sulfur Dioxide (SO2)	$ per metric ton	$48,900	US DOT, Benefit-Cost Analysis Guidance for Discretionary Grants Program, December 2018.
Volatile Organic Compounds (VOC)	$ per metric ton	$2,000	US DOT, Benefit-Cost Analysis Guidance for Discretionary Grants Program, December 2018.
Calculated **Aggregate** Emission Costs, 2019-2035			
Auto	$/mile	$0.0022	Calculated by HDR for assumed average speed of 65mph.
Truck	$/mile	$0.0185	Calculated by HDR for assumed average speed of 65mph.
Calculated **Aggregate** Emission Costs, 2036-2041			
Auto	$/mile	$0.0007	Calculated by HDR for assumed average speed of 65mph.
Truck	$/mile	$0.0023	Calculated by HDR for assumed average speed of 65mph.

7.3.3 BENEFIT ESTIMATES

The estimated benefits of vehicle operating cost savings are shown in Table 10. Total environmental benefits over the analysis period amount to $0.4 million in constant 2017 dollars or $0.2 million in dollars discounted at 7 percent.

Table 10. Estimates of Environmental Benefits, Millions of 2017 Dollars

	In Constant Dollars	Discounted at 7 Percent	Discounted at 3 Percent
Monetary Value of Environmental Benefits	$0.4	$0.2	$0.3

8. Summary of Findings and BCA Outcomes

Table 11 summarizes the BCA findings. Annual costs and benefits are estimated over the life cycle of the project (years from 2019 to 2042). As stated earlier, construction is expected to be completed by end of July 2023. Benefits accrue during the operation of the project (over the years 2023-2042, beginning in August 2023).

Table 11. Overall Results of the Benefit Cost Analysis, Millions of 2017 Dollars*

Project Evaluation Metric	Undiscounted	Present Value at 7% Discount Rate	Present Value at 3% Discount Rate
Total Benefits	$143.4	$54.1	$92.1
Total O&M Costs	$2.7	$0.9	$1.7
Total Construction Costs	$21.5	$16.3	$19.1
Net Present Value	$119.1	$36.9	$71.3
Benefit / Cost Ratio	6.5	3.3	4.7
Internal Rate of Return (%)	26.3%		

**Unless indicated otherwise*

Considering all monetized benefits and costs, the estimated internal rate of return of the project is 26.3 percent. With a 7 percent real discount rate, the $16.3 million investment would result in $54.1 million in total benefits, a Net Present Value of $37 million, and a Benefit/Cost Ratio of approximately 3.3.

With a 3 percent real discount rate, the Net Present Value of the project is $71.3 million, with a Benefit/Cost Ratio of 4.7.

Table 12 compiles all project benefits evaluated. The table demonstrates that the majority of project benefits (79 percent) is accounted for by travel time savings and vehicle operating cost savings. The avoidance in accident costs accounts for 21 percent of the overall benefits, while environmental cost savings account for 0.3 percent.

Table 12. Overall Benefits, Millions of 2017 Dollars

Benefit Categories	Over Project Lifecycle		
	Undiscounted	Present Value at 7% Discount Rate	Present Value at 3% Discount Rate
Travel Time Savings	$57.9	$21.7	$37.1
Vehicle Operating Cost Savings	$55.4	$21.0	$35.6
Reduction in Accident Costs	$29.6	$11.2	$19.1
Environmental Cost Savings	$0.4	$0.2	$0.3
Total Benefits	**$143.4**	**$54.1**	**$92.1**

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 sensitivity analysis was conducted with respect to changes in the value of travel time, value of statistical life, capital cost estimate, and annual O&M. The changes in the value of statistical life and capital cost estimate are the parameters that have the greater impact on net present value.

The outcomes of the quantitative analysis for the changes in value of travel time, value of statistical life, capital cost estimate, and rate of growth in traffic estimate using a 7 percent discount rate are summarized in the Table 13. The table provides the percentage change in project NPV associated with variations in variables or parameters (listed in row), as indicated in the column headers. The table demonstrates that this project maintains strong outcomes, even in situations when key input values change in the direction that reduces net benefits. In all situations examined, the Benefit-Cost Ratio remains well above 1.

Table 13. Quantitative Assessment of Sensitivity, Summary

Parameters	Change in Parameter Value	New NPV	% Change in NPV	New B/C Ratio
Value of Travel Time	Lower Bound of Range Recommended by US DOT ($10.35 for autos and $22.86 for trucks)	$30.8	-16.4%	2.9
	Upper Bound of Range Recommended by US DOT ($17.69 for autos and $34.34 for trucks)	$41.2	11.6%	3.5
Value of Statistical Life	Lower Bound of Range Recommended by US DOT ($5.4 million)	$33.2	-10.1%	3.0
	Upper Bound of Range Recommended by US DOT ($13.4 million)	$40.3	9.2%	3.5
Capital Cost Estimate	25% Reduction	$41.0	11.1%	4.3
	25% Increase	$32.8	-11.1%	2.6
Rate of Growth in Traffic	Reduction from 1.98% to 1% Annually	$30.5	-17.2%	2.9