Benefit Cost Analysis Narrative

Multimodal Improvements to Safety Connect Tulsa at the US-75 and W. 81st Street Interchange

Tulsa, Oklahoma

February 28, 2024

OKLAHOMA Transportation

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Benefit-Cost Analysis

Executive Summary

The Benefit-Cost Analysis (BCA) of this grant application compares the costs and benefits of the proposed investment project. 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) and City of Tulsa (COT) propose to reconstruct the existing US-75/W. 81st Street interchange as a Diverging Diamond Interchange (DDI), provide additional capacity on W. 81st Street, and provide new pedestrian and bicycle facilities across US-75. This innovative design will improve safety and traffic flow and provide a connection for non-vehicular traffic where none exists today. Specific improvements planned as part of the project include:

- Replace the northbound and southbound bridges on US-75 over W. 81st Street as 70'-wide steel bridges to accommodate future widening of US-75,
- Reconstruct the existing standard diamond interchange to a diverging diamond interchange (DDI), including accommodation for bicycles and pedestrians across US-75,
- Reconstruct the portions of US-75 and interchange ramps necessary to accommodate the new bridges and interchange with new concrete pavement,
- Widen W. 81st Street from S. Tacoma Ave. across US-75 through the eastern ramp intersection to a 5-lane section including two 12'-wide lanes in each direction, a 12' center turn lane, and 12' multipurpose trail on both sides, and
- Construct subsurface storm drain on W. 81st Street to convey stormwater.

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 23 years, including one year of project development, two years of construction, and 20 years of operations[1]. Total project development and construction costs (undiscounted) are estimated at $27.3 million in 2022 dollars. For this BCA, cost estimates were de-escalated or escalated to 2022 dollars depending upon the year the cost estimate was completed using the Gross Domestic Product (GDP) Deflator, per USDOT BCA Guideline requirements[2].

All relevant data and calculations used to derive the benefits and costs of the project are shown in the BCA model that accompanies this grant application. Based on the analysis presented in the rest of this document, the Project is expected to generate $49.24 million in discounted benefits and $23.9 million in discounted capital costs using a 3.1 percent real discount rate[3]. Therefore, the Project is expected to generate a Net Present Value of $25.3 million and a Benefit/Cost (BC) Ratio of 2.06 as shown below in **Tables 1 and 2** and **Figure 1**.

[1] Sensitivity analysis also considered an evaluation period with 30 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.
[2] Benefit Cost Analysis Guidance 2024 Update.pdf (transportation.gov)
[3] All benefits, costs and savings are discounted at 3.1%, except for CO2 which was discounted at 2% per USDOT BCA Guidelines cited above

Table 1: Summary of Benefits

Baseline Status and Problems to be Addressed	Changes to Baseline	Types of Impacts & Benefits	Population Affected by Impacts	Benefit Value (2022 $ millions, 3.1% discount)
The US-75 corridor is included in the top 5% of freight bottlenecks in the Tulsa area and is listed as a critical freight corridor in ODOT's State Freight Plan. A specific challenge associated with the interchange is to adequately accommodate existing future and travel demand. The current interchange movements are operating at a Level of Service D. Additionally, there are no multimodal accommodations across US-75.	The Oklahoma Department of Transportation (ODOT) and City of Tulsa (COT) propose to reconstruct the existing US-75/W. 81st Street interchange as a diverging diamond interchange (DDI), provide additional capacity on W. 81st Street, and provide new pedestrian and bicycle facilities across US-75. This innovative design will improve safety and traffic flow and provide a connection for non-vehicular traffic where none exists today.	***Impact*** - New diverging diamond interchange ***Benefit*** - Improved vehicle safety	Vehicle Owners and Truck Operators	$ 3.36
		Impact - Reduced vehicular delays at interchange ***Benefit*** - Reduction in travel times	Vehicle Owners and Truck Operators	$ 27.88
		Impact - Shorter delays at interchange ***Benefit*** - Reduced vehicle operating costs (fuel reduction)	Vehicle Owners and Truck Operators	$ 8.92
		Impact - Reduced time spent idling during intersection delays ***Benefit*** - Emissions reduction	Vehicle Owners, Truck Operators, and Residents of adjacent communities	$ 0.23
		Impact - New sidewalks providing a dedicated crossing of US-75 ***Benefit*** – Enhanced pedestrians and cyclist amenities and mobility	Residents of adjacent communities, Pedestrians & Cyclists	$ 3.23
		Impact - New sidewalks will provide opportunities for modal shift to active transportation ***Benefit*** – Health benefits associated with walking	Residents of adjacent communities, Pedestrians & Cyclists	$ 1.76
		Impact - New bridges at proposed interchange ***Benefit*** - Reduced bridge hits and reduced maintenance costs over the life of the project.	Vehicle Owners, Truck Operators, and ODOT	$ 0.02
		Impact – New infrastructure will require less maintenance ***Benefit*** - Reduced maintenance costs.	ODOT	$ 2.20
		Impact - New bridges at proposed interchange ***Benefit*** - Extended residual life of bridges at proposed interchange	ODOT	$ 1.64
Total				**$ 49.24**

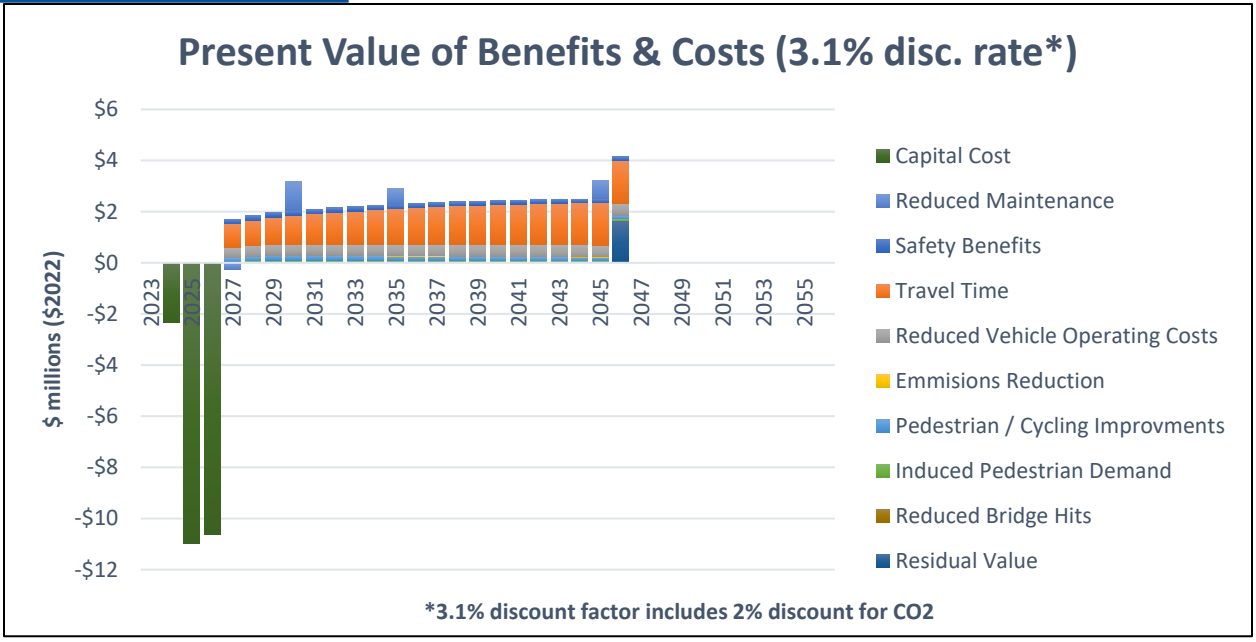

Figure 1: Net Present Value of Benefits and Costs (3.1% Discount Rate)

Table 2: Summary of BCA Outcomes, Millions of Dollars in 2022

Project Evaluation Metric	Undiscounted	Present Value at 2% Discount Rate	Present Value at 3.1% Discount Rate
Total Benefits	$82.3	$58.8	$49.2
Total Capital (Cost) / Savings	$(27.3)	$(25.1)	$(23.9)
Net Present Value (NPV)	$55.0	$33.7	$25.3
Benefit / Cost Ratio	3.01	2.34	2.06
Internal Rate of Return	10.2%		

In addition to the monetized benefits, the project is expected to generate benefits / disbenefits that are more difficult to quantify. A brief description of those benefits / disbenefits is provided below. Benefits are described more fully in the Merit Criteria narrative.

- **Improved Mobility and Community Connectivity:** The Project will improve traffic flow at the US-75/W. 81st Street Interchange through the construction of a diverging diamond interchange (DDI). The Project will provide a multimodal connection across US-75 and improve access to amenities on both sides of US-75. The Project will increase access to bus transit, facilitating access to job centers such as Tulsa Hills, as well as vital services and amenities along the routes. Routes in this corridor also provide access to downtown Tulsa, which offers jobs and government services. After the connection under US-75 is completed, many pedestrians will experience shorter walking distances and walking times to these destinations. Improved mobility of area residents can then be expected to reduce barriers to opportunities more generally, including barriers to education and employment.

- **Quality of Life:** The area lacks a connected sidewalk network connecting its residents to a variety of destinations. By providing a safer and shorter pedestrian connection, the Project will increase access to affordable transportation choices for non-motorized travelers. The installation of a multi-use path across US-75 will encourage a modal shift to transit and active transportation and could reduce vehicle miles traveled.

- **Economic Competitiveness**: The US-75/W. 81st Street Interchange Project will promote long-term economic growth in the US-75 corridor. Designated for commercial development in the City of Tulsa's comprehensive plan (Planitulsa), it is anticipated that the land adjacent to US-75 on both sides of the highway will continue to develop with commercial property and the Project will enhance mobility for future development.

- **Construction Disbenefits**: Disbenefits are negative outcomes that the project may cause during construction, such as increased delay or increased collisions. Construction disbenefits would likely occur during the construction of the US-75/W. 81st Street Interchange Project. However, construction disbenefits would also occur during maintenance and redecking activities that would be required under the No Build scenario. It is assumed that the disbenefits in either the build or no build scenario would be similar and would not significantly change the relative costs or benefits. Therefore, they are not calculated or quantified in this BCA.

Introduction and Methodology

This document provides detailed technical information on the benefit-cost analysis (BCA) conducted in support of the grant application for the Multimodal Improvements to Safely Connect Tulsa at the US-75 and W. 81st Street Interchange Project (Project). The BCA includes the monetized benefits and costs measured using USDOT Benefit Cost Analysis Guidance 2024 Update (published December 5, 2023), 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. The specific methodology adopted for this application is based on the BCA guidance developed by USDOT and is consistent with the RAISE program guidelines. In particular, the methodology involves:

- Establishing existing and future conditions under the build and no-build scenarios,
- Assessing benefits with respect to project requirements listed in RAISE Notice of Funding Opportunity (NOFO) document,
- 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 safety benefits, travel time savings, operating cost savings, emission reduction benefits, and facility amenity benefits, while relying on industry best practices for the valuation of other effects,
- Discounting future benefits and costs with the real discount rate recommended by USDOT (3.1 percent, except for carbon dioxide, which is discounted at 2 percent, per new USDOT BCA Guidelines), and
- Conducting a sensitivity analysis to assess the impacts of changes in key input assumptions.

Project Overview

The Project entails reconstruction of the US-75/W. 81st Street interchange and associated improvements on W. 81st Street in the city of Tulsa, Oklahoma (**Figure 2**). US-75 is on the National Highway System (NHS) and National Highway Freight Network (NHFN) and is among the highest volume truck freight routes in the state. US-75 is included in the top 5% of freight bottlenecks in the Tulsa area and is listed as a critical freight corridor in ODOT's State Freight Plan, 2023-2030.

The Project proposes to reconstruct the existing US-75/W. 81st Street interchange as a diverging diamond interchange (DDI), provide additional capacity on W. 81 Street, and provide new pedestrian and bicycle facilities across US-75 (**Figure 3**). This innovative design will improve safety and traffic flow and provide a connection for non-vehicular traffic where none exists today. Specific improvements planned as part of the project include:

- Replace the northbound and southbound bridges on US-75 over W. 81st Street as 70'-wide steel bridges to accommodate future widening of US-75,

- Reconstruct the existing standard diamond interchange to a diverging diamond interchange (DDI), including accommodation for bicycles and pedestrians across US-75,
- Reconstruct the portions of US-75 and interchange ramps necessary to accommodate the new bridges and interchange with new concrete pavement,
- Widen W. 81st Street from S. Tacoma Avenue across US-75 through the eastern ramp intersection to a 5-lane section including two 12'-wide lanes in each direction, a 12' center turn lane, and 12' multiuse trail on both sides (**Figure 4**), and
- Construct subsurface storm drain on W. 81st Street to convey stormwater.

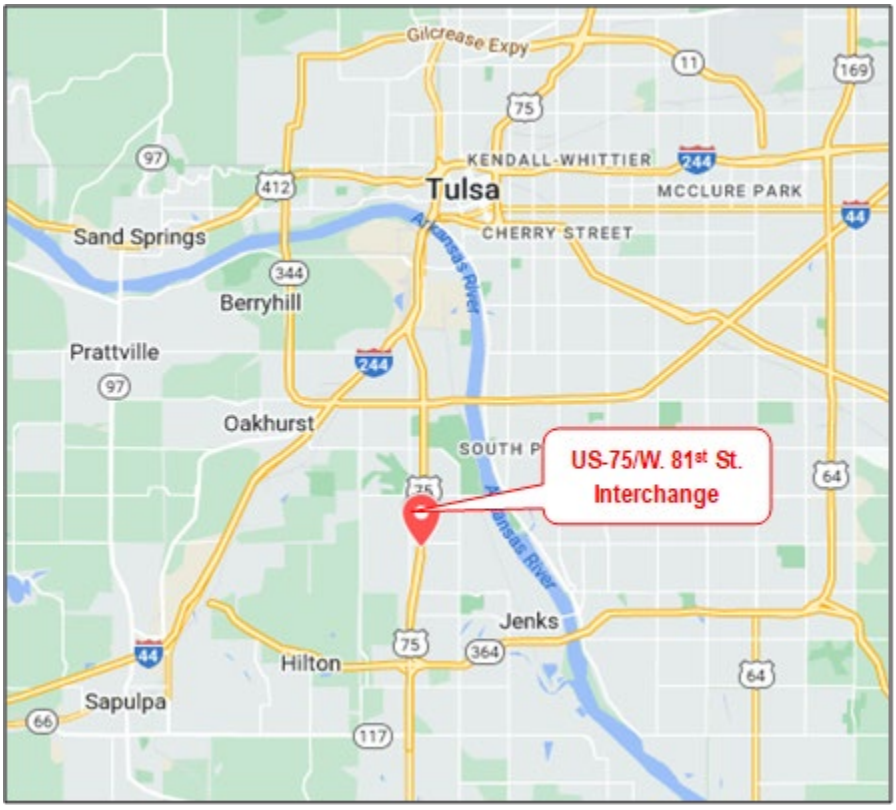

Figure 2: US-75/W. 81st Street Interchange Location Map

Figure 3: Proposed Diverging Diamond Interchange

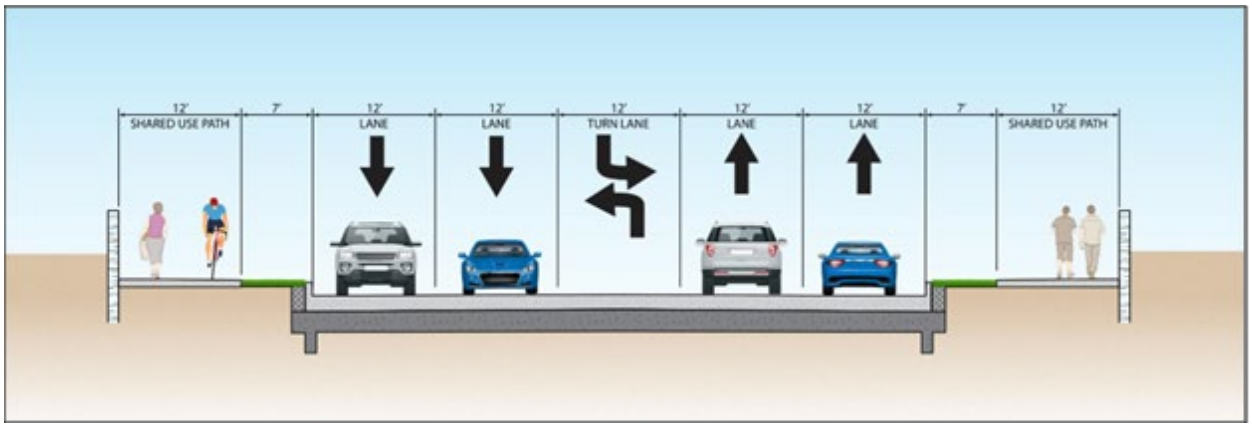

Figure 4: Proposed Typical Section, W. 81st Street

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 for both US-75 and W. 81st Street 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:

- Improved vehicle and pedestrian/bicycle safety due to new diverging diamond interchange and dedicated multiuse trails,
- Reduction in travel times for automobiles and trucks from faster travel times and reduced delay at surrounding intersections,
- Reduction in vehicle operating costs due to reduced fuel used and other operating costs associated with intersection delays,
- Reduction in emissions due to operational improvements and reduced fuel used,
- Improved pedestrian and bicyclist comfort due to new multiuse trails,
- Health benefits from increased active transportation trips,
- Reduced potential damages from bridge hits on low clearance US-75 bridges, and
- Increased useful life and residual value of the US-75 bridges.

Project Cost and Schedule – Alternative Case (Build)

Total project capital development and construction costs are estimated at $29.3 million in nominal dollars, based on the year that each cost estimate (construction, utilities, right-of-way, and design) was developed. Note that design, right-of-way, and utility relocation costs have either been previously incurred or will be incurred prior to grant award. For this BCA, these costs were adjusted to 2022 dollars using a GDP deflator[4]. The adjusted project development and construction cost in real dollars amounts to $27.3 million in 2022 undiscounted dollars and $23.9 million discounted at 3.1 percent. Project construction is anticipated to start in 2025 and take two years with completion by end of 2026. Therefore, 2027 is assumed as the Project opening year and first year of Project-related benefits[5].

Project Cost – Base Case (No Build)

The Base Case (No Build) assumes no capital development or construction. **Table 3** provides a summary of Project costs.

Table 3: Summary of Project Capital Costs, $2022 Undiscounted

Development Phase	Cost
Design	$1,832,708
Right-of-way	$473,760
Utilities	$240,114
Construction	$24,788,929
Total	**$27,335,510**

[4] The adjustment applied a factor to costs in 2018, 2022 and 2023 dollars using the GDP deflator as shown in Table A-7 (Benefit Cost Analysis Guidance 2024 Update.pdf (transportation.gov)

[5] Construction years were rounded to the nearest year

Operating and Maintenance Expenditures

The Base Case would require major maintenance and/or rehabilitation in 2030, 2035 and 2045 estimated at $1.6 million, $1.0 million and $1.6 million (year of expenditure dollars), respectively for joint work and two future redecking projects. In 2022 dollars, the total major maintenance rehabilitation costs required are estimated at about $3.9 million undiscounted.

While the Alternative Case has maintenance costs associated with the project lifecycle, it is less than what would be incurred under the Base Case. Thus, the Alternative case creates a net savings in maintenance costs. The Project will require $326,707 in maintenance in 2027 and then no major maintenance until 2055 (outside the analysis period). **Table 4** shows the maintenance savings of the Project. In discounted dollars (3.1%), total maintenance savings is $2.2 million.

Table 4: Project Maintenance Savings, $2022 millions Undiscounted

Cost Category	Undiscounted	Present Value at 2% Discount Rate	Present Value at 3.1% Discount Rate
Capital Cost	$27.3	$25.1	$23.9
Maintenance (negative is savings)	-$3.6	-$2.6	**-$2.2**

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 5** below.

Table 5: Benefit Categories of the US-75/W. 81st Street Interchange Project

Criteria	Benefit(s)	Description	Monetized	Qualitative
Safety	Increased vehicle safety	DDI is expected to reduce collisions and fatalities.	Yes	Yes
	Added pedestrian comfort and safety	The new multiuse paths will provide a safe environment for pedestrians.	Yes	Yes
Environmental Sustainability	Emissions reduction	The DDI is expected to reduce congestion and travel times which would reduce the amount of fuel used	Yes	Yes
Quality of Life	Health benefits	Sidewalk access will be extended to improve active transportation opportunities in an underserved area, likely resulting in additional pedestrian trips.	Yes	Yes
Mobility and Community Connectivity	Multi-path connection	The proposed design would include connections for cyclists and pedestrians to easily travel along the interchange and more safely access transit.	Yes	Yes
Economic Competitiveness and Opportunity	Contribution to local economic development and growth	Increased access to adjacent development will increase economic impact of mixed used real estate	No	Yes

	Travel time savings	Reduced travel time and increased reliability will increase the efficiency and movement of the goods and people surrounding the project.	Yes	Yes
	Facilitate tourism opportunities	Improved mobility on US-75 will facilitate tourism by enhancing access to local and regional destinations	No	Yes
State of Good Repair	Reduced Operations & Maintenance Cost	Bridge replacement will reduce O&M	Yes	Yes
	Residual Value	Useful life of bridges will be extended	Yes	Yes
	Reduced bridge hits / damages	The new vertical clearance of the proposed bridges is expected to reduce bridge-vehicle collisions.	Yes	Yes
Partnership and Collaboration	ODOT and COT Collaboration	Project advancements and coordination have already been established allowing for a smooth transition into design and letting of the future project	No	Yes
	DBE Partnerships	ODOT has exceeded its recent DBE goals and completes contractor reviews to monitor utilization of women and minorities	No	Yes
Innovation	Sensors to Enhance Inspection	Use of strain gauges to serve as maturity meters in newly placed concrete	No	Yes
	DDI	Implement innovative geometry	No	Yes
	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

General Assumptions

The BCA measures benefits against costs throughout a period of analysis beginning at the start of construction and including 20 years of operations. The Project will fully reconstruct the US-75/W. 81st Street interchange with new US-75 bridges and pavement on the interchange ramps and W. 81st Street. The mainline pavement on US-75 will remain unimproved and the project is primarily an operational improvement. Therefore a 20-year operating period was chosen as a conservative estimate for the overall Project. Additional useful life of the new bridges is anticipated and is described under Residual Value below. The methodology makes several important assumptions and seeks to avoid overestimation of benefits and underestimation of costs. Specifically:

- Input prices, costs, and benefits are expressed in 2022 dollars.
- The period of analysis begins in 2024 and ends in 2046. It includes three years of project development and construction in 2024 - 2026 and 20 years of operations (2027 – 2046).

- A constant 3.1 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 2 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 2027 (no ramp-up).[6]

Delay Forecasts and Pedestrian Counts

The delay forecast is a critical component of the benefit-cost analysis as multiple benefits depend on the vehicle delays using the project area roads under No-Build and Build scenarios. Travel time savings for vehicles, operating cost savings, and emission reductions are all directly correlated with delay. Traffic volumes at the US-75/W. 81st Street interchange are anticipated to grow over the next 20 years. According to ODOT projections, traffic at the interchange is anticipated to grow approximately 2% per year through 2045[7]. Per feedback from USDOT on ODOT's FY 2022 RAISE grant debrief on this project, the 2% growth rate was considered too high since it is triple the growth rate for City of Tulsa. The 2% growth rate was maintained in this analysis as it is consistent with historic traffic growth on this section of US-75. Since 2020 when traffic decreased significantly due to the COVID-19 pandemic, volumes on US-75 have increased by over 2% per year[8]. Further, the 2% growth rate is consistent with the growth rate for the city of Glenpool located just south of the interchange. US-75 is the primary transportation corridor for Glenpool and is one of the fastest growing cities in the Tulsa metropolitan area. The U.S. Census shows that the population of Glenpool increased 3.8% from 2020 to 2022 and grew 26.7% from 2010 to 2020.[9] Based on a historical growth rate of 2%, average annual daily traffic volumes (AADT) on US-75 are expected to grow from 28,400 vehicles per day (vpd) in 2018 to 43,800 vpd in 2045.

Another comment received on the 2022 USDOT debrief was related to annualization of delay. Delay was annualized over the entire year for this interchange rather than the typical weekdays only. Demand at this interchange is driven not only by commuter patterns but by retail, church, and restaurant trips, altering the typical pronounced AM and PM peaking patterns. The shops and restaurants in the Tulsa Hills development draw lunch hour and weekend traffic in volumes equaling or exceeding the typical commuter peak hours. Weekend delay can be significant as demonstrated by Google traffic (**Figure 5**). Further, weekday traffic counts show that the interchange experiences a midday peak hour delay that is even higher than the AM peak (**Figure 6**). Midday traffic comprises 7.7% of entering traffic, AM comprises 5.7%, and PM about 8.5%. For this analysis the AM and PM delay was averaged to estimate the midday value which results in a conservative estimate. Using a 365-day year, current and future delays were established for vehicular traffic as shown below in **Table 6**. The sensitivity analysis portion of this memo illustrates scenarios where delay is increased by 20% and where the midday peak delay savings is removed entirely. These scenarios result in BC ratios of 1.85 and 1.54 respectively.

[6] A two-year ramp up was assumed for induced pedestrian trips. See Health Benefits section below.
[7] ODOT Design Traffic, 2018 and 2045, developed 10/25/2017 – see attachments at US-75/81st RAISE.
[8] ODOT AADT Counts, Count Site 00720171, US-75 north of W. 81st Street AADT Traffic Counts | ODOT Spotlight (arcgis.com)
[9] U.S. Census Bureau QuickFacts: Glenpool city, Oklahoma

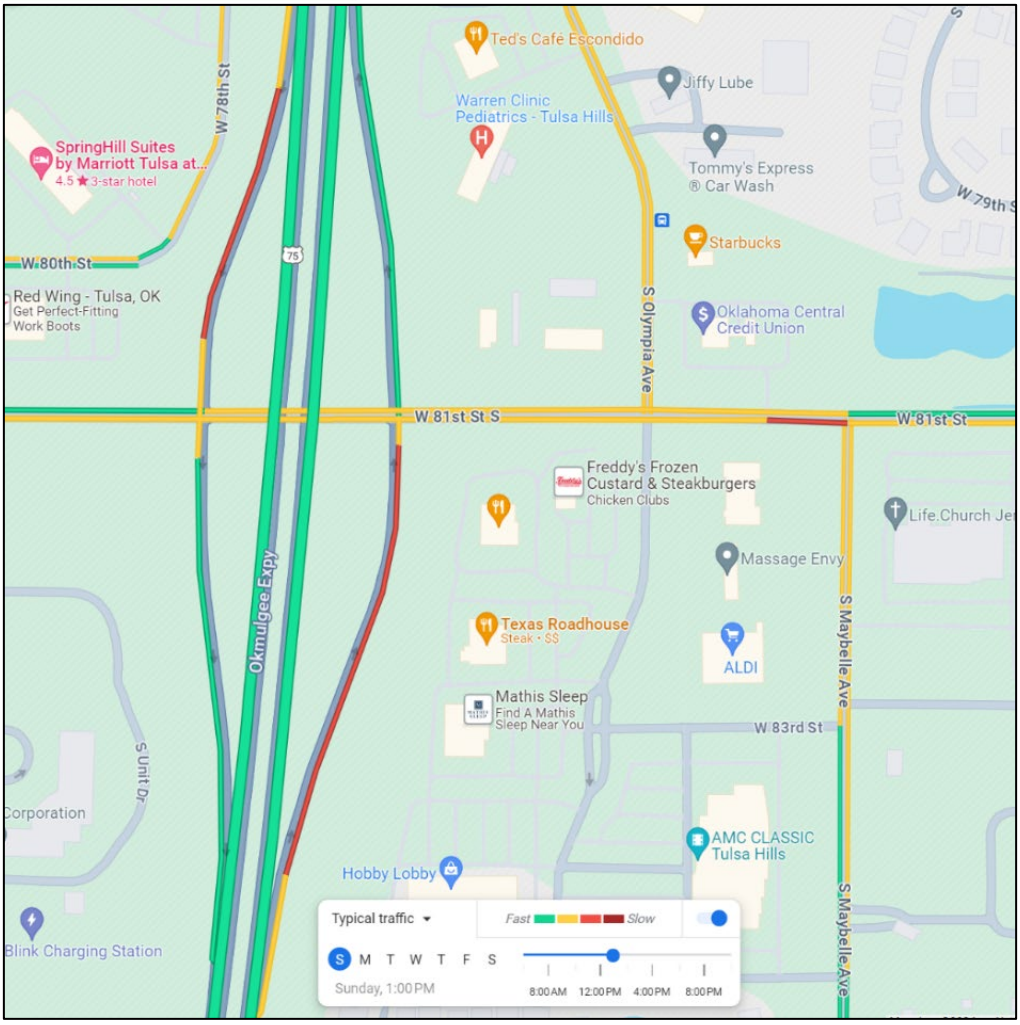

Figure 5: Google traffic showing delay at the US-75/W. 81s Street interchange, Sunday at 1:00 PM

Table 6: Vehicle Hours of Delay, 2023 and 2046

Synchro Analysis: Total Vehicle-Hours per Day	2023			2046		
	AM	Noon	PM	AM	Noon	PM
Existing	47	45.5	44	179	214	249
Proposed	27	29.5	32	85	115	145
Benefit	20	16	12	94	99	104

Source: ODOT Design Traffic Data and Synchro Analysis

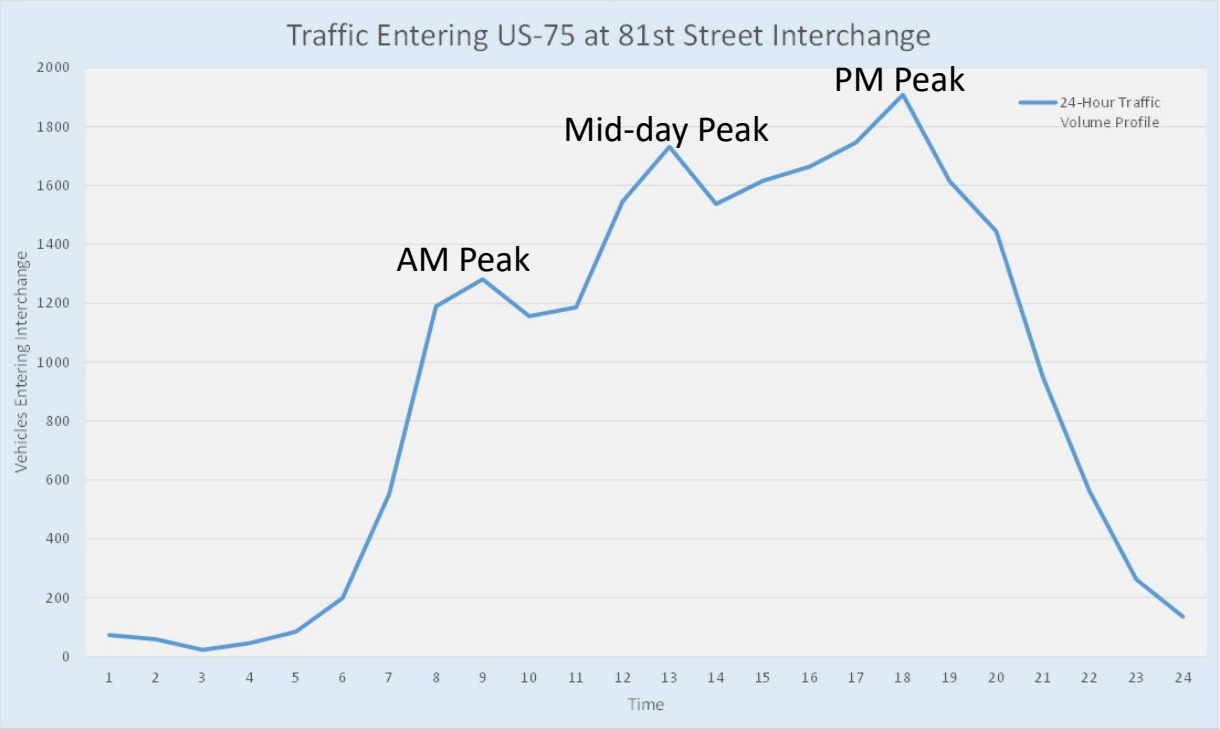

Figure 6: Traffic Volumes Entering US-75 from W. 81st Street[10]

Benefits

This section describes the measurement approach used for each quantifiable benefit or impact category identified in **Table 5** and provides an overview of the methodologies and assumptions. A summary of all benefits is presented in **Table 7**.

Table 7: Summary of Benefits, Millions of Dollars in 2022

Benefits ($ millions)	Undiscounted	2% Discount Rate	3.1% Discount Rate
Safety Benefits	$5.40	$3.96	$3.36
Travel Time	$46.68	$33.30	$27.88
Reduced Vehicle Operating Costs	$14.65	$10.58	$8.92
Emissions Reduction*	$0.38	$0.27	$0.23
Pedestrian / Cycling Improvements	$5.20	$3.81	$3.23
Health Benefits	$2.86	$2.08	$1.76
Reduced Bridge Hits	$0.03	$0.03	$0.02
Reduced Maintenance	$3.62	$2.61	$2.20
Residual Value	$3.51	$2.14	$1.64
Present Value of Benefit	**$82.33**	**$58.78**	**$49.24**

*Emissions 3.1% discount factor includes 2% discount for CO2

[10] Raw traffic counts from ODOT US-75 Corridor Study in progress [JP 35460(05)]

Safety Benefits

Quantified safety benefits include reduction in expected number of crashes due to safer interchange configuration through the DDI. Collision data as reported in ODOT's Safe-T database from 2012-2021 is shown in **Table 8** and **Figure 7**. Only the collisions reported at the US-75 ramp/W. 81st Street intersections are reported to not overestimate the collision reduction benefit.

Figure 7: US-75 Collision Heat Map (2012-2021), ODOT Safe-T Database

According to the *Federal Highway Administration DDI Informational Guide 2nd Edition* (NCHRP Report 959), a DDI interchange can be expected to provide a Crash Modification Factor (CMF) of 0.52 for projects that construct a DDI in place of two signalized ramp terminal intersections on a crossroad with a speed limit of 40 mph and zero lane drops[11]. This CMF was selected in part based on feedback from USDOT on the FY 2022 RAISE application for this project that considered the CMF of 0.434 used in that application was too high and was found to be the best fit for the proposed project. Based on a 0.52 CMF the project is expected to reduce total crashes during the analysis period from 98 total crashes to 51 total crashes under the Build alternative. This collision reduction was monetized according to values presented in Appendix A, Table A-1 in the BCA Guidance, producing a benefit of $3.36 million. The sensitivity analysis portion of this memo shows that even by reducing the CMF by 20% (i.e. a CMF of 0.624) the BC ratio remains 2.03.

Table 8: Collision Data, 2012-2021

Collision Type	Count	Rate/Year
Non-incapacitating injuries or possible injury	16	1.78
PDO	18	2.00
Total Crashes	34	3.78

Source: ODOT Collision Data, 2012-2021

Travel Time Savings

The Project is anticipated to generate vehicular and pedestrian travel time savings. Design traffic volumes provided by ODOT were analyzed using Synchro SimTraffic for the 2023 and 2046 Build and No-Build scenarios. The vehicle delays under the No-Build scenario, as shown in **Table 6**, amount to 136.5 vehicles hours of delay per day in 2023 and are forecast to increase to 642 vehicle hours of delay per day by 2046. The Project is expected to reduce delay to 88.5 vehicles hours per day in 2023 (base year for comparison) and 345 vehicle hours of delay per day in 2046, thus creating a savings of 48 and 297 vehicle-hours per day in 2023 and 2046, respectively. The

[11] Chapter 4 - Safety | Diverging Diamond Interchange Informational Guide, Second Edition | The National Academies Press, (Exhibit 4-7)

proposed DDI is anticipated to increase traffic throughput and avoid delays associated with the existing signalized intersections. The assumptions used in the estimation of travel time savings for vehicles are summarized in **Table 9** below and produced a savings of $27.88 million.

Table 9: Travel Time Saving Assumptions - Vehicles

Variable	Unit	Value
All Purposes	$/person/hour	$18.80
Passenger Vehicles All Travel	Per vehicle	$1.67

Source: USDOT BCA Guidance for Discretionary Grant Programs

The Project is also anticipated to produce travel time savings for pedestrians and cyclists. Today, the shortest distance required for pedestrians and cyclists to cross US-75 at a reasonably safe location is almost 4 miles. This is because there are no pedestrian facilities available on W. 81st Street in the vicinity of the Project. Given the distance, it is unlikely that many pedestrians or even cyclists are making this trip. Because no data exists on existing pedestrian routes or travel times across US-75, pedestrian travel time savings were not quantified in this BCA.

Operating Cost Savings

While the Project will not reduce total vehicle miles traveled, it will reduce total vehicle delay, which in turn reduces fuel consumption. The Synchro analysis provided total fuel consumption (gallons/day). Total gallons were monetized according to values provided in the USDOT BCA Guidance Appendix A, Table A-4. The total value of reduced vehicle operating cost through reduced fuel consumption equates to $8.92 million, discounted at 3.1%. **Table 10** summarizes the fuel consumption reduction.

Table 10: Estimated Fuel Consumption Savings (gal.), 2023 and 2046

Synchro Analysis: Fuel Consumption	2023			2046		
	AM	Noon	PM	AM	Noon	PM
Existing	116	115	114	253	280.5	308
Proposed	94	98	102	174	199.5	225
Benefit	22	17	12	79	81	83

Source: ODOT Design Traffic Data, Synchro Modeling, 65% design plans

Emissions Reduction Benefits

Similar to reduced vehicle operating costs, all emissions reductions will be achieved by the Project through reduced delay and fuel savings since total vehicle miles remain unchanged. The Synchro analysis provided total kilogram (kg) of emissions per day for carbon dioxide (CO_2), nitrogen oxide (NO_X) and volatile organic compounds (VOC); however, only CO_2 and NO_X were monetized for the BCA. Total emissions are shown in **Table 11** on the next page.

Table 11: Anticipated Emissions Reduction

Emissions (kg)	2023					
	AM		Noon		PM	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
CO_2	8.08	6.6	8.03	6.87	7.97	7.13
NO_X	1.57	1.28	1.56	1.335	1.55	1.39
VOC	1.87	1.53	1.86	1.59	1.85	1.65
	2046					
	AM		Noon		PM	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
CO_2	17.7	12.19	19.62	13.97	21.54	15.74
NO_X	3.44	2.37	3.83	2.73	4.19	3.06
VOC	4.1	2.83	4.55	3.24	4.99	3.64

Source: ODOT Design Traffic Data, Synchro Modeling

Using values provided in the BCA Guidance Appendix A, Table A-6, the benefit associated with emissions reductions totals to $230,000, discounted at 3.1%, except for CO_2 which was discounted at 2% per USDOT BCA Guidelines because greenhouse gas (GHG) emissions can have long-lasting, even intergenerational impacts.

Facility Amenity Benefits

The existing roadway within the Project corridor lacks pedestrian amenities including sidewalks, dedicated crosswalks and pedestrian-activated signalized intersections. The additional amenities proposed by the Project will improve the quality or comfort of journeys made through forms of active transportation. Since there are no pedestrian facilities today, any such facilities proposed by the Project are a direct benefit. The assumptions related to pedestrian improvements are provided in **Table 12** based on 65% design plans for the Project. The benefit associated with increased pedestrian facilities totals to $3.23 million, discounted at 3.1%.

Table 12: Pedestrian Amenities

Variable	Unit	Value
Proposed Sidewalk Width	feet	12.0
Number of Marked-Crosswalks	each	8
Number of Signals for Pedestrian Crossing	each	4
Sidewalk length	miles	0.53

Source: ODOT 65% design plans

Health Benefits

The Project will include a new 12-foot sidewalk on W. 81st Street across US-75, providing a safe multimodal crossing of US-75 that does not exist today. Given this connection, some future trips may become more feasible on foot or bike and encourage more people to walk or bike to their destinations. American Community Survey (ACS) 2022 data shows that 1.4% of the population of Tract 67.13 (west of US-75) and 0% of the population of Tract 67.12 (east of US-75) walked to work[12]. Using a simple technique to forecast pedestrian demand based on commute share and

[12] ACS 2022 5-Year estimates Table S0801, Tract 67.12 and 67.13, Tulsa County, Oklahoma

future AADT, approximately 2% of future traffic on W. 81st Street could be expected to shift to pedestrian trips[13]. However, because no project-specific data exists to forecast demand, and because there are so many factors that influence mode choice even on a given day, a 1% increase was used as a conservative number to estimate future health benefits of this mode shift. This increase was annualized over 200 days/year, roughly equivalent to the growing season in Tulsa[14] and a reasonable estimation of good-weather days suitable for walking. For the BCA, a conservative two-year "ramp up" of pedestrian volume was also used. In the first year, only 50% of the demand would be realized, while the second year would see 75%. The "ramp-up" assumptions are a measure to account for the time it would take motorists to notice the new pedestrian facilities and make the decision to use them in lieu of driving when appropriate. While induced pedestrian demand does create a noticeable benefit ($1.76 million), it is not a critical portion of the BC ratio; the sensitivity section of this memo includes a sensitivity that removes this benefit of induced pedestrian demand where the BC ratio would be reduced from 2.06 to 1.91.

Reduced Bridge Hits

The Project will replace the existing US-75 bridges over W. 81st Street. The existing bridges have insufficient vertical clearance (14'-7") and have an elevated exposure to vehicle hits. The Project would replace the bridges with 17' high bridges to meet ODOT's vertical clearance standard of 16'-9".

ODOT provided data related to the damage incurred for low-clearance bridges throughout the State. This analysis focused on probability and average damage incurred within ODOT District 8 where the Project is located. Based on the assumptions provided in **Table 13** below, the Project would eliminate the risk of bridge hits which translates to a benefit of $20,000, discounted at 3.1%.

Table 13: Bridge Hit Reduction

Variable	Unit	Value
Number of Bridge Hits in District 8	count	10
Period of Bridge Hits Analyzed	years	4
Number of Low Clearance Bridge in District 8	count	276
Probability of Bridge Hit	incidents / Period	3.62%
Probability of Bridge Hit	incidents / year	0.91%
Bridge Replacement Cost	$	$ -
Average bridge damage per hit	$	$ 187,061
Total cost of bridge hit	$ / incident	$ 187,061

Source: ODOT, $2022

Residual Value

The Project includes construction of two new bridges on US-75 over W. 81st Street. For the purposes of calculating a residual value for this analysis the new US-75 bridges are assumed to have a service life of 40 years. While service life depends on many factors, 40 years was selected

[13] Pedestrian mode share = 2.2 x pedestrian commute share, Griffin, Greg, 2009. "Simple Techniques for Forecasting Bicycle and Pedestrian Demand". Practicing Planner 7, 3. Pedestrian commute share assumed to be the average of Tract 67.13 and 67.12 (0.85%).
[14] National Weather Service Tulsa Climate Overview (weather.gov)

for the Project based on the National Bridge Investment Analysis System (NBIAS) forecast of the closure date of NBI 32674, a steel structure similar to the proposed Project bridges constructed in 2021 at the US-75 and I-44 interchange, approximately 3 miles north of the Project. The NBIAS tool forecasts closure of NBI 32674 in 2062, 41 years after being built.

Residual value was calculated on the remaining use life of the bridge structures only. Bridge costs were taken from the latest engineer's cost estimate, based on 65% plans (2023). Costs include the permanent bridge structure only and exclude the cost of temporary structures and removal of existing structures. The residual value was calculated assuming a straight-line depreciation and a service life of 40 years for the bridge structures. No other project components were assumed to have any remaining useful life at the end of the analysis period. Under the No Build scenario, the existing bridges would not have any remaining useful life in 2046. The residual value was added to project benefits in the last year of the analysis period, 2046 and resulted in a benefit of $1.64 million discounted at 3.1%. Related assumptions are provided in **Table 14** below.

Table 14: Residual Value, $2022

Variable	Unit	Value
Residual Life (Project Bridge Cost)	$	$ 7,022,865
Useful Life	Years	40
Existing Asset Useful Value	$	$ -

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 vehicle delay, health benefits, value of CMF, capital cost, as well as years of operations included in Project BCA analysis. Each of these factors were individually increased or decreased as shown in **Table 15** below. A combined downside scenario was also included, where both the elimination of the midday peak hour delay and the health benefits were removed. **Table 15** provides the percentage changes in project NPV associated with variations in variables or parameters.

Table 15: BCA Sensitivity Analysis

Parameters	Change in Parameter Value	New NPV	% Change in NPV	New B/C Ratio
Base Case	N/A	$25.31	N/A	2.06
Sensitivities				
Vehicle Delay	20% Reduction in Delays	$ 20.41	-19.4%	1.85
	20% Increase in Delays	$ 30.22	19.4%	2.26
	Elimination of noon peak hour	$ 12.97	-48.8%	1.54
Induced Pedestrian Demand	Elimination of health benefits	$ 21.76	-14.0%	1.91
CMF for DDI	20% Reduction (CMF 0.624)	$ 24.58	-2.9%	2.03
	20% Increase (CMF 0.416)	$ 26.04	2.9%	2.09
Capital Cost[15]	20% Reduction	$ 29.63	17.1%	2.51
	20% Increase *(net of 15% contingency)*	$ 24.23	-4.3%	1.97
Analysis Period	30 Year Analysis Period	$ 49.19	94.3%	3.06
Combined Downside	-Elimination of noon peak hour, and -Elimination of Induced Ped Demand	$9.42	-62.8%	1.39

The table demonstrates that under the alternative parameter values that may depress Project NPV, including a combined downside scenario, the Project maintains NPV above $9.42 million and BC Ratio of 1.39 or higher which demonstrated the resiliency of the Project's quantitative merits.

[15] Construction cost includes a 15% cost contingency meaning a 20% cost increase would be partially absorbed by the project's contingency and result in a net cost increase of 5%.