Appendix A: Benefit-Cost Analysis Technical Memo

BENEFIT-COST ANALYSIS

EXECUTIVE SUMMARY

This benefit-cost analysis (BCA) for the *City of Tulsa Bridge Project: Improving Tulsa's River Crossings*, for submission to the U.S. Department of Transportation (USDOT) as a requirement for a discretionary grant application for the 2022 Bridge Investment Program, is conducted in accordance with the benefit-cost guidance as outlined by USDOT in the Benefit-Cost Analysis Guidance for Discretionary Grant Programs, released in March 2022 (revised). The period of analysis corresponds to 30 years of benefits after operations begin in 2028.

The project will extend the functional life of four critical, non-interstate bridges by addressing the state of good repair improvements on each of them. The City of Tulsa is requesting $9,996,120 of Bridge Investment Program funding to support the completion of this project ($11.5 million, nominal or $7.5 million in discounted 2020 dollars. Table 1 provides an overview of the cost of the proposed improvements. These costs already include savings derived from the bundling of the four bridges. While consisting of a more efficient practice than addressing each bridge individually, bundling implies an overall cost reduction of approximately 5%.

Table 1: Overview of the *City of Tulsa Bridge Project: Improving Tulsa's River Crossings* (Project Costs)

Bridge	Reference	Total Length (ft)	Project Total Cost (Nominal)	Project Total Cost (Discounted)	Work Type
NBI 19838	245 / SW Blvd	1,412.00	$4,291,800	$2,804,671	Improve deck, install LED (Light Emitting Diode) lights, repair superstructure, repair substructure.
NBI 20866	258 / 23rd St	1,734.91	$4,443,900	$2,903,965	Improve deck, install LED lights, repair superstructure, repair substructure.
NBI 20579	300A / 71st St	2,177.10	$2,415,500	$1,579,711	Repair deck, repair superstructure, repair substructure.
NBI 16548	301 / 71st St at Joe Creek	168	$346,900	$229,215	Repair substructure.
	Total	**5,492.01**	**$11,498,100**	**$7,517,562**	

The Project will incur operations and maintenance (O&M) costs. O&M costs for the 2028-2057 period would total $329.1 million (or $64.4 million of discounted 2020 dollars) under the "No Build" scenario, whereas under the "Build" scenario, these costs will be reduced to $270.6 million (or $47.7 million while discounted). O&M efficiency derived from the repairs will consequently generate savings of $58.5 million in undiscounted dollars, or $16.7 million when discounted at the seven percent annual discount rate.

Due to improved lighting on the bridges, the Project will reduce crashes, resulting in avoided crash costs of $5.8 million undiscounted and $1.4 million in 2020 discounted dollars.

The Project will generate $18.0 million in discounted net benefits using a seven percent discount rate through 2057. The Project will reduce crash incidents and operations and maintenance costs. Using a seven percent discount rate, this leads to an overall project Net Present Value of $10.5 million and a **Benefit Cost Ratio (BCR) of 2.40**.[1] The overall project benefit matrix is in Table 2.

Table 2: *City of Tulsa Bridge Project: Improving Tulsa's River Crossings* – Impacts and Benefits Summary, Monetary Values in Millions of Discounted 2020 dollars

Current Status/Baseline & Problem to be Addressed	Change to Baseline/ Alternatives	Economic Benefit	Monetized Benefits ($2020), 2028-2057 (at 7% discount rate)	Page Reference in BCA
Aging infrastructure resulting in higher O&M costs	Deck, superstructure and substructure repairs and improvement.	Reduced O&M costs, reduced need, and frequency for repairs	$16.7 million	A-7
On-bridge crashes	Lighting additions at two out of four bridges	Reduction in crash incidents: Reduction in costs associated with fatality, injury, and property damage crashes	$1.4 million	A-10

Source: Cambridge Systematics, Inc.

1. INTRODUCTION

A benefit-cost analysis (BCA) was conducted for the *City of Tulsa Bridge Project: Improving Tulsa's River Crossings*, for submission to the U.S. Department of Transportation (USDOT) as a requirement for a discretionary grant application for the 2022 Bridge Investment Program. This appendix is organized as follows:

- Section 2 contains the Project description.
- Section 3 documents the BCA methodology, including key methodological components, assumptions, and the study scenarios.
- Section 4 contains a detailed explanation and calculation of the Project benefits.
- Section 5 contains a detailed explanation and calculation of the Project costs.

[1] Per USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs (March 2022, Revised), savings in operations and maintenance costs are included in the numerator along with other project benefits when calculating the benefit-cost ratio.

- Section 6 contains the detailed results of the BCA.

2. PROJECT DESCRIPTION

The City of Tulsa is proposing state of good repair improvements to four critical bridges: the Southwest Boulevard Bridge, 23rd Street Bridge, 71st Street Bridge, and Joe Creek Bridge. These bridges operate as the only non-Interstate crossings over the Arkansas River, providing critical connections to a growing Census-designated Urbanized Area with a population of approximately 411,000. This includes a vibrant central business district of approximately 35,000 workers, a large freight cluster directly across the river from Downtown in West Tulsa, and a diverse cluster of hospitality, tourism, education, and healthcare centers in South Tulsa.

To address the degradation of multiple components of these bridges, the City of Tulsa, having already allocated $391,300 for the project to reach 30 percent of design planning, is requesting $9,996,120 of Bridge Investment Program (BIP) grant funding to supplement $1,110,680 of committed local funding for the project. This funding will be used to address deck, superstructure, and substructure state of good repair improvements for each bridge. As part of these improvements, non-motorized infrastructure in the form of multimodal paths will be repaired, along with the installation of new LED (Light Emitting Diode) lighting. As a result of safety improvements and operations and maintenance savings, this project will generate $2.40 in benefits for every $1 invested.

Constructed throughout the 20th century, each of the four bridges are reaching the end of their functional life. Two of these bridges already carry a 'structurally deficient' rating based on National Bridge Inspection Standards (NBIS). The remaining two bridges are considered 'At Risk' for becoming structurally deficient. For the time being, all four bridges are safe for travel. However, this investment will allow for more timely and comprehensive repairs that will save money and reduce maintenance activities in the long run.

3. BENEFIT COST ANALYSIS FRAMEWORK

The BCA provides an evaluation framework to assess the economic advantages (benefits) and disadvantages (costs) of a potential infrastructure project. Project benefits and costs are broadly defined and are quantified in monetary terms to the extent possible. The overall goal of the project BCA is to assess whether the expected benefits of the project justify the costs from a national perspective. The BCA framework attempts to capture the net welfare change created by the project, including cost savings and increases in welfare (benefits), as well as disbenefits where costs can be identified (e.g., project capital costs), and welfare reductions where some groups are expected to be made worse off because of the proposed project.

The BCA framework involves defining a Base or "No Build" scenario, which is compared to the "Build" scenario. The BCA assesses the incremental difference between the "Build" scenario and the "No Build" scenario, which represents the net change in welfare. BCAs are forward-looking exercises which seek to assess the incremental change in welfare over a project life cycle. The importance of future changes is determined through discounting, which is meant to reflect the time value of money.

KEY METHODOLOGICAL COMPONENTS

The project BCA is conducted in accordance with the benefit-cost methodology recommended by the USDOT.[2] The methodology includes the following key components:

- Defining existing and future conditions under the "No Build" (Base) scenario as well as under the "Build" scenario;
- Assessing the project benefits over the 30 years of operations beyond the Project completion when benefits accrue and using USDOT recommended values to monetize traffic crashes by severity while relying on best practices for monetization of any other benefits or disbenefits;
- Estimating the project capital costs during Project construction and Project operation and maintenance costs over the 30 years of operations beyond the Project completion when benefits accrue; and
- Discounting Project benefits and costs to 2020 dollars using a real discount rate of 7 percent consistent with USDOT guidance.

KEY ASSUMPTIONS

The assessment of the Project benefits and costs associated with the *City of Tulsa Bridge Project: Improving Tulsa's River Crossings* involve the following key assumptions:

- The evaluation period includes the construction during which capital expenditures are undertaken, plus 30 years of operations beyond the Project completion within which to evaluate ongoing benefits and costs.
- The construction phase of the Project will begin in 2026 ending in 2027, at which point the Project will be deemed complete.
- The Project will be opened in 2028 and the 30-year operational period will conclude in 2057. Although segments of the project will be completed early, benefits are assumed to begin accruing when all the project segments are completed.
- All Project benefits and costs are conservatively assumed to occur at the end of each calendar year for purposes of present value discounting.
- Monetary values of Project costs and benefits are expressed in constant, year-end 2020 dollars.

"BUILD" AND "NO BUILD" SCENARIOS

The analysis of the *City of Tulsa Bridge Project: Improving Tulsa's River Crossings* considered how the balance of costs and benefits resulting from the construction of the Project would result in long-term benefits. This is accomplished by comparing the "Build" scenario relative to the "No-Build" scenario.

[2] U.S. Department of Transportation. Benefit-Cost Analysis Guidance for Discretionary Grant Programs, March 2022 (Revised).

- The "No Build" (Base) scenario would consist of leaving the bridges as they currently stand with routine operational and maintenance costs to maintain current levels of service.

- The "Build" scenario would rehabilitate the bridges, making repairs and some improvements on their decks, adding LED (Light Emitting Diode) lighting to two of the four bridges, and repairing their superstructures and substructures. This scenario would entail the capital costs associated with the construction until the Project has been completed, and then routine, albeit reduced, operational and maintenance costs once the Project is in use over the 30-year evaluation period.

4. PROJECT BENEFITS

ECONOMIC COMPETITIVENESS – QUALITATIVE ASSESSMENT

Mobility and economic competitiveness are key drivers of this bridge improvement process. In total, these four bridges carried over 175,000 person-miles in 2019, helping to facilitate the flow of people and goods alike across the Arkansas River, as well as Joe Creek. Due in large part to the growing economic strength of Tulsa as a state and regional commerce hub, total person-miles carried by these four bridges is expected to increase by 81 percent to approximately 316,000 person-miles by 2050.

The four bridges slated for improvement play an outsized role in the facilitation of employment access across Tulsa. Over 66,000 jobs are located within 1.5 miles of these four bridges, representing a quarter of Tulsa's total employment despite comprising less than 10 percent of the city's total area.[3]

Home to over 35,000 workers, Downtown Tulsa contains a mix of corporate, retail, and hospitality jobs, in addition to a growing residential population. Key freight-based employers including HollyFrontier's Tulsa Refinery and BNSF's Cherokee Rail Yard are located at the other end of the Southwest Boulevard Bridge, the only non-Interstate connection over the Arkansas River into and out of Downtown Tulsa. Both facilities, as part of this larger cluster of freight facilities in West Tulsa, are also directly accessible through the West 23rd Street Bridge.

South of Downtown Tulsa and the west Tulsa freight cluster, East 71st Street forms another key gateway to the city's major job clusters, including Oral Roberts University, River Spirit Casino Resort, and the Oklahoma Surgical Hospital, in addition to a mix of retail and hospitality establishments. Overall as a result of these repairs, the four bridges will be more reliable and less prone to closures, which will allow for the uninterrupted flow of commerce across these various economic hubs.

The upgrade of each of these four bridges will directly lead to well-paying jobs in the construction sector throughout the extent of this project. The median hourly wage in Oklahoma is $18.03 as compared to $21.64 in construction.[4] This represents a 20 percent premium over the prevailing median hourly wage.

CLIMATE CHANGE, RESILIENCY, AND ENVIRONMENTAL IMPACTS - QUALITATIVE ASSESSMENT

This project aims to promote environmental resiliency in relation to the city's transportation infrastructure network. As part of the state of good repair improvements, the multimodal paths along each bridge will be

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[3] https://onthemap.ces.census.gov/

[4] https://www.bls.gov/oes/current/oes_ok.htm#47-0000

repaired to encourage the use of climate-friendly non-motorized forms of transportation such as walking and cycling. These multimodal paths will provide direct connections to the city's River Parks trail system which runs along both sides of the Arkansas River. Additionally, three of the four bridges slated for state of good repair improvements carry multiple Tulsa Transit bus routes. In relation to environmental justice, these transit routes play a pivotal role in supporting mobility in several minority and Historically Disadvantaged Communities.

As outlined for two out of the three bridges spanning the Arkansas River, state of good repair upgrades for the decks will include replacement and installation of new LED lighting. In addition to safety benefits, this installation of LED lights will yield positive environmental impacts. In comparison to older lights, new LED lights can be up to 80 percent more energy efficient.[5] In turn, the new, brighter lights will provide a safer, more welcoming environment for non-motorized, greener modes of transportation, including walking and cycling. Furthermore, because the project will extend the useful life of these four assets, the prevention of full bridge replacement will reduce the need for carbon-intensive materials such as concrete. These repairs will also help reduce the negative effects from yearly freeze and thaw cycles which can accelerate concrete deterioration.

During the construction phase of the project, contractors performing the rehabilitation work may be able to use a Snooper vehicle instead of constructing a temporary work road in the river. The City of Tulsa will discuss this opportunity with contractors to encourage its use to reduce environmental impacts on waterflows and aquatic life below the bridges, which could result if a temporary work road were constructed. If a temporary work road has to be utilized, the City will work with the US Army Corps of Engineers and the US Fish and Wildlife Service to minimize impacts to flood control releases from Keystone Dam upstream, and to aquatic species in the river. Typically, work roads in the Arkansas River are limited to half of the channel at a time to minimize these impacts.

OPERATIONS AND MAINTENANCE COST SAVINGS – QUANTITATIVE ASSESSMENT

Based on data provided by the City of Tulsa, the Operations and Maintenance costs (O&M) for the assets constructed under this project will be significantly less than the O&M costs for the "No Build" scenario. This is due to the deck, superstructure and substructure repairs and improvement that in turn reduce the frequency and magnitude of maintenance and rehabilitation required. The "Build" versus "No-Build" O&M costs are:

30-year O&M Costs under the "No Build' scenario:

- Rehabilitation work in the years 2040 and 2052.
- Regular maintenance every 3 years, except when there is an overlap with rehabilitation works. Resulting years are: 2028, 2031, 2034, 2037, 2043, 2046, 2049, and 2055.
- Total 30-year "No Build" O&M = $329.1 million, or $64.4 million when discounted.

30-year O&M Costs under the "Build" Scenario:

- Rehabilitation work in the year 2046.
- Regular maintenance starts in 2034 and every 6 years, except when there is an overlap with rehabilitation works. Resulting years are: 2034, 2040, 2052, and 2057.

[5] https://www.sepco-solarlighting.com/blog/the-advantages-of-led-lights-for-the-environment#:~:text=A%20longer%20life%20span%20means,%2C%20packaging%20materials%2C%20and%20transportation.

- Total 30-year “Build” O&M = $270.6 million, or $47.7 million when discounted.

Standardized costs for the aforementioned interventions are inflated to Year Of Expenditure (YOE) across the 30-year period by using the FHWA National Highway Construction Cost Index annual increase of 6.33% observed from Q4 2009 to Q4 2019[6]. The baseline for this inflation is 2022, the year in which the estimates where produced.

Table 3 summarizes the “Build” versus “No Build” project O&M costs. Building the project will save $58.5 million in nominal O&M costs and $16.7 million in discounted O&M costs.

Table 3: *City of Tulsa Bridge Project: Improving Tulsa’s River Crossings* – Life Cycle Project Costs, 2028-2057

Year	Build O&M Costs		No Build O&M Costs		Build O&M Cost Savings Nominal	Build O&M Cost Savings Discounted
	Nominal	Discounted	Nominal	Discounted		
2028	$0	$0	$3,211,871	$1,869,338	$3,211,871	$1,869,338
2029	$0	$0	$0	$0	$0	$0
2030	$0	$0	$0	$0	$0	$0
2031	$0	$0	$3,861,228	$1,834,442	$3,861,228	$1,834,442
2032	$0	$0	$0	$0	$0	$0
2033	$0	$0	$0	$0	$0	$0
2034	$4,641,870	$1,800,197	$4,641,870	$1,800,197	$0	$0
2035	$0	$0	$0	$0	$0	$0
2036	$0	$0	$0	$0	$0	$0
2037	$0	$0	$5,580,336	$1,766,592	$5,580,336	$1,766,592
2038	$0	$0	$0	$0	$0	$0
2039	$0	$0	$0	$0	$0	$0
2040	$63,466,775	$16,401,021	$139,426,259	$36,030,395	$75,959,484	$19,629,374
2041	$0	$0	$0	$0	$0	$0
2042	$0	$0	$0	$0	$0	$0
2043	$0	$0	$8,064,831	$1,701,251	$8,064,831	$1,701,251
2044	$0	$0	$0	$0	$0	$0
2045	$0	$0	$0	$0	$0	$0
2046	$119,473,730	$20,572,838	$9,695,332	$1,669,493	- $109,778,398	- $18,903,345
2047	$0	$0	$0	$0	$0	$0
2048	$0	$0	$0	$0	$0	$0
2049	$0	$0	$11,655,479	$1,638,327	$11,655,479	$1,638,327
2050	$0	$0	$0	$0	$0	$0
2051	$0	$0	$0	$0	$0	$0
2052	$63,927,376	$7,335,099	$126,107,260	$14,469,689	$62,179,884	$7,134,590
2053	$0	$0	$0	$0	$0	$0
2054	$0	$0	$0	$0	$0	$0

[6] https://www.fhwa.dot.gov/policy/otps/nhcci/

Year	Build O&M Costs Nominal	Build O&M Costs Discounted	No Build O&M Costs Nominal	No Build O&M Costs Discounted	Build O&M Cost Savings Nominal	Build O&M Cost Savings Discounted
2055	$0	$0	$16,844,768	$1,577,730	$16,844,768	$1,577,730
2056	$0	$0	$0	$0	$0	$0
2057	$19,044,810	$1,558,034	$0	$0	- $19,044,810	- $1,558,034
TOTAL	**$270,554,561**	**$47,667,189**	**$329,089,234**	**$64,357,453**	**$58,534,673**	**$16,690,265**

Source: Cambridge Systematics, Inc.

CRASH COST SAVINGS – QUANTITATIVE ASSESSMENT

The safety benefits assessed in this analysis are based on a reduction in automotive (car and truck) crashes resulting directly from the *City of Tulsa Bridge Project: Improving Tulsa's River Crossings*.

Safety benefits result from the reduction in the number of predicted annual crashes from the "Build" scenario relative to the "No-Build" scenario. The estimation of these benefits involved the following:

- Historical crashes for the project roadway segment and its approaching intersections. A 79-month timeframe was analyzed to estimate the average number of annual crashes and their severity.[7] These crashes represent the "No Build" scenario.

- The types of crashes from the "No Build" scenario were reviewed and compared to the efficacy of safety treatments envisioned for the "Build" scenario. The efficacy (crash reduction) estimates were developed using the Crash Modification Factors Clearinghouse compilation[8] of research on the crash modification/reduction capabilities of various safety treatments. These are documented in the accompanying BCA spreadsheet. The considered treatment is the one referred to as "INSTALL BRIDGE LIGHTING" which for this project reduces the crashes by 59 percent.[9] The following formula was used:

  $$Crash\ Reduction\ \% = 1 - Crash\ Modification\ Factor$$

  In this case:

  $$Crash\ Reduction\ \% = 1 - 0.41 = 59\%$$

- The crash reduction factor was applied to the "No Build" crashes to calculate the "Build" crashes. The reduction in crashes, monetized, represents the baseline annual safety benefits of the proposed treatment.

[7] Source: Oklahoma Department of Transportation
[8] https://www.cmfclearinghouse.org/
[9] http://www.cmfclearinghouse.org/detail.cfm?facid=659

- The average annual crash figures and costs were grown annually to reflect the overall growth in vehicle miles traveled (VMT) on Tulsa's bridges. The assumed growth rate used is 2 percent per year.

- Then, the number of reduced crashes by severity was multiplied by the corresponding comprehensive unit cost of motor vehicle crash consequences by crash severity (Table 4), to determine the total safety cost reduction. All property damage only (PDO) crashes are assumed to involve 1.748 vehicles, based on crash data presented by U.S. Department of Transportation, National Highway Traffic Safety Administration.[10]

- The cost reductions for each crash type were then summed to generate the total safety benefit.

Table 4: Comprehensive Unit Costs of Motor Vehicle Crashes by Crash Severity

Variable	Unit	Value	Source
Fatality	$/Fatality	**$11,600,000**	U.S. Department of Transportation, *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*, March 2022 (Revised)
Serious Injury	$/Injury	**$1,218,000**	U.S. Department of Transportation, *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*, March 2022 (Revised); Departmental Guidance Treatment of the Value of Preventing Fatalities and Injuries in Preparing Economic Analyses, March 2021.
Non-Incapacitating Injury	$/Injury	**$151,100**	U.S. Department of Transportation, *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*, March 2022 (Revised)
Possible Injury	$/Injury	**$77,200**	U.S. Department of Transportation, *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*, March 2022 (Revised)
Property Damage Only Accident (No Injury)	$/Crash	$4,600 per vehicle x 1.748 vehicles per crash = **$8,041** per PDO crash	U.S. Department of Transportation, *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*, (March 2022 - Revised)

[10] U.S. Department of Transportation, National Highway Traffic Safety Administration, *The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (Revised),* May 2015.

Table 5 presents the motor vehicle crash reduction benefits. In total, the reduction in automobile and truck crashes reduces crash costs by **$5.8 million** and **$1.4 million** discounted to 2020 dollars.

Table 5: Crash Reduction Benefits Resulting from the *City of Tulsa Bridge Project: Improving Tulsa's River Crossings*, 2028-2057

Year	Total Crash Savings	
	Nominal $	Discounted $2020
2028	$142,570	$82,977
2029	$145,421	$79,100
2030	$148,330	$75,403
2031	$151,296	$71,880
2032	$154,322	$68,521
2033	$157,409	$65,319
2034	$160,557	$62,267
2035	$163,768	$59,357
2036	$167,043	$56,583
2037	$170,384	$53,939
2038	$173,792	$51,419
2039	$177,268	$49,016
2040	$180,813	$46,726
2041	$184,429	$44,542
2042	$188,118	$42,461
2043	$191,880	$40,477
2044	$195,718	$38,585
2045	$199,632	$36,782
2046	$203,625	$35,063
2047	$207,697	$33,425
2048	$211,851	$31,863
2049	$216,088	$30,374
2050	$220,410	$28,955
2051	$224,818	$27,602
2052	$229,315	$26,312
2053	$233,901	$25,082
2054	$238,579	$23,910
2055	$243,351	$22,793
2056	$248,218	$21,728
2057	$253,182	$20,713
TOTAL	**$5,783,788**	**$1,353,172**

Source: Cambridge Systematics, Inc.

PROJECT BENEFITS SUMMARY

Table 6 shows the *City of Tulsa Bridge Project: Improving Tulsa's River Crossings* long-term benefits, aligning the benefit categories with the Statutory Evaluation Requirements of the Bridge Investment Program.

Table 6: Project Benefits by Long-Term Outcome Category, Millions of Dollars

Long-Term Outcome	Benefit Category	Benefit Description	Benefits (Millions of $)	Benefits 7% Discount (Millions of $2020)
Reduced O&M Costs	Economic Competitiveness	Lower costs to maintain facilities	$58.5	$16.7
Safety	Reduced Crash Incidents	Reduction in traffic fatalities/injuries and PDO crashes, including pedestrians and bicycles	$5.8	$1.4
Total			**$64.3**	**$18.0**

Source: Cambridge Systematics, Inc.

5. PROJECT COSTS

CAPITAL COSTS

The capital costs associated with the *City of Tulsa Bridge Project: Improving Tulsa's River Crossings* (Table 7) are primarily associated with the actual construction. Construction costs will total $10.4 million in nominal dollars. Additional costs for engineering and NEPA (National Environmental Policy Act) fees, representing another $1.1 million in nominal dollars, should precede them. Scheduling in Table 7 is not perfectly aligned with the actual project schedule, because whole year increments are used as inputs.

Table 7: Project Schedule and Costs

Variable	Value	Unit
Preliminary Design / NEPA Start	2023	year
Preliminary Design / NEPA End	2024	year
Final Design Start and End	2025	year
Construction Start	2025	year
Construction End	2027	year
Construction Duration	2	years
Project Opening	2028	year
Capital Cost – Construction	$10.4	Millions of $
Engineering Fees, NEPA fees	$1.1	Millions of $
Total Project Cost	$11.5	Millions of $

Source: City of Tulsa.

6. SUMMARY OF RESULTS

EVALUATION MEASURES

The BCA converts potential gains (benefits) and losses (costs) from the *City of Tulsa Bridge Project: Improving Tulsa's River Crossings* into monetary units and compares them. The following common benefit-cost evaluation measures are included in this BCA:

- Net Present Value (NPV): NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.

- Benefit Cost Ratio (BCR): The present value of incremental benefits is divided by the present value of incremental costs to yield the BCR. The BCR expresses the relation of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of the costs.

BCA RESULTS

Table 8 presents the evaluation results for *the City of Tulsa Bridge Project: Improving Tulsa's River Crossings.* Results are presented in undiscounted and discounted at seven percent dollars. All benefits and costs are estimated over an evaluation period extending 30 years beyond system completion in 2027 (starting in 2028). The total net benefits from the Project improvements within the analysis period represent **$18.0 million** (including the O&M cost savings and crash reduction cost savings) when discounted at seven percent. The total capital costs, including engineering and construction, etc. are calculated to be **$7.5 million** when discounted at seven percent. The difference of the discounted benefits and costs equal an NPV of **$10.5 million**, whereas their implied ratio (BCR) is **2.40:1.**

Table 9 summarizes the results of the BCA by year. The full spreadsheet model is attached with the application.

Table 8: *City of Tulsa Bridge Project: Improving Tulsa's River* Crossings – Evaluation Measures

BCA Metric	Project Lifecycle	
	Nominal (Millions of Year of Expenditure $)	7% Discount (Millions of 2020$)
Benefits:		
Operations & Maintenance Savings	$58,534,673	$16,690,265
Safety Crash Cost Reductions	$5,783,788	$1,353,172
Total Benefits	**$64,318,461**	**$18,043,437**
Total Costs	**$11,498,100**	**$7,517,562**
Benefit/Cost Ratio	**5.59**	**2.40**
Net Present Value	**$52,820,361**	**$10,525,875**

Source: Cambridge Systematics, Inc.

Table 9: *City of Tulsa Bridge Project: Improving Tulsa's River* Crossings – Life-Cycle Benefit-Cost Analysis

	Nominal Costs and Benefits		Discounted Costs and Benefits	
Year	Nominal Costs	Nominal Benefits	Costs (7% Discount) ($2020)	Benefits (7% Discount) ($2020)
2023	$195,650	$0	$159,709	$0
2024	$195,650	$0	$149,260	$0
2025	$726,900	$0	$518,270	$0
2026	$5,189,950	$0	$3,458,283	$0
2027	$5,189,950	$0	$3,232,040	$0

	Nominal Costs and Benefits		Discounted Costs and Benefits	
Year	Nominal Costs	Nominal Benefits	Costs (7% Discount) ($2020)	Benefits (7% Discount) ($2020)
2028	$0	$3,354,441	$0	$1,952,315
2029	$0	$145,421	$0	$79,100
2030	$0	$148,330	$0	$75,403
2031	$0	$4,012,525	$0	$1,906,322
2032	$0	$154,322	$0	$68,521
2033	$0	$157,409	$0	$65,319
2034	$0	$160,557	$0	$62,267
2035	$0	$163,768	$0	$59,357
2036	$0	$167,043	$0	$56,583
2037	$0	$5,750,721	$0	$1,820,531
2038	$0	$173,792	$0	$51,419
2039	$0	$177,268	$0	$49,016
2040	$0	$76,140,297	$0	$19,676,100
2041	$0	$184,429	$0	$44,542
2042	$0	$188,118	$0	$42,461
2043	$0	$8,256,711	$0	$1,741,727
2044	$0	$195,718	$0	$38,585
2045	$0	$199,632	$0	$36,782
2046	$0	- $109,574,773	$0	- $18,868,282
2047	$0	$207,697	$0	$33,425
2048	$0	$211,851	$0	$31,863
2049	$0	$11,871,568	$0	$1,668,701
2050	$0	$220,410	$0	$28,955
2051	$0	$224,818	$0	$27,602
2052	$0	$62,409,199	$0	$7,160,902
2053	$0	$233,901	$0	$25,082
2054	$0	$238,579	$0	$23,910
2055	$0	$17,088,118	$0	$1,600,523
2056	$0	$248,218	$0	$21,728
2057	$0	- $18,791,628	$0	- $1,537,321
TOTAL	**$11,498,100**	**$64,318,461**	**$7,517,562**	**$18,043,437**

Source: Cambridge Systematics, Inc.

7. SENSITIVITY TESTING

A sensitivity analysis is used to help identify which variables have the greatest impact on the BCA results. This analysis can be used to estimate how changes to key variables from their preferred value affect the results and how sensitive the results are to these changes. This allows for the assessment of the strength of the BCA, including whether the results reached using the preferred set of input variables are significantly different by reasonable departures from those values. Table 10 summarizes the key variables which have been tested for sensitivity and the results of this analysis.

First, sensitivity was tested by increasing the expected crash modification factor by 50% to 0.82 (from 0.41). The resulting seven percent discounted BCR was 2.28, with an NPV of $9.6 million.

Second, a sensitivity was tested by eliminating the growth for annual average daily traffic at the bridges (from an annual 2% to 0%), resulting in a seven percent discounted BCR of 2.35, and an NPV of $10.2 million.

Finally, a third sensitivity was tested by reducing the FHWA National Construction Cost Index inflation factor used to cost the operations and maintenance costs of the bridge in both "Build" and "No-Build" scenarios from an annual 6.33% to 0%. This sensitivity derived in a seven percent discounted BCR of 1.13 and an NPV of $1.0 million.

The preservation of positive NPVs and BCRs greater than 1 suggest the robustness of the project even under unexpectedly more adverse conditions during the 30-year benefit period.

Table 10: *City of Tulsa Bridge Project: Improving Tulsa's River Crossings* Sensitivity Analysis

Sensitivity Variable	Sensitivity Value	New BCR (Discounted 7%)	New NPV (Millions of $2020)
Increase Crash Modification Factor (implies a smaller reduction in crashes)	+50% (0.82, was 0.41)	2.28	$9.6
Decrease Annual Average Daily Traffic Growth Rate	-100% (0%, was 2%)	2.35	$10.2
Decrease Annual National Construction Cost Index increase rate	-100% (0%, was 6.33%)	1.13	$1.0

Source: Cambridge Systematics, Inc.