Roosevelt Memorial Bridge Investment Project

Bryan and Marshall Counties, Oklahoma

Benefit Cost Analysis

Technical Memo

November 2023

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Benefit-Cost Analysis

Executive Summary

The Benefit-Cost Analysis (BCA) for the Roosevelt Memorial Bridge Investment Project application compares the costs and benefits of the proposed Project. The analysis utilized the Bridge Investment Program Benefit-Cost Analysis Tool v.1.0.1 (BCA Tool) and associated User Manual released by USDOT with the NOFO for the 2023-2026 Bridge Investment Program (BIP) NOFO. To the extent possible, expected benefits were monetized. A qualitative discussion is presented for benefits that are more difficult to quantify.

The Oklahoma Department of Transportation (ODOT) proposes to construct a new multimodal bridge across Lake Texoma to replace NBI Structure No. 10965 in Bryan County, Oklahoma. Specific improvements planned as part of the project include:

- Construction of a new four-lane bridge with standard shoulders and bicycle/pedestrian accommodations carrying US-70 over Lake Texoma.
- Widening US-70 between State Park Road and Willow Springs Road to a five-lane section (two driving lanes in each direction and a center turn lane) to provide continuity with the sections to the east and west.
- Providing safety features such as lighting, median barrier, and rumble strips, turn lanes where needed at intersections, and a traffic signal and crosswalk at the State Park Road intersection to accommodate traffic from adjacent development.

Table 1 below summarizes the changes expected from the project, and the associated quantified benefits. The period of analysis used in the estimation of benefits and costs is 33 years, including three years of construction, and 30 years of operations[1]. The project will construct a new facility with a 75-year design life and so a longer analysis period was selected. Total project development and construction costs are estimated at $250.6 million. Costs were entered into the BCA Tool in today's dollars and automatically de-escalated to 2021 and discounted for a total discounted capital cost of $180.9 million.

All relevant data and calculations used to derive the benefits and costs of the project are shown in the BCA Tool that accompanies this grant application. Based on the analysis presented in the rest of this document, the Project is expected to generate $1.23 billion in discounted benefits and $180.9 million in discounted capital costs (**Table 1**). Therefore, the Project is expected to generate a Net Present Value of $1.05 billion and a Benefit/Cost Ratio of 6.79 as shown below in **Table 2**.

[1] Sensitivity analysis also considered an evaluation period with 20 years of Project operations. The results of this analysis (for Project NPV and BC ratio) are reported in the BCA Sensitivity Analysis section while the BCA spreadsheet model submitted with this application contains full results.

Table 1: Summary of Monetized Benefits

Baseline Status and Problems to be Addressed	Change to Baseline	Types of Impacts & Benefits	Population Affected by Impacts	Benefit Value (2021 $ millions, 7% discount)
The existing bridge is functionally obsolete and at-risk of becoming structurally deficient. Without improvement, level of service (LOS) on the bridge would decline to LOS E due to projected traffic growth. The Roosevelt Bridge has a demonstrated history of high collision rates on and near the bridge, particularly severe collisions such as injuries and fatalities. The existing Roosevelt Bridge is narrow and does not provide any pedestrian or bicycle accommodations.	ODOT proposes to construct a new four-lane bridge with standard shoulders and bicycle/pedestrian accommodations carrying US-70 over Lake Texoma, widen US-70 between State Park Road and Willow Springs Road to a five-lane section, and provide turn lanes where needed at intersections, and a traffic signal and crosswalk at the State Park Road intersection to accommodate future traffic demand.	***Impact*** - Enhanced roadway design ***Benefit*** - Improved vehicle safety	Vehicle Owners and Truck Operators	$ 269.5
		Impact - Reduced vehicular delays and avoided detours due to structure condition ***Benefit*** - Reduction in travel times	Vehicle Owners, and Truck Operators	$ 514.5
		Impact - Reduced vehicular delays and avoided detours due to structure condition ***Benefit*** - Reduced vehicle operating costs (fuel reduction)	Vehicle Owners and Truck Operators	$ 370.0
		Impact - Reduced time spent idling during delays ***Benefit*** - Emissions reduction	Vehicle Owners, Truck Operators, and Residents of adjacent communities	$ 57.9
		Impact - Removal of overhead truss structure ***Benefit*** – Elimination of bridge hits	Vehicle Owners, Truck Operators, and ODOT	$ 0.1
		Impact **–** Raise in profile grade of new bridge ***Benefit*** **–** Avoidance of closures due to flooding	Vehicle Owners, Truck Operators, and ODOT	$ 1.5
		Impact – Avoided impacts to communities on the detour route ***Benefit*** – Noise reduction	Vehicle Owners, Truck Operators, and Residents of adjacent communities	$ 0.4
		Impact – New structure with less frequent maintenance requirements ***Benefit*** – Maintenance cost savings.	ODOT	$ 7.2
		Impact - New bridge ***Benefit*** – Extended residual life of bridge	ODOT	$ 7.1
Total				**$ 1,228.1**

Table 2: Summary of BCA Outcomes, Millions of 2021 Dollars

Category	Benefit	Percent of Total Benefits
Safety	$ 269,427,194	**22%**
Travel Time	$ 514,458,554	**42%**
VOC	$ 369,956,460	**30%**
Resilience	$ 1,482,952	**<1%**
Health and Amenity	$ -	**0%**
CO2 Emissions	$ 49,567,803	**4%**
Non-CO2 Emissions	$ 8,341,068	**1%**
Other Environmental	$ 411,677	**<1%**
Maintenance	$ 7,205,779	**1%**
Residual Value	$ 7,130,288	**1%**
Other Benefits	$ 103,358	**<1%**
Total Benefits	$ 1,228,130,134	**100%**
Total Discounted Costs	$ 180,857,776	**N/A**
BCR	6.79	**N/A**
Net Present Value (NPV)	$ 1,047,272,358	**N/A**

In addition to the monetized benefits, the project is expected to generate benefits that are more difficult to quantify. A brief description of those benefits is provided below. More detail is presented in the **Merit Criteria** section of the application narrative.

- **Economic Impacts, Freight Movement, and Job Creation**: The existing Roosevelt Bridge currently carries 8,500 vpd with 9% trucks. This number is expected to increase to 27,300 vpd by 2050. Without improvements, LOS on US-70 is anticipated to worsen to LOS E by 2050 and result in significant congestion. The additional two lanes planned as part of the Roosevelt Bridge Project will improve safety and Level of Service on the bridge to LOS B, and remove a bottleneck created by the existing two-lane facility.

  The existing Roosevelt Bridge does not have sufficient capacity to accommodate the anticipated traffic demand. US-70 is an important link on the National Highway System (NHS) and provides critical east-west connectivity across southern Oklahoma, linking major freight routes such as I-35, US-69, and US-75. The City of Ardmore at I-35 and US-70 is the home of several large distribution centers including DOT Foods, Dollar General and Best Buy. Congestion on I-35 is well documented and is the subject of a major new study recently initiated by ODOT. As congestion worsens on I-35, US-70 to US-69 becomes a more attractive route for the freight supply chain to the Dallas Metroplex.

- **Equity, Multimodal Options, and Quality of Life:** The Roosevelt Bridge Project will improve the quality of life for local and regional users. As a critical east-west link, the Roosevelt Bridge provides one of only two crossings of Lake Texoma within the 30 miles between Tishomingo, OK and Denison, TX. Improving the bridge to provide a safe,

multimodal crossing with sufficient capacity to meet current and future demand will improve mobility for all users for future generations. Reliability will be improved with increased capacity providing improved traffic flow, as well as additional bridge width to provide a safer facility, allow collisions to be cleared more quickly, and provide emergency responders better access. The Project will provide accommodation for pedestrians and bicyclists where none exist today. A new multimodal crossing of Lake Texoma would offer opportunity to all sectors of the population. Given the location of Lake Texoma within a Historically Disadvantaged Community, providing bicycle and pedestrian accommodations on the bridge would increase mobility options for local underserved communities. While pedestrian and bicycle travel time savings can potentially be quantified, without sufficient data on existing pedestrian and bicycle trips this benefit was not monetized in this application.

- **Innovation Areas: Technology, Project Delivery, and Financing:**

  Progressive Design Build (PDB): ODOT intends to deliver the Roosevelt Bridge Project as the state's first PDB project. The complexity of the US-70 over Lake Texoma Bridge has many features that would benefit from early owner and contractor collaboration. PDB allows the owner and design-builder to collaborate at the earliest stages of the project development.

  Innovative Technology: ODOT commits to providing 3D computer models of the project as part of the contracting process. This technology will allow contractors to utilize the most recent GPS controlled equipment with Automated Machine Guidance in the construction process.

  Accelerated Bridge Construction (ABC): ODOT has considered ABC techniques under the assumption that a new bridge will be constructed to carry US-70 over Lake Texoma. The use of ABC techniques has the potential to shorten construction time, reduce construction costs, reduce traffic impacts, improve worker safety and improve the quality control of materials.

Introduction and Methodology

This document provides detailed technical information on the benefit-cost analysis (BCA) conducted in support of the grant application for the Project. The BCA includes the monetized benefits and costs measured using the USDOT BCA Tool, 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. While a BCA is just one of many tools that can be used in making decisions about infrastructure investments, it provides a useful benchmark from which to evaluate and compare potential transportation investments. This memo documents the assumptions used to produce the analysis, a description of the baseline, the sources of data used to project the outcome of the project, and the values of key input parameters. The methodology and calculations are derived from the USDOT BCA Tool.

Project Overview

The proposed Project will construct a new multimodal bridge across Lake Texoma. The existing Roosevelt Bridge carries US-70 over Lake Texoma and provides a critical east-west connection across southern Oklahoma (**Figure 1**). The bridge is 4,943 feet long and carries two traffic lanes, one in each direction, on a 24-foot-wide deck with no shoulders. The bridge was constructed in 1942 and is composed of 87 spans, including a 250-foot-long Warren through-truss, and is eligible for inclusion in the National Register of Historic Places (NRHP). The bridge is functionally obsolete and in fair condition, with a likelihood of falling into poor condition (structurally deficient) within three years. The bridge currently carries 8,500 vpd. With major development underway, future traffic volumes are anticipated to exceed 27,000 vpd by 2050[2].

The Project will provide a new structure designed with a 75-year life to today's standards, with sufficient capacity to accommodate future traffic demand. The Project will significantly reduce fatalities and serious injuries, improve the efficiency and reliability of the movement of people and freight, increase resiliency to severe weather events, and provide affordable transportation options to a Historically Disadvantaged Community and Area of Persistent Poverty through accommodations for bicycles and pedestrians. More detail about the Project's safety, state of good repair, economic, resiliency, and equity/quality of life outcomes are presented in the application narrative.

Figure 1: Roosevelt Bridge Location Map

[2] See Traffic Analysis Memo at ODOT Roosevelt Bridge

Specific improvements planned as part of the Project include:

- Construction of a new four-lane bridge on a new alignment with 12' driving lanes and 10' outside shoulders and barrier-separated bicycle/pedestrian accommodations carrying US-70 traffic over Lake Texoma.
- Widening of US-70 between State Park Road and Willow Springs Road to a five-lane section (two 12-foot driving lanes in each direction and center turn lane) to provide continuity with the sections to the east and west.
- Providing safety features such as lighting, median barrier, and rumble strips, turn lanes where needed at intersections, and a traffic signal and crosswalk at the State Park Road intersection to accommodate traffic from adjacent development.

The Project includes replacement of the existing Roosevelt Bridge which is approximately one mile long. The Project also includes reconstruction and widening of the US-70 roadway from State Park Road on the west to Willow Springs Road on the east for a total distance of 4.0 miles (**Figure 2**). In addition to the existing bridge, the Project includes 0.3 mile of US-70 on the west (west approach), the bridge itself, the 0.95-mile lake causeway, and 1.8-mile land causeway. These extents are included in the Project because they include the remaining 2-lane portions of US-70 between the adjacent 5-lane sections. The new bridge is anticipated to be approximately 2 miles long on a new alignment to the south. This new bridge would eliminate the lake causeway and would tie back into the land causeway. Improvements to the entire Project extents are necessary to accommodate the new bridge and to achieve the desired capacity and level of service. Improving just the one-mile bridge structure would not eliminate the existing bottleneck.

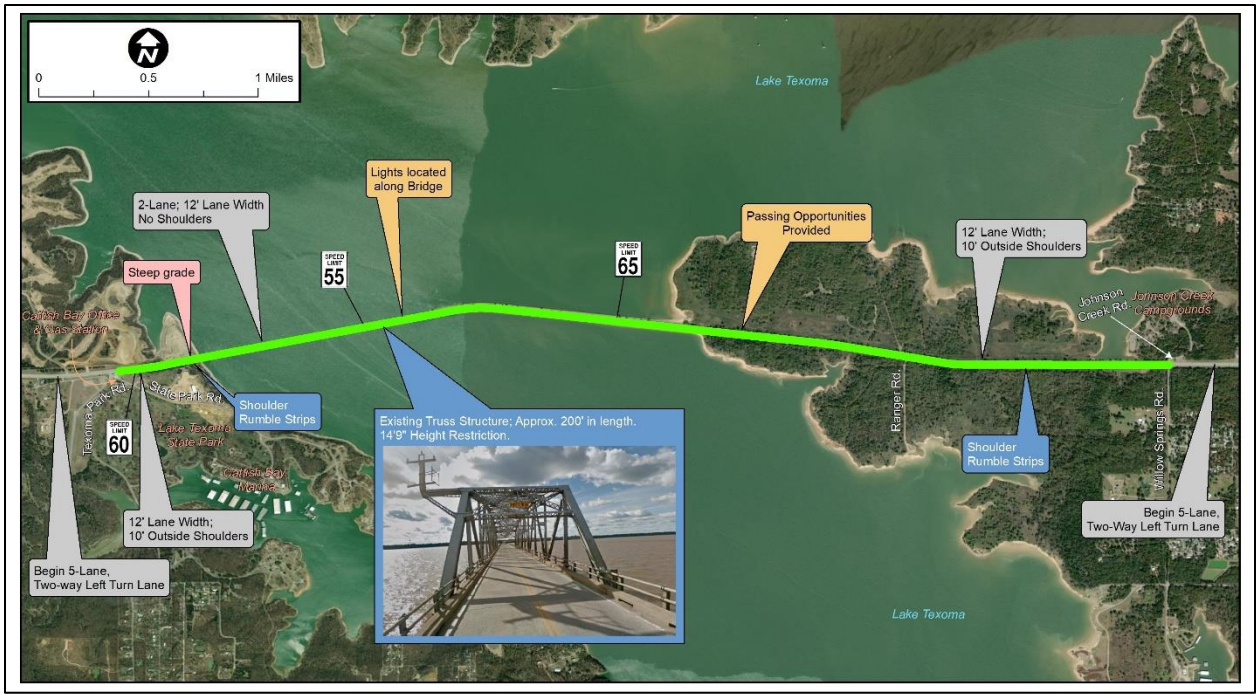

Figure 2: Roosevelt Bridge Project Extents

Base Case and Alternative

The Base Case for the Project is defined as the "No Build" scenario. This scenario reflects no capital improvements within the project limits but would require certain maintenance and rehabilitation costs over the analysis period.

The Alternative Case is defined as the Build scenario as described in the Project Description section above.

Types of Impacts

The proposed Project is expected to have the following impacts:

- Reduction in expected number of crashes due to a wider bridge with standard shoulders and other safety enhancements including shoulder rumble strips, lighting, and median barrier,
- Reduction in travel times and operating costs for automobiles and trucks from faster travel times and reduced delays, with minor disbenefits during construction,
- Reduction in travel times and vehicle operating costs due to avoidance of detours that would be required if the bridge is not improved,
- Improved resiliency to flooding events and avoidance of closured due to flooding,
- Improved pedestrian access as well as health and amenity benefits and improved comfort and safety due to new pedestrian and bicycle accommodations,
- Reduction in noise and emissions due to avoided detours,
- Decreased maintenance costs and increased useful life of the US-70 bridge, and
- Reduced potential damages from bridge hits.

Project Cost and Schedule – Alternative Case

Total project capital development and construction costs are estimated at $250.6 million in today's dollars. The BCA Tool adjusted these costs to 2021 dollars and discounted them by 7%. The adjusted project development and construction cost amounts to $180.9 million in discounted dollars (Bridge Tab Table 12 of the BCA Tool). Project construction is anticipated to start in 2025 and take three years with completion by early 2028. For simplicity, 2028 is assumed as the Project opening year and first year of Project-related benefits.

The Project will require maintenance during the 30-year operating period that is estimated at $1,071,648 (Bridge Tab Table 17 of the BCA Tool).

- Inspections (2-year frequency) - $20,000
- Miscellaneous repairs (20-year frequency) - $771,648

Project Cost – Base Case

The Base Case (No Build) assumes no capital development or construction. However, the Base Case would require major maintenance and rehabilitation over the next 15 years. It is estimated the bridge would require closure in 2038 so no maintenance costs are assumed after that point. Maintenance costs of the No Build include the following:

- Annual inspections (1-year frequency) - $50,000
- Deck replacement (25-year frequency beginning in 5 years) - $8,526,675
- Painting steel (20-year frequency beginning in 5 years) - $4,056,811

- Other miscellaneous repairs (20-year frequency beginning in 5 years) - $405,681

The total major maintenance rehabilitation costs required are estimated at about $13.7 million. While the Alternative Case has maintenance costs associated with the project lifecycle planning, it is less than what would be incurred under the Base Case when discounted over time. Thus, the Alternative case creates a net savings in maintenance costs of approximately $7.2 million in discounted costs (BCA Tool Bridge Tab Table 17).

Alignment with Selection Criteria

The main benefit categories associated with the Project are mapped into the merit criteria set forth by U.S. DOT in **Table 3** below.

Table 3: Benefit Categories of the Project

Criteria	Benefit(s)	Description	Monetized	Qualitative
Safety	Increased vehicle safety	Widened bridge, and addition of shoulders, rumble strips, lighting, and median barrier are expected to reduce collisions and fatalities. Also savings from avoidance of detours as associated crashes.	Yes	Yes
	Added pedestrian and bicycle comfort and safety	The new pedestrian and bicycle accommodations will provide a safe environment for pedestrian and bicyclists	No	Yes
State of Good Repair	Reduced O&M Cost	Bridge replacement will reduce O&M	Yes	Yes
	Residual Value	Useful life of bridge will be extended	Yes	Yes
	Reduced bridge hits / damages	The removal of the truss is expected to reduce bridge hits	Yes	Yes
	Detour avoidance	Bridge replacement will avoid costly detours when the bridge is load posted and eventually closed	Yes	Yes
Economic Impacts, Freight Movement, and Job Creation	Contribution to local economic development and growth	Economic impact of construction project and increased access to adjacent development.	No	Yes
	Travel time savings	Travel time reliability will increase the efficiency and movement of the goods and people surrounding the project.	Yes	Yes
	Support good paying jobs and strong labor standards	Construction will provide good paying jobs and will provide equal	No	Yes

Criteria	Benefit(s)	Description	Monetized	Qualitative
		employment opportunities.		
Climate Change, Resiliency, and the Environment	Emissions reduction	Detour avoidance will reduce emissions.	Yes	Yes
	Noise reduction	Detour avoidance will reduce noise impacts along the detour route.	Yes	Yes
	Flood Resiliency	The raise in elevation of the bridge will reduce future bridge closures and detour delay	Yes	Yes
Equity, Multimodal Options, and Quality of Life	Pedestrian and bicycle accommodation	The new pedestrian and bicycle accommodations will provide a safe environment for pedestrian and bicyclists to access for park users	No	Yes
Innovation Areas: Technology, Project Delivery, and Financing	Use of New Technologies	The use of 3D models, GPS controlled equipment, and E-construction methods will be utilized in the implementation of this project.	No	Yes
	Accelerated Bridge Construction	ABCs have the potential to shorten construction time.	No	Yes
	Progressive Design Build	The Project would be ODOT's first Project Design Build Project.	No	Yes

General Assumptions

The BCA measures benefits against costs throughout a period of analysis beginning at the start of construction and including 30 years of operations. The methodology makes several important assumptions and seeks to avoid overestimation of benefits and underestimation of costs. These assumptions are documented in the USDOT BCA Tool. Specifically:

- Input prices, costs, and benefits are expressed in 2021 dollars.
- The period of analysis begins in 2028 and ends in 2057. The project includes three years of project development and three years of construction in 2025 - 2027 prior to the 30-year analysis period (2028 – 2057).
- A constant 7 percent real discount rate is assumed throughout the period of analysis, except for benefits impacts related to CO_2 greenhouse (GHG) emissions which are discounted at a 3 percent real discount rate.
- Opening year demand and benefits are inputs to the BCA and are assumed to be fully realized after construction is finished and project starts operations in 2028 (no ramp-up).

Delay Forecasts

The delay forecast is a critical component of the BCA as multiple benefits depend on the vehicle delays using the project area roads under No-Build and Build scenarios. In the BCA Tool, delay savings is estimated as a function of the increase in speeds anticipated with the Project (i.e. from 55 to 65 mph as shown in Bridge Tab Table 43). While this estimate was used in the calculation of Project benefits, this number is likely underestimated. In the final year under the No-Build condition, speeds on the bridge are likely to be less than 55 mph due to congestion and decreased Level of Service (estimated at E by the Project traffic analysis). Traffic volumes used in this BCA were extracted from the Roosevelt Bridge traffic analysis rather than from NBI data. The project specific traffic analysis was based on actual count data collected in 2021 and processed into design traffic volumes that are shown in Table 53 of the BCA Tool Bridge Tab. Synchro 11 analysis software was used to evaluate traffic operations at the study intersections and produce Level of Service values for both Build and No-Build and existing and future conditions. More detail can be found in the Traffic Analysis Memo at ODOT Roosevelt Bridge. While travel time benefits to pedestrian and cyclist travel times are also anticipated, these were not monetized due to lack of current pedestrian/cyclist use of the bridge and an unknown number of future users.

Bridge Posting and Closure Dates

The BCA Tool uses FHWA's National Bridge Investment Analysis System (NBIAS) to estimate the years that the bridge would require posting and ultimately be closed, based on statistical data. Based on the NBIAS data, the Roosevelt Bridge would require full posting (all trucks and buses) in 2048 and would require closure in 2052. However, based on the extensive analysis of the existing bridge completed by ODOT, multiple deficiencies in numerous components were identified that suggest load posting and closure would likely occur much sooner. The concrete deck has multiple large spalls throughout and areas where the deck lifts off the steel floor beams due to pack rust. All joints have lost their seals allowing water to flow onto the steel beams and girders supporting the deck. Many of the steel floor beams in the approach spans have significant corrosion and section loss resulting in substantial member capacity reduction. Numerous bearings have sheared bolts and shifted bearing plates. The metal bridge rail has numerous connections that are sheared, missing, or other failed connections. The rail has also been impacted multiple times by vehicles resulting in misalignment and damaged posts throughout. See the Analysis of Existing Bridge Report for more details, available at ODOT Roosevelt Bridge.

While ratings on the bridge may not fall to a 2 or a 3 before posting/closure, there are safety risks associated with the bridge that demand a quicker response. The bridge railing would likely fail today if struck during a collision. Fatality rates on the bridge are double the statewide average. ODOT's study of the bridge and understanding of the safety risks the bridge presents suggest that load posting could occur as soon as next year; however, 10 years (2033) was used as a conservative estimate for the purposes of this BCA. The year of closure, 2038, is consistent with the NBIAS method of estimating year of closure approximately 3.68 years after posting. In this case 5 years as assumed as a conservative estimate. See Tables 24 and 25 on the Bridge Tab in the BCA Tool.[3]

[3] Sensitivity analysis also considered the years of posting and closure suggested by NBIAS (2048 and 2052). The results of this analysis (for Project NPV and BC ratio) are reported in the BCA Sensitivity Analysis section.

Benefits

This section describes the measurement approach used for each quantifiable benefit or impact category identified in **Table 1** and provides an overview of the methodologies and assumptions. A summary of all benefits is presented in **Table 2**.

Safety Benefits

There were 58 total collisions on the Roosevelt Bridge and approaches from 2016 to 2020. Quantified safety benefits include reduction in expected number of crashes through safety enhancements including widening from 2-lanes to 4-lanes, shoulder rumble strips, lighting, and median barrier. Using a Crash Modification Factor (CMF) approach, the project provides a CMF of 0.44[4]. This rate is expected to reduce average annual crashes by 6.5. Monetization of crashes is calculated by the BCA Tool according to values provided in the BCA Guidance document (Table 39 in the BCA Tool). In addition, the Project will realize safety benefits from avoided detouring. Under the Base Case, the existing bridge would require posting for all trucks and buses in 2033 and full closure in 2038. After 2033, all trucks and buses would be required to use a 21.5-mile detour. After 2038, all vehicles would be required to use the detour (**Figure 2**). In total, safety benefits of the Project are estimated at $263.0 million. Safety benefits are reduced somewhat by the increased collision risk due to the presence of work zones during construction. This disbenefit was estimated by using a CMF to reduce shoulder width that would suggest a 2% increase in crashes.[5] This value was entered into Bridge Tab Table 19 and resulted in a safety disbenefit of $432,810.

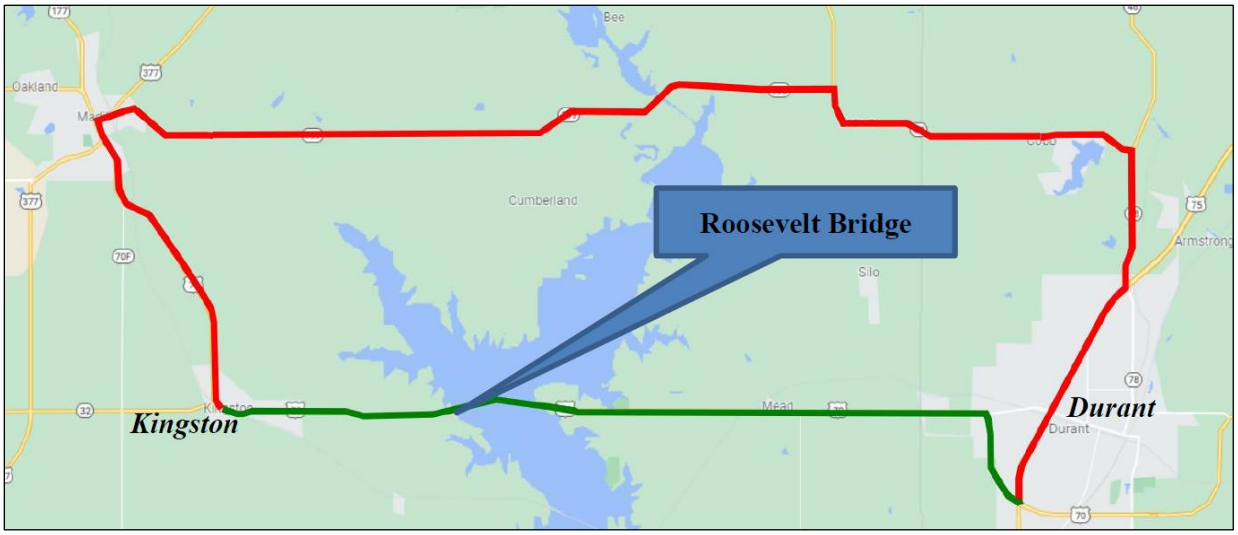

Figure 2: Roosevelt Bridge Detour

[4] CMF derived from combination of several countermeasures, including widening from 2 to 4 lanes (CMF 7573, 53% reduction), shoulder rumble strips (CMF 7267, 13-51% reduction), lighting (CMF 11026/11027, 28% nighttime reduction), and median barrier (CMF 974, 43% reduction). The countermeasures are multiplicative when added to calculate the overall crash reduction percentage.

[5] CMF 886 assuming reduction in shoulder width from 6' to 5'.

By 2057, the project is anticipated to impact 4,456,968 person-miles traveled (PMT) assuming the average daily traffic volumes shown in Bridge Tab Table 53 of the BCA Tool, including 9% truck traffic and 1.67 persons/vehicle (per BCA guidance) traveling the 4-mile project distance (see Column M of Bridge Tab Table 53). Providing a new bridge with two lanes in each direction will allow the Roosevelt Bridge to operate at an acceptable level of service for both people and freight.

Travel Time Savings

The Roosevelt Bridge project will add a lane in each direction to US-70 and will provide travel time and mobility related benefits in addition to those from the avoidance of detours due to bridge posting/closure. Using Table 43 in the BCA Tool Bridge Tab, the average travel time savings is 0.67 minutes/vehicle. Under the No Build scenario, the posted speed limit would remain 55 miles per hour (mph). With the additional lanes and added shoulders the new speed limit on the bridge would be 65 mph. Travel time savings due to delay reduction results in a $514.5 million benefit. However, as discussed above, this benefit is likely underestimated since congestion and delay in 2057 under the Base Case scenario would reduce speeds below 55 mph.

The project is also anticipated to provide travel time savings to pedestrians and cyclists. The project will add a designated pedestrian and bicycle facility across Lake Texoma where none exists today. It is anticipated that this facility will attract users from among the visitors to Lake Texoma as well as from those looking for a more affordable mode of transportation. However, these benefits are not monetized in the BCA due to a lack of data on how many pedestrians and cyclists would use the future facility. Since there is no facility today there is no count data or other sources to form the basis of an estimate.

As shown in **Figure 2**, a closure of the Roosevelt Bridge would result in a detour of approximately 39.1 miles (red route). For the purposes of determining a detour distance, it is assumed the majority of the traffic is travelling a distance at minimum of 17.6 miles between Kingston and Durant (green route), creating a 21.5-mile detour. The impact of detours related to structural degradation assumed the bridge would be load posted in 2033 and all trucks and buses would be forced to use the detour, while a full closure would occur by 2038. The closest detour to cross Lake Texoma is to use Route 199 to the north. As described above, according to the ODOT State Bridge Engineer, it is likely the existing bridge will require posting in the near term. However, to be conservative, 10 years was used in this analysis for posting, and 15 years to closure This closure would be permanent under the No Build scenario.

Travel time savings are reduced somewhat by delays during construction. It is estimated that work zones will be in place approximately 270 days for each of the last two years of construction. Because the majority of the new bridge can be constructed without affecting existing traffic, no impacts were assumed in year one. Disbenefits of work zone delays are estimated at $398,507.

Resiliency

The avoided detours benefit was calculated to estimate the benefit of eliminating future detours due to flood events. Based on historical data, flood events that force the Roosevelt Bridge to be closed due to high water occur once every 25 years and require closures to all traffic of roughly seven days on average. While this frequency may increase in the future due to climate change and more extreme weather events, the same 4% annual probability was assumed from opening year to final year. No structural damage was assumed due to lack of data, although this certainly may

occur due to stress on the substructure. The Project will reduce the flooding potential to essentially zero (0.005%) with a 6-foot raise in the vertical profile of the bridge to be well above the water surface elevation of the 200-year storm event. Flood events are not accounted for once the detour related to structural degradation is place. Resiliency benefits are estimated at $1.5 million.

Reduced Vehicle Operating Costs

According to the BCA Tool User Manual, vehicle operating costs are captured in the benefits of delay savings and detour avoidance. Estimated vehicle operating cost savings of the Roosevelt Bridge project are $370.0 million.

Emissions Reduction

Emissions reduction benefits are captured in the delay savings and detour avoidance benefits. Emissions reduction benefits for the Roosevelt Bridge are estimated at $49.6 million for CO2 and $8.3 million for non-CO2 emissions.

Other Environmental

The BCA Tool calculates noise reduction benefits as a result of detour avoidance. The benefit is calculated at $411,677.

Maintenance Savings

As described above, the total major maintenance and rehabilitation costs required under the Base Case are estimated at about $13.7 million, compared to the Alternative Case at approximately $1.1 million. While the Alternative Case has maintenance costs associated with the project lifecycle planning, it is less than what would be incurred under the Base Case when discounted over time. Thus, the Alternative case creates a net savings in maintenance costs of approximately $7.2 million in discounted costs (BCA Tool Bridge Tab Table 17).

Residual Value

The residual value of project assets is calculated in Bridge Tab Table 13 of the BCA Tool. Under the No Build scenario, the existing bridges would not have any remaining useful life in 2057. The new bridge is assumed to have a design life of 75 years and represents approximately 75% of the project cost. Associated approach roadway improvements are estimated at 25% of the project cost and are estimated to have a 20-year design life. The residual value translates to a benefit of $7.1 million in discounted savings.

Reduced Bridge Hits

The Project will replace the existing bridge structure that has a truss span with insufficient vertical clearance and is more subject to vehicle hits. The Project would construct a new bridge without the truss span, eliminating the potential for a vehicle hit. These benefits are included in Bridge Tab Table 51 of the BCA Tool and are based on the assumptions in **Table 4**. Given that a bridge hit occurs approximately once every six years at an average cost of approximately $75,000 based on historical ODOT data, the benefit of the project is assumed to be approximately $12,500 annually. This results in a total benefit of $103,358 over the life of the project.

Table 4: Bridge Hit Reduction

Variable	Unit	Value
Number of Bridge Hits	count	3
Period of Bridge Hits Analyzed	years	18
Probability of Bridge Hit	incidents / Period	300.00%
Probability of Bridge Hit	incidents / year	16.67%
Bridge Replacement Cost	$	Full replacement cost not considered
Average bridge damage per hit	$	$ 75,000
Total cost of bridge hit	$/incident	$ 75,000

Source: ODOT

BCA Sensitivity Analysis

The BCA outcomes presented in the previous sections rely on many 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 "critical variables"—the variables and model parameters whose variations have the greatest impact on the BCA outcomes.

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 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 detour assumptions, value of CMFs, capital cost, as well as years of operations included in Project BCA analysis. The outcomes of the analysis are summarized in **Table 5** below. The table provides the percentage changes in project NPV associated with variations in variables or parameters.

Table 5: BCA Sensitivity Analysis

Parameters	Change in Parameter Value	New NPV (millions of discounted $)	% Change in NPV	New B/C Ratio
Future Detour Timing (full detour)	5 Years Earlier	$1,462.0	39.6%	9.08
	5 Years Later	$691.9	-33.9%	4.83
	2052 per NBIAS	$187.8	-82.1%	2.04
CMF	20% Reduction	$1,036.1	-1.1%	6.73
	20% Increase	$1,058.4	1.1%	6.85
Capital Cost	20% Reduction	$1,081.5	3.3%	8.45
	20% Increase	$1,013.1	-3.3%	5.68
Analysis Period	20 Year Analysis Period	$613.2	-41.4%	4.39

The table demonstrates that under the alternative parameter values that may depress Project NPV, the Project maintains NPV above zero and BC Ratio of 2.04 or higher. Using the years of posting and closure suggested by the BCA Tool (2048 and 2052), Project NPV decreases 82.1% to $187.8 million but the BC ratio still remains positive at 2.04. When the number of years of Project operations is decreased from 30 to 20, Project NPV decreases by 41.4% percent to $613.2 million and the BC ratio decreases to 4.39. Other positive changes (i.e. moving the bridge posting and closure dates five years earlier or reducing capital costs by 20%) increase the NPV and BC ratios to close to 9.