Benefit-Cost Analysis Supplementary Documentation

RAISE Discretionary Grant Program

KY 54 Corridor Improvements

Daviess County, Kentucky

July 12, 2021

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Executive Summary

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

The project for which this BCA is conducted is the KY 54 Corridor Improvement Project ("the Project"). The KY 54 is the highest volume highway in the Daviess County/City of Owensboro region, serving over 30,000 vehicles every day. It also has high projected growth and a high existing crash rate, making improvements to the highway imperative. The Project will improve the most critical part of the corridor, which connects key commercial, industrial, and residential areas of the city and County. This portion of the corridor is flanked by commercial land uses, and even with strict access management already in place, there are observable capacity and safety issues typically more associated with larger urban areas. Approval of this 2021 RAISE Grant Application would result in the construction of 1.9 miles of improvements, including additional lanes, a raised median, an upgraded drainage system, and improved pedestrian and bicycle facilities.

The proposed sections to be improved on the KY 54 Corridor are presented in **Figure 1**.

Figure 1: Project Overview

A summary of the changes expected from the Project and the associated benefits (discounted at 7 percent) is provided in Table ES-1 (in dollars of 2019).

Table ES - 1: Summary of Infrastructure Improvements and Associated Benefits

Current Status or Baseline & Problems to Be Addressed	Changes to Baseline / Alternatives	Type of Impacts	Population Affected by Impacts	Economic Benefits	Summary of Results (Discounted 2019$)
Located in Owensboro, Kentucky, KY 54 is a principal arterial and a major commercial corridor connecting Owensboro to nearby Whitesville. The current facility is a typical 5-lane section with two lanes in each direction with a two-way left-turn lane in-between. This existing roadway section is not equipped to safely carry the volume of traffic travelling along this urban corridor due to a lack of capacity.	The KY 54 project seeks to improve the corridor by improving lane capacity, controlling left-turn access, upgrading grading and drainage systems, enhancing pedestrian and bicycle facilities, and providing additional safety upgrades to the rural corridor. The upgrades to the corridor are divided into two sections. Section 1 extends from the US 60 interchange to Ralph Road. Within this segment, the roadway will be changed from the existing five-lane section to a six-lane section with raised medians. Starting at Hayden Road, an 8-foot shared-use path will be added to the northside of KY 54 to the end of Section 1. Section 2 runs from Ralph Road to Thurston Dermont Road (KY 1456). Within this section, the roadway will be repaved and reprofiled with an upgraded drainage system to improve safety during storm events. Section 2 will also have a 10-foot shared used path added to the northside of KY 54.	By adding a travel lane in each direction while bringing greater control to the locations where left turns are allowed, travel time will be improved during critical high-demand periods.	Local residents and motorists within the State	Improved travel time savings	$36.6 M
		There is a disbenefit in improved safety due to expanded corridor capacity and more traffic volumes from improved lane capacity.	Local residents and motorists within the State	Improved Safety and Avoided Accident Costs	-$6.0 M
		Reduced criteria air contaminants (CAC) pollution from steady speeds due to additional lanes.	Local residents and the general public	Improved Emissions Costs	$0.04 M
		Reduced greenhouse gas (GHG) pollution from steady speeds due to additional lanes.	Local residents and the general public		$0.67 M
		Increased long-term maintenance and rehabilitation costs as a result of additional lane miles.	Agency operating KY 54; Local residents	Increased Maintenance Costs	-$0.05 M
		Residual value of capital assets.	Project sponsors	Residual Value	$1.9 M
		Vehicles are able to travel at a higher speed due to the improved connectivity from road widening, which reduces vehicle fuel costs while driving.	Local residents and motorists within the State	Vehicle Operating Cost Savings	$2.7 M
		The additional travel lanes and greater control of the locations where left turns are allowed will improve travel time reliability.	Local residents and motorists within the State	Travel time reliability	Not Monetized
		Improved lane capacity and upgrades to the corridor will improve vehicle mobility and the roadway connectivity between Owensboro and Whitesville.	Local residents and the general public	Improved mobility and connectivity	Not Monetized

The period of analysis used in the estimation of benefits and costs corresponds to 28 years, including 8 years of construction and project support from 2019 to 2026 and 20 years of operations from 2027 to 2046. The total (undiscounted) Project costs are estimated to be $41.6 million in 2019 dollars.

Tables ES-2 to ES-7 provide various summaries of the relevant data and calculations used to derive the benefits and costs of the Project. Based on the analysis presented in this document, the project is expected to generate $35.9 million in discounted benefits and $33.1 million in discounted costs. Therefore, the project is expected to generate a **Net Present Value of $2.8 million** and a **Benefit-Cost Ratio of 1.1**.

Table ES - 2: Overall Results of the Benefit Cost Analysis, 2019 Dollars

Project Evaluation Metric	Discounted at 7%[1]
Total Benefits	$35,895,131
Total Costs	$33,121,164
Net Present Value	$2,773,967
Benefit / Cost Ratio	1.1
Payback Period (years)	19.2 yrs
Internal Rate of Return (%)	7.50%

Table ES - 3: Summary of Project Costs, in Undiscounted 2019 Dollars, by Funding Source

Project Component	Total	Kentucky Transportation Cabinet	Daviess County	City of Owensboro	USDOT RAISE Request
Previously Expended	$11,844,724	-	-	-	-
Design	$117,274	$117,274	-	-	-
Right of Way Acquisition	$2,931,862	$2,931,862	-	-	-
Utility Relocation	$8,648,994	$8,648,994	-	-	-
Permitting Fees	$1,465,931	-	-	-	$1,465,931
Construction	$16,555,250	-	$454,465	$454,465	$15,646,320
Total	**$41,564,036**	**$11,698,131**	**$454,465**	**$454,465**	**$17,112,251**

In addition to the monetized benefits, the Project would generate other benefits that are difficult to quantify. A brief description of those unquantified benefits is provided below.

Safety

- The upgrades to the pedestrian and bicycle facilities along the corridor will provide notable safety improvements. The existing project area features two elementary schools and numerous businesses with limited pedestrian facilities and no bicycle facilities to allow safe access. The addition of the 8’ to 10’ shared use path and the upgrades to the adjacent sidewalk will provide a safe and inviting area for pedestrian and bicyclists to access the corridor with separation from the KY 54 vehicular traffic.
- The current stormwater upgrades will make the corridor safe to travel on during extreme weather events

Environmental Sustainability

[1] 3 percent discount rate for the benefits from reduction in CO2 emissions, and 7 percent discount rate for everything else, as per USDOT BCA Guidance, February 2021.

This project includes several drainage upgrades that will help prevent this critical corridor from flooding and becoming inoperable. Improvements made to this corridor will also ensure that it is resilient to future traffic growth as well, keeping the corridor moving along efficiently even as traffic is expected to increase over the next 20 years.

Quality of Life

Improving this corridor will improve travel time reliability for both local and regional travel.

- Improved access to education and health care facilities: This corridor includes access to 3 elementary schools (and a future middle school) and direct access to the only Level III Trauma center in western Kentucky, Owensboro Health.
- Improved access to pedestrian and bicycle facilities: This project will also connect pedestrians and bicyclists to commercial areas and neighborhoods, on safe and properly designed shared-use-paths, with modern crosswalk and updated signal facilities.
- Improved multimodal access: The benefits of reduced congestion will be fully realized by the public who use and depend on the Owensboro Transit System for their main mode of transportation.

Economic Competitiveness

The Greater Owensboro Economic Development Corporation indicates the region's top 2 employers are Healthcare and Retail, which are impacted by this corridor. This project will decrease travel times along the corridor for residents who live east of Owensboro and work at Owensboro Health, thus improving access to jobs. In addition, improved access and connectivity between Owensboro and the City of Whitesville and many other rural communities will provide significant economic improvement.

State of Good Repair

New storm system facilities are included in this project, including sufficiently sized catch basins, pipes, and drainage channels to carry the stormwater away efficiently. Also included with this project are utility relocations that will allow the utilities to replace their aging lines. In the case of the water utility, upsize the line to meet future demand in the area. The cost to replace these aging utility lines, separate from the roadway project, would again be several orders of magnitude higher than the relocation cost of putting new lines in with this project.

Table ES - 4: Summary of Project Benefits and Costs, 2019 Dollars

Calendar Year	Project Year	Total Benefits (Undiscounted)	Total Capital Costs (Undiscounted)	Undiscounted Net Benefits	Discounted Total Benefits	Discounted Total Costs	Discounted Net Benefits
2019	1	-	$3,948,241	-$3,948,241	-	$3,948,241	-$3,948,241
2020	2	-	$3,948,241	-$3,948,241	-	$3,689,945	-$3,689,945
2021	3	-	$3,948,241	-$3,948,241	-	$3,448,547	-$3,448,547
2022	4	-	$4,749,715	-$4,749,715	-	$3,877,182	-$3,877,182
2023	5	-	$13,145,494	-$13,145,494	-	$10,028,634	-$10,028,634
2024	6	-	$7,519,738	-$7,519,738	-	$5,361,470	-$5,361,470
2025	7	-	$1,986,630	-$1,986,630	-	$1,323,775	-$1,323,775
2026	8	-	$2,317,735	-$2,317,735	-	$1,443,369	-$1,443,369
2027	9	$1,858,794	-	$1,858,794	$1,081,835	-	$1,081,835
2028	10	$2,361,445	-	$2,361,445	$1,295,101	-	$1,295,101
2029	11	$2,819,705	-	$2,819,705	$1,444,783	-	$1,444,783
2030	12	$3,160,530	-	$3,160,530	$1,513,610	-	$1,513,610
2031	13	$3,583,439	-	$3,583,439	$1,603,948	-	$1,603,948
2032	14	$4,137,269	-	$4,137,269	$1,730,421	-	$1,730,421
2033	15	$4,414,959	-	$4,414,959	$1,712,197	-	$1,712,197
2034	16	$4,882,517	-	$4,882,517	$1,769,649	-	$1,769,649
2035	17	$5,443,763	-	$5,443,763	$1,869,432	-	$1,869,432
2036	18	$5,873,433	-	$5,873,433	$1,885,674	-	$1,885,674
2037	19	$6,146,197	-	$6,146,197	$1,845,510	-	$1,845,510
2038	20	$6,727,647	-	$6,727,647	$1,888,023	-	$1,888,023
2039	21	$7,156,134	-	$7,156,134	$1,849,281	-	$1,849,281
2040	22	$7,682,763	-	$7,682,763	$1,855,488	-	$1,855,488
2041	23	$7,945,071	-	$7,945,071	$1,793,307	-	$1,793,307
2042	24	$8,570,709	-	$8,570,709	$1,861,587	-	$1,861,587
2043	25	$9,291,645	-	$9,291,645	$1,886,641	-	$1,886,641
2044	26	$9,436,593	-	$9,436,593	$1,794,626	-	$1,794,626
2045	27	$9,666,253	-	$9,666,253	$1,664,485	-	$1,664,485
2046	28	$22,056,319	-	$22,056,319	$3,549,532	-	$3,549,532
Total		**$133,215,186**	**$41,564,036**	**$91,651,150**	**$35,895,131**	**$33,121,164**	**$2,773,967**

Table ES - 5: Summary of Project Benefits by Benefit Type, in Undiscounted 2019 Dollars

Calendar Year	Benefit Year	Travel Time Savings	Vehicle Operating Costs Savings	Accident Cost Savings	CAC Emission Cost Savings	GHG Emission Cost Savings	O&M Cost Savings	Residual Value
2019	1	-	-	-	-	-	-	-
2020	2	-	-	-	-	-	-	-
2021	3	-	-	-	-	-	-	-
2022	4	-	-	-	-	-	-	-
2023	5	-	-	-	-	-	-	-
2024	6	-	-	-	-	-	-	-
2025	7	-	-	-	-	-	-	-
2026	8	-	-	-	-	-	-	-
2027	9	$2,768,217	$256,813	-$1,160,303	-	-	-$5,932	-
2028	10	$3,148,280	$291,365	-$1,125,978	$5,924	$47,786	-$5,932	-
2029	11	$3,528,344	$334,869	-$1,091,653	$5,769	$48,308	-$5,932	-
2030	12	$3,908,408	$261,642	-$1,057,328	$5,623	$48,779	-$6,594	-
2031	13	$4,288,472	$268,855	-$1,023,004	$5,750	$49,960	-$6,594	-
2032	14	$4,668,535	$406,991	-$988,679	$5,878	$51,137	-$6,594	-
2033	15	$5,048,599	$327,308	-$954,354	-	-	-$6,594	-
2034	16	$5,428,663	$380,477	-$920,029	-	-	-$6,594	-
2035	17	$5,808,727	$428,370	-$885,704	$11,472	$89,445	-$8,547	-
2036	18	$6,188,790	$441,883	-$851,379	$11,521	$91,164	-$8,547	-
2037	19	$6,568,854	$298,517	-$817,054	$11,565	$92,862	-$8,547	-
2038	20	$6,948,918	$463,864	-$782,729	$11,606	$94,536	-$8,547	-
2039	21	$7,328,982	$584,104	-$748,404	-	-	-$8,547	-
2040	22	$7,709,045	$696,344	-$714,079	-	-	-$8,547	-
2041	23	$8,089,109	$544,263	-$679,754	-	-	-$8,547	-
2042	24	$8,469,173	$555,491	-$645,430	$18,708	$181,314	-$8,547	-
2043	25	$8,849,237	$857,128	-$611,105	$18,952	$185,980	-$8,547	-
2044	26	$9,229,300	$582,729	-$576,780	$19,195	$190,695	-$8,547	-
2045	27	$9,609,364	$607,891	-$542,455	-	-	-$8,547	-
2046	28	$9,989,428	$722,556	-$508,130	-	-	-$8,547	$11,861,012
Total		**$127,576,445**	**$9,311,457**	**-$16,684,332**	**$131,961**	**$1,171,967**	**-$153,324**	**$11,861,012**

Table ES - 6: Summary of Pertinent Quantifiable Data (Part 1)

Calendar Year	Benefit Year	Avoided Gasoline Consumption (gallons)	Avoided Diesel Consumption (gallons)	Personal Hours Saved (hours)	Fatalities Avoided (fatalities)	Injuries Avoided (injuries)	PDOs Avoided
2019	1	-	-	-	-	-	-
2020	2	-	-	-	-	-	-
2021	3	-	-	-	-	-	-
2022	4	-	-	-	-	-	-
2023	5	-	-	-	-	-	-
2024	6	-	-	-	-	-	-
2025	7	-	-	-	-	-	-
2026	8	-	-	-	-	-	-
2027	9	108,710	7,911	152,417	-0.07	-4.58	20
2028	10	120,925	10,005	173,343	-0.07	-4.33	21
2029	11	135,590	12,168	194,269	-0.07	-4.09	23
2030	12	101,876	9,318	215,195	-0.07	-3.84	25
2031	13	103,624	9,478	236,121	-0.07	-3.59	27
2032	14	158,059	11,659	257,048	-0.07	-3.34	29
2033	15	124,974	8,633	277,974	-0.07	-3.10	30
2034	16	145,159	7,590	298,900	-0.07	-2.85	32
2035	17	163,621	6,438	319,826	-0.07	-2.60	34
2036	18	166,207	6,612	340,752	-0.07	-2.36	36
2037	19	111,736	4,452	361,678	-0.07	-2.11	38
2038	20	171,379	6,743	382,604	-0.07	-1.86	39
2039	21	205,818	13,916	403,531	-0.07	-1.61	41
2040	22	238,717	21,222	424,457	-0.07	-1.37	43
2041	23	181,660	19,210	445,383	-0.07	-1.12	45
2042	24	181,723	19,487	466,309	-0.07	-0.87	47
2043	25	277,761	29,646	487,235	-0.07	-0.63	48
2044	26	186,895	20,041	508,161	-0.07	-0.38	50
2045	27	192,150	20,401	529,087	-0.07	-0.13	52
2046	28	238,055	15,032	550,014	-0.07	0.12	54
Total		**3,314,639**	**259,960**	**7,024,303**	**-1**	**-45**	**736**

Table ES - 7: Summary of Pertinent Quantifiable Data (Part 2)

Calendar Year	Benefit Year	CO2 Emissions Avoided (tons)	NOx Emissions Avoided (tons)	PM Emissions Avoided (tons)	SO2 Emissions Avoided (tons)
2019	1	-	-	-	-
2020	2	-	-	-	-
2021	3	-	-	-	-
2022	4	-	-	-	-
2023	5	-	-	-	-
2024	6	-	-	-	-
2025	7	-	-	-	-
2026	8	-	-	-	-
2027	9	-	-	-	-
2028	10	810	0.29	0.0007	0.0052
2029	11	805	0.29	0.0006	0.0052
2030	12	800	0.28	0.0004	0.0051
2031	13	806	0.28	0.0005	0.0052
2032	14	812	0.29	0.0005	0.0052
2033	15	-	-	-	-
2034	16	-	-	-	-
2035	17	1,335	0.54	0.0015	0.0086
2036	18	1,341	0.55	0.0014	0.0087
2037	19	1,346	0.56	0.0013	0.0087
2038	20	1,351	0.56	0.0012	0.0087
2039	21	-	-	-	-
2040	22	-	-	-	-
2041	23	-	-	-	-
2042	24	2,418	0.91	0.0019	0.0156
2043	25	2,447	0.92	0.0019	0.0158
2044	26	-	-	-	-
2045	27	-	-	-	-
2046	28	-	-	-	-
Total		**14,269**	**5.47**	**0.01**	**0.09**

1 Introduction

This document provides detailed technical information on the economic analyses conducted in support of the grant application for the KY 54 Corridor Improvements Project (the Project). The remainder of this document is organized as follows.

- **Section 2 – Methodological Framework** introduces the conceptual framework used in the Benefit-Cost Analysis (BCA).
- **Section 3 – Project Overview** provides an overview of the Project, including a brief description of existing conditions and proposed alternatives; a summary of cost estimates and schedule; and a description of the types of effects that the Project is expected to generate.
- **Section 4 – General Assumptions** discusses the general assumptions used in the estimation of project costs and benefits.
- **Section 5 – Traffic Projections** provides estimates of travel demand and traffic growth.
- **Section 6 – Benefits Measurement, Data, and Assumptions** outlines specific data elements and assumptions pertaining to the long-term outcome selection criteria along with associated benefit estimates.
- **Section 7 – Summary of Findings and Benefit-Cost Outcomes** presents estimates of the Project's Net Present Value (NPV), its Benefit/Cost ratio (BCR) and other project evaluation metrics.
- **Section 8 – Sensitivity Analysis** provides the results of the sensitivity analysis.

Note that additional data tables are provided within the BCA model including annual estimates of benefits and costs to assist the U.S. Department of Transportation (USDOT) in its review of the application.[2]

2 Methodological Framework

The BCA conducted for this Project includes the monetized benefits and costs measured using USDOT guidance, as well as the qualitative impacts generated by the Project. A BCA provides estimates of the benefits 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.[3]

[2] While the models and software themselves do not accompany this appendix, they are provided separately as part of the application.
[3] USDOT, Benefit-Cost Analysis Guidance for Discretionary Grant Programs, February 2021.

While BCA is just one of many tools that can be used in making decisions about infrastructure investments, USDOT believes that it provides a useful benchmark for evaluating and comparing potential transportation investments.[4]

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 No Build and Build scenarios;
- Assessing benefits with respect to each of the merit criteria identified in the NOFO;
- Measuring benefits in dollar terms, whenever possible, and expressing benefits and costs in a common unit of measurement;
- Using US DOT guidance for the valuation of travel time savings, safety benefits and reductions in air emissions, while relying on industry best practice for the valuation of other effects;
- Discounting future benefits and costs with the real discount rates recommended by US DOT (3 percent for CO_2 related impacts and 7 percent for all other impacts); and,
- Conducting a sensitivity analysis to assess the impacts of changes in key estimating assumptions.

3 Project Overview

Located in Daviess County, east of the City of Owensboro, Kentucky, the KY 54 corridor is one of the region's most significant routes. It provides critical connectivity between the City of Owensboro and communities to the east and anchors the region's largest commercial area.

Following the reconstruction of the KY 54 and US 60 interchange in 2013, extensive development has been constructed with more plans in the future. Located within the corridor area are three elementary schools, several shopping centers, three subdivisions and numerous restaurants and retail areas. All this development has resulted in congestion and an increase in accidents within the KY 54 corridor. The area near the interchange with US 60 is congested during peak traffic periods which is a trend that is expected to worsen. Additionally, KY 54 near US 60 also exhibits a crash rate higher than similar facilities, with many crashes clustered near intersections. This rapid growth has resulted in the need to improve the corridor.

The proposed KY 54 improvements seek to improve the corridor by improving lane capacity, controlling left-turn access, upgrading grading and drainage systems, and enhancing pedestrian and bicycle facilities. The project will reduce the current congestion on KY 54 and accommodate increasing traffic volumes as growth continues while improving safety by reducing crashes. This will provide improved regional mobility between Owensboro and communities to the east.

The upgrades to the corridor are divided into four sections, see **Figure 2**. Section 1 extends from the US 60 interchange to Ralph Road. Within this segment, the roadway will be widened to a six-lane section with raised medians. Starting at Hayden Road, an 8-foot shared-use path will be added to the northside of KY 54 within Section 1. Section 2 is from Ralph Road to Thurston Dermont Road (KY 1456). Within this section, the roadway will be repaved and reprofiled with an upgraded drainage

[4] Ibid.

system to improve safety during storm events. Section 2 will also have a 10-foot shared used path added to the northside of KY 54. The KY 54 project included in this 2021 RAISE Grant application include Section 1 and Section 2 improvements.

Figure 2: KY 54 Project Sections

The remainder of the proposed project is from Thurston Dermont Road (KY 1456) to Pleasant Point Drive and is divided into Sections 3 and 4 for different improvements. Section 3 is from KY 1456 to Countryside Drive and will widen the existing rural section to a three-lane urban section with a two-way left-turn lane and an 8-foot shared use path. Section 4 is from Countryside Drive to Pleasant Point Drive and will widen the existing rural section to improve lane width and add 8-foot paved shoulders. Section 3 and 4 improvements will be developed in the future by KYTC following construction of the Section 1 and Section 2 improvements.

3.1 Base and Alternative Case

A single base case, “No Build”, and an alternative “Build” scenario have been developed to assess the benefits and costs associated with the Project.

In the No Build scenario, the KY 54 Corridor does not anticipate changes and reflects the continuation of current conditions. The current facility is a typical 5-lane section with two lanes in each direction with a two-way left-turn lane in-between. This existing roadway section is not equipped to safely carry the volume of traffic travelling along this urban corridor due to a lack of capacity. As such, travel time and efficiency challenges are key areas of concern.

The Build scenario assumes that the Project components described above will be constructed as planned. The upgrades to the corridor are divided into two sections. Section 1 extends from the US 60 interchange to Ralph Road. Within this segment, the roadway will be changed from the existing five-lane section to a six-lane section with raised medians. Starting at Hayden Road, an 8-foot shared-use path will be added to the northside of KY 54 to the end of Section 1. Section 2 runs from Ralph Road to Thurston Dermont Road (KY 1456). Within this section, the roadway will be repaved and

reprofiled with an upgraded drainage system to improve safety during storm events. Section 2 will also have a 10-foot shared used path added to the northside of KY 54.

3.2 Types of Impacts

The KY 54 Corridor Improvement project is expected to have significant impacts to travel time savings and reliability. The additional lanes and the greater control to the locations where left turns are allowed will improve congestion and travel time during critical high demand periods. As the Project looks to improve the average traveling speeds along the KY 54 corridor, the improved speeds are expected to reduce vehicle emissions and vehicle operating costs. While the corridor improvements would improve the overall crash rate of vehicles, the expanded corridor capacity will result in more traffic volumes, which would impact crash severity.

Over the lifecycle of the analysis, **the Project will:**

- Save an estimated 7 million person-hours;
- avoid 3 million gallons of gasoline consumption and 259,960 gallons of diesel consumption;
- avoid 14,269 metric tons of CO2 emissions, 5.47 metric tons of Nitrogen Oxides (NOx) emissions, 0.01 metric tons of PM emissions and 0.09 metric tons of SO2 emissions;
- avoid 736 Property Damage Only (PDO) collisions but may result in 1 fatal collision and 45 injury collisions.

3.3 Project Cost and Schedule

The total cost of the Project in 2019 dollars is $41.6 million. Table 1 summarizes the Project's expenditure profile by year. The Project is currently in the advanced stages of design. Construction for Section 1 is expected to take two years, with an opening date in late 2024. Construction for Section 2 is also expected to take two years, with an opening date in 2026. For the purposes of the BCA, all benefits begin to accrue after substantial completion of the Project and

Table 1: Project Expenditure Profile, 2019 Dollars

Calendar Year	Capital Expenditures	
	Undiscounted	Discounted at 7 Percent
2019	$3,948,241	$3,948,241
2020	$3,948,241	$3,689,945
2021	$3,948,241	$3,448,547
2022	$4,749,715	$3,877,182
2023	$13,145,494	$10,028,634
2024	$7,519,738	$5,361,470
2025	$1,986,630	$1,323,775
2026	$2,317,735	$1,443,369
Total Costs	**$41,564,036**	**$33,121,164**

3.4 Impacts on Selection Criteria

The main benefit categories associated with the Project are mapped into the five merit criteria set forth by USDOT in the table below.

Table 2: Benefit Categories and Expected Effects on Selection Criteria

Merit Criteria	Impact Categories	Description	Inclusion
Safety	Increased Accident Costs	There is a disbenefit in improved safety due to expanded corridor capacity and more traffic volumes from improved lane capacity.	Monetized
	Improved Safety	Upgrades to the pedestrian and bicycle facilities along the corridor will provide a safe and inviting area for pedestrian and bicyclists to access the corridor with separation from the KY 54 vehicular traffic. As well, current stormwater upgrades will make the corridor safe to travel on during extreme weather events.	Qualitative
Environmental Sustainability	Reduced Emission costs	Reduced criteria air contaminants (CAC) and greenhouse gas (GHG) pollution from steady speeds due to additional lanes.	Monetized
Quality of Life	Improved Mobility and Connectivity	Improved lane capacity and upgrades to the corridor will improve vehicle mobility and the roadway connectivity between Owensboro and Whitesville.	Qualitative
	Improved Travel Time Reliability	The additional travel lanes and greater control to the locations where left-turns are allowed will improve travel time reliability.	Qualitative
Economic Competitiveness	Travel Time Savings	By adding an additional travel lane in each direction while bringing greater control to the locations where left-turns are allowed, travel time will be improved during critical high demand periods.	Monetized
	Vehicle Operating Cost Savings	Vehicles are able to travel at a higher speed as a result of the improved connectivity from road widening, which reduces vehicle fuel costs while driving.	Monetized
State of Good Repair	Increased Maintenance Costs	Increased long-term maintenance and rehabilitation costs as a result of additional lane miles.	Monetized
	Residual Value of Asset	Residual value of capital assets.	Monetized

4 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 monetized benefits and costs are estimated in 2019 dollars with future dollars discounted in compliance with RAISE requirements using a 3 percent real rate for CO_2 impacts and 7 percent real rate for all other impacts.

The methodology makes several important assumptions and seeks to avoid overestimation of benefits and underestimation of costs. Specifically:

- Input prices are expressed in 2019 dollars;
- The period of analysis begins in 2019 and ends in 2046. It includes project development and construction years (2019 – 2026) and 20 years of operations (2027 – 2046);
- A constant 3 percent real discount rate for CO_2 impacts and 7 percent real discount rate for all other impacts are assumed throughout the period of analysis.
- Opening year demand and benefits are inputs to the BCA and assumed to be realized in the first full year after construction is finished in 2026 (no ramp-up); and
- Unless specified otherwise, the results shown in this document correspond to the effects of the Build scenario relative to the No Build scenarios defined in Section 3.

General assumptions used for the entire BCA analysis for the Project are provided in **Table 3**.

Table 3: General Assumptions Used in the Analysis

Variable Name	Unit	Value	Source
Real Discount Rate	percent	7%	USDOT BCA Guidance 2021
Real Discount Rate for Carbon Dioxide (CO2)	percent	3%	
Real Discount Rate - Sensitivity	percent	3%	
Base Year of Analysis	year	2019	
Operational Period of Analysis	years	20	
Working Days per Year	days/year	250	Based on number of working days per year in Kentucky
Days per Year	days/year	365	Known
Seconds in an Hour	seconds/hour	3600	Known
Grams per Metric Ton	grams/metric ton	1,000,000	Standardized conversion.
Inflation Adjustment Factor (2021 to 2019)	adjustment factor	0.977	Bureau of Economic Analysis, National Income and Product Accounts, Table 1.1.9, "Implicit Price Deflators for Gross Domestic Product" (May 2021)
Start of Project Development	year	2019	Project Schedule
First Year of Full Benefits	year	2027	
End year of Analysis	year	2046	Based on project schedule and operational period of analysis

5 Traffic Projections

Reasonable demand projections are important to ensure reliable BCA output results. Ultimately the magnitude of the long-term benefit accruing over the Project's study period are primarily a function of

the vehicle traffic along section 1 and section 2 of the KY 54 Corridor. Specifically, demand is reflected in the distance that roadway users travel and the time that roadway users spend traveling.

5.1 Methodology

The travel time analysis was conducted using Synchro/Simtraffic version 10 to analyze the operational conditions for opening and design year peak hour (AM and PM) volumes. The Synchro networks were developed based on the existing/No Build and Build geometries for the study area corridor. The signal timings for the signalized intersections were assumed to be coordinated and were optimized to benefit the corridor as well as the individual movements as possible. It was assumed that the signal timings would change between opening and design year and that they would differ between No Build and Build. Additionally, it was assumed that for safety purposes that the Build signal timing would feature protected-only phasing along KY 54 as turning vehicles would have to cross three travel lanes, which can create safety issues.

The volumes were derived from the traffic forecast for the corridor previously developed by KYTC. The traffic forecasts were developed in 2013, but the volume projections proved to be reasonably accurate for the latest traffic count information (2019) along the corridor. Therefore, the same growth factors were used. The volumes were interpolated for the opening year (assumed 2025) and extrapolated beyond the original horizon year (2040) for the design year (2045). The previous traffic forecast included daily segment volumes and peak (AM and PM) turning movements for No Build and Build scenarios.

Simtraffic simulations were used to determine the peak hour travel times for both build year scenarios. These were developed from averaging five simulation runs with random seedings. The segments of the corridor were broken based on directionality and project segment (segment 1 and segment 2).

To generate daily travel time estimates, the volume-weighted peak travel time reduction benefit was used as the standard or normalized benefit value. The daily volume distribution (derived from an existing hourly count along the corridor) was applied against the opening and design year annual average daily traffic (AADT), generating hourly volumes for each hour of the day. As travel time benefits are anticipated to be primarily effective during peak periods, an exponential equation was developed based on the relationship of the assumed peak volume with the subject hourly volume and applied against the standard peak benefit value. This allowed for a distribution of the peak travel time benefits on a curved scale, which reflected exponentially more benefit for hours of higher volume (daytime hours) than those with lower volume (evening, overnight, early morning hours). This did not negate benefits during lower volume hours as it assumes that the operations of a better-timed signal system will show some benefits even if the volume is not in a congested condition.

5.2 Traffic Assumptions and Projections

The traffic assumptions and projections used in the estimation of travel demand are shown in **Table 4**. Although the projections are only presented for 2025 and 2045, it is assumed that annual volumes are expected to adjust linearly.

Table 4: Traffic Assumptions and Projections used in the Estimation of Traffic and Travel Time

Variable Name	Unit	Value	Source
Traffic Share - Trucks	percent	3%	Traffic Forecasts developed by KYTC
Affected Segment Length	miles	1.87	Total miles of study area
Annual Average Daily Traffic			
2025	vehicles/year	29,300	Weighted corridor AADT for forecasted segment AADTs from Traffic Forecasts developed by KYTC
2045	vehicles/year	40,300	
Daily Weighted Average Speeds			
2025 - No Build	miles/hour	24.36	Weighted harmonic speed means from speeds that are based on SimTraffic Model results, forecasted AADTs, and existing count data at count stations 030D91 and 030294
2045 - No Build	miles/hour	9.80	
2025 - Build	miles/hour	28.14	
2045 - Build	miles/hour	12.07	
Daily Weighted Average Vehicle Hours Travelled (VHT)			
2025 - No Build	vehicle-hours/day	1,871	Based on SimTraffic Model results, forecasted AADTs, and existing count data at count stations 030D91 and 030294
2045 - No Build	vehicle-hours/day	7,695	
2025 - Build	vehicle-hours/day	1,569	
2045 - Build	vehicle-hours/day	6,251	

6 Benefits Measurement, Data, and Assumptions

This section describes the measurement approach used for each benefit or impact category identified in Table 2. The section also provides an overview of the associated methodology, assumptions, and estimates.

6.1 Safety Benefits

Accident costs, and impacts on life, limb, and property are a significant component of road user costs. Road safety is a key economic factor in the planning of roads, as well as an important indicator of transportation efficiency, while outside the economic context, highway safety is often the object of public concern.

The proposed Project would promote USDOT's long-term safety outcome by redesigning the roadways with additional lanes and installing a raised median to reduce the number of conflict points on the corridor. While the latter items provide improved safety conditions and improve overall crash rates, the increased vehicle capacity of the roadway may increase the likelihood of severe crashes bringing a minor safety disbenefit to the overall result.

6.1.1 Methodology

The predictive safety analysis was conducted following the Highway Safety Manual (HSM) methods via the implementation of the Interactive Highway Safety Design Model (IHSDM) software. IHSDM provides a user interface to import roadway data for the horizontal and vertical alignments and to

input roadway feature information (number of lanes, shoulder information, median information, etc.) to create an accurate representation of the study roadway. Once the roadway features are entered, the software can perform the predictive safety analysis using the input features with the HSM factors and equations.

For the KY 54 analysis, a No Build (existing configuration) and Build (proposed widening) were developed for an anticipated 20-year project lifecycle. The roadway and intersection geometries through the project segments were programmed based on the existing conditions and provided roadway plan sheet details.

The results of the analysis were post-processed in excel to examine the severity breakdown of the crashes. For segment 1 of the Build condition (six-lane divided [6D]), the software provides a breakdown of the anticipated severity. However, for segment 2 (five-lane [5T]), the software only provides the breakdown between fatal and injury crashes (FI) and property-damage-only crashes (PDO). For both segments in the No Build condition, the output is only the FI and PDO breakdown as both segments are 5T. To obtain the severity breakdown for the 5T segments, the historic severity distribution was applied as it is assumed the crash experience will be similar as the typical section of the roadway remains unchanged for the 5T segments.

Accidents were transformed into events using the Kentucky State Police's Collision Analysis Center (KY Collision Analysis) historical crash data of the study area from 2015 to 2019. The number of fatalities, injuries, and vehicles involved were determined for each crash type.

Safety benefits impacts are then calculated as the number of accident events, by type, expected under the No Build versus Build scenario and monetized using the social values of accident costs recommended by USDOT. The cost of injury was weighted accordingly based on the distribution of the number of injuries by severity (possible injury, non-incapacitating injury, and incapacitating injury) determined from the KY Collision Analysis.

6.1.2 Assumptions

General assumptions used to monetize the safety benefits are presented in **Table 5**.

Table 5: Assumptions Used in the Estimation of Accident Cost Savings

Variable Name	Unit	Value	Source
Fatal Accident Rates			
2025 - No Build	accidents/year	0.20	Based IHSDM crash rates and existing crash rates of project area from Kentucky State Police's Collision Analysis Center, between 2015 to 2019
2045 - No Build	accidents/year	0.33	
2025 - Build	accidents/year	0.26	
2045 - Build	accidents/year	0.39	
Injury Accident Rates			
2025 - No Build	accidents/year	22.15	Based IHSDM crash rates and existing crash rates of project area from Kentucky State Police's Collision Analysis Center, between 2015 to 2019
2045 - No Build	accidents/year	36.99	
2025 - Build	accidents/year	25.67	
2045 - Build	accidents/year	37.08	
Property Damage Only Accident Rates			

Variable Name	Unit	Value	Source
2025 - No Build	accidents/year	46.48	Based IHSDM crash rates and existing crash rates of project area from Kentucky State Police's Collision Analysis Center, between 2015 to 2019
2045 - No Build	accidents/year	77.24	
2025 - Build	accidents/year	34.86	
2045 - Build	accidents/year	51.29	
Events per Accident			
Fatalities per Crash	fatalities/accident	1.00	Kentucky State Police's Collision Analysis Center; Calculated based on crash data at project location, KY 54 corridor in Daviess County from milepost 0.05 to 4.257, between 2015 and 2019
Injuries per Crash	injuries/accident	1.44	
Vehicles Damaged per Fatal Crash	damaged vehicles/accident	1.00	
Vehicles Damaged per Injury Crash	damaged vehicles/accident	2.06	
Vehicles Damaged per PDO Crash	damaged vehicles/accident	2.02	
Accident Costs			
Fatal (K)	$/fatality	$10,900,000	USDOT BCA Guidance 2021 ($2019), Table A-1
Injuries	$/injury	$108,670	
Property Damage (O)	$/damaged vehicle	$3,700	

6.1.1 Benefit Estimates

Table 6 contains the monetized benefits over the life cycle of the project, split out by accident severity. With a 7 percent discount rate applied to the benefits, the total present value results in a net disbenefit of approximately -$6.0 million dollars.

Table 6: Estimates of Accident Cost Savings, 2019 Dollars

	Over the Project Lifecycle	
	In Constant Dollars	Discounted at 7 Percent
Savings from Reduced Fatalities	-$14,554,937	-$4,812,871
Savings from Reduced Injuries	-$4,851,047	-$1,987,263
Savings from Reduced Property Damage Only	$2,721,653	$801,947
Total	**-$16,684,332**	**-$5,998,187**

6.1 Environmental Sustainability Benefits

The proposed Project would contribute to environmental sustainability through a net reduction in vehicle emissions due to improved roadway speeds and reduced travel delay along the KY 54. Environmental costs are increasingly considered an essential component in the evaluation of transportation projects. The main environmental impacts of vehicle use, and exhaust emissions can impose wide-ranging social costs on people, materials, and vegetation. The negative effects of pollution depend on the quantity of pollution produced and the types of pollutants emitted, and the conditions into which the pollution is released.

6.1.1 Methodology

The Environmental Protection Agency (EPA) MOVES model was used to generate emissions rates for passenger cars and trucks in Daviess County for various speeds and years. Emissions rates of Criteria air contaminants (CACs) and Greenhouse gases (GHG) were estimated in grams per mile. Total emissions for vehicles on KY 54 were then computed using the VMT and calculated average speeds. The per-unit monetary social values for each emission type were then applied to the change in overall emissions on an annual basis, following USDOT guidelines. The change in total emission costs between the No Build and Build cases indicates the total avoided emission costs due to the Project.

6.1.1 Assumptions

General assumptions used to monetize the environmental sustainability benefits are presented in the table below.

Table 7: Assumptions used to Monetize Environmental Sustainability Benefits (2019$/metric ton)

Variable Name	Unit	Year	CO2	NOx	PM2.5	SO2	Source
Truck Emission Factors- No Build	grams per mile	2020-2060	Varies by year				MOVES run in June 2021 based on the emission characteristics of Daviess County - Kentucky. Truck emissions used an average of emission rates of single unit long-haul truck and single unit short-haul truck , with diesel as the fuel. Automobile emissions used passenger car as the vehicle type, with gasoline as the fuel type. Forecasted vehicle travel speeds in the No Build case were used. MOVES values were gathered from 2020, 2030, 2040, 2050 and 2060. Values were interpolated between those years.
Auto Emission Factors - No Build							
Truck Emission Factors - Build	grams per mile	2020-2060	Varies by year				MOVES run in June 2021 based on the emission characteristics of Daviess County - Kentucky. Truck emissions used an average of emission rates of single unit long-haul truck and single unit short-haul truck , with diesel as the fuel. Automobile emissions used passenger car as the vehicle type, with gasoline as the fuel type. Forecasted vehicle travel speeds in the Build case were used. MOVES values were gathered from 2020, 2030, 2040, 2050 and

Variable Name	Unit	Year	CO2	NOx	PM2.5	SO2	Source
Auto Emission Factors - Build							2060. Values were interpolated between those years.

Table 8: Monetized Value of Emissions

Year	Social Cost of Emissions (2019$/metric ton)				Source
	NOx	SO2	PM2.5	CO2	
2022	$16,100	$42,100	$755,500	$53	CO2 Values based on the Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (August 2016) https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf. Values are inflated from 2007 dollars to 2019 dollars using the GDP deflator. Per US DOT Benefit Cost Analysis Guidance 2021, CO2 emissions values will be discounted using a 3 percent discount rate, while all other benefit streams will be discounted by 7%. Other values from the Safer Affordable Fuel-Efficient Vehicles Rule for MY2021-MY2026 Passenger Cars and Light Trucks Preliminary Regulatory Impact Analysis (March 2020)" https://nhtsa.gov/sites/nhtsa.dot.gov/files/documents/final_safe_fria_web_version_200701.pdf. Values are inflated from 2016 dollars to 2019 dollars using the GDP deflator, and are kept constant beyond 2050.
2023	$16,400	$43,000	$769,000	$54	
2024	$16,600	$43,900	$782,700	$55	
2025	$16,800	$44,900	$796,600	$56	
2026	$17,000	$45,500	$807,500	$57	
2027	$17,300	$46,200	$818,600	$58	
2028	$17,500	$46,900	$829,800	$59	
2029	$17,700	$47,600	$841,200	$60	
2030	$18,000	$48,200	$852,700	$61	
2031	$18,000	$48,200	$852,700	$62	
2032	$18,000	$48,200	$852,700	$63	
2033	$18,000	$48,200	$852,700	$64	
2034	$18,000	$48,200	$852,700	$66	
2035	$18,000	$48,200	$852,700	$67	
2036	$18,000	$48,200	$852,700	$68	
2037	$18,000	$48,200	$852,700	$69	
2038	$18,000	$48,200	$852,700	$70	
2039	$18,000	$48,200	$852,700	$71	
2040	$18,000	$48,200	$852,700	$72	
2041	$18,000	$48,200	$852,700	$73	
2042	$18,000	$48,200	$852,700	$75	
2043	$18,000	$48,200	$852,700	$76	
2044	$18,000	$48,200	$852,700	$77	
2045	$18,000	$48,200	$852,700	$78	
2046	$18,000	$48,200	$852,700	$79	

6.1.2 Benefit Estimates

The table below shows the estimates of environmental sustainability benefits from reduced emission costs. With a 3 percent discount rate for benefits from reduction in CO_2 emissions (per USDOT Guidance), and 7 percent discount rate for everything else, the estimated present value of benefits over the Project life cycle is $711 thousand dollars.

Table 9: Monetized Value of Emissions

	Over the Project Lifecycle	
	In Constant Dollars	Discounted at 7 Percent[5]
Green House Gas (GHG)	$1,171,967	$671,463
Criteria Air Contaminants (CAC)	$131,961	$39,202
Total	**$1,303,928**	**$710,665**

6.1 Quality of Life

Improving this corridor will improve travel time reliability and mobility and connectivity for both local and regional travel.

- Improved access to education and health care facilities: This corridor includes access to 3 elementary schools (and a future middle school) and direct access to the only Level III Trauma center in western Kentucky, Owensboro Health.
- Improved access to pedestrian and bicycle facilities: This project will also connect pedestrians and bicyclists to commercial areas and neighborhoods, on safe and properly designed shared-use-paths, with modern crosswalk and updated signal facilities.
- Improved multimodal access: The benefits of reduced congestion will be fully realized by the public who use and depend on the Owensboro Transit System for their main mode of transportation.

6.2 Economic Competitiveness

The proposed project would contribute to enhancing the region's economic competitiveness through improvements in the mobility of people and goods within and across the study area. In this analysis, two measures of mobility are presented: travel-time savings and out-of-pocket transportation cost savings.

6.2.1 Methodology

Travel time savings are estimated by comparing the vehicle hours traveled (VHT) in the No Build and Build cases. The vehicle hours traveled are interpolated from the simtraffic model, described in Section 5.1, and converted to person-hours traveled using assumptions around average vehicle occupancy and the percentage of truck traffic. The person-hours traveled is then monetized using the value of time provided in the U.S. DOT BCA guidance.

[5] 3 percent discount rate for the benefits from reduction in CO2 emissions, and 7 percent discount rate for everything else, as per USDOT BCA Guidance, February 2021.

Out-of-pocket travel cost savings, which include vehicle fuel and non-fuel operating costs are calculated based on the VMT. Vehicle fuel operating costs are estimated through fuel consumption rates per mile, based on average vehicle speeds and fuel prices from the US Energy Information Administration's (EIA) Annual Energy Outlook Release. The USDOT guidance provides recommendations on non-fuel operating costs on a dollar per mile basis, which is used to monetize the non-fuel operating costs.

6.2.2 Assumptions

The assumptions used in the estimation of economic competitiveness benefits from travel time savings and vehicle operating cost savings are summarized in the tables below.

Table 10: Assumptions Used in the Estimation of Travel Time Savings

Variable Name	Unit	Value	Source
Average Vehicle Occupancy (Weekday Peak) - Auto	persons/vehicle	1.48	2017 National Household Travel Survey
Average Vehicle Occupancy (Weekday Peak) - Truck	persons/vehicle	1.00	Assumption
Value of Time - Auto	$/person-hr	$17.90	US DOT BCA Guidance 2021 ($2019)
Value of Time - Truck	$/person-hr	$30.80	

Table 11: Assumptions Used in the Estimation of Vehicle Operating Cost Savings

Variable Name	Unit	Value	Source
Non-Fuel Operating Cost - Auto	$/vehicle-mile	$0.31	American Automobile Association, Your Driving Costs – 2019 Edition (2019); excluding fuel costs
Non-Fuel Operating Cost - Truck	$/vehicle-mile	$0.53	American Transportation Research Institute, An Analysis of the Operational Costs of Trucking: 2020 Update; excluding fuel costs
Retail Fuel Prices - Gasoline	$/gallon	varies by year	Refer to Table 10 below.
Retail Fuel Prices - Diesel	$/gallon	varies by year	

Table 12: Gasoline and Diesel Prices by Year

Year	Gasoline Prices	Diesel Prices	Source
2019	$2.12	$2.45	HDR calculations using U.S. Energy Information Administration (EIA) Annual Energy Outlook data (2020
2020	$2.10	$2.35	
2021	$2.11	$2.37	
2022	$2.11	$2.42	
2023	$2.11	$2.44	
2024	$2.08	$2.50	
2025	$2.11	$2.52	

Year	Gasoline Prices	Diesel Prices	Source
2026	$2.14	$2.58	Release). Net of federal and state taxes.
2027	$2.17	$2.60	
2028	$2.19	$2.65	
2029	$2.23	$2.68	
2030	$2.32	$2.75	
2031	$2.34	$2.91	
2032	$2.37	$2.95	
2033	$2.42	$2.98	
2034	$2.47	$3.01	
2035	$2.50	$3.05	
2036	$2.54	$3.08	
2037	$2.55	$3.08	
2038	$2.67	$3.11	
2039	$2.72	$3.17	
2040	$2.75	$3.19	
2041	$2.77	$3.22	
2042	$2.82	$3.28	
2043	$2.83	$3.28	
2044	$2.45	$0.31	
2045	$2.35	$0.53	

6.2.3 Benefit Estimates

Economic competitiveness benefits associated with the Project are shown below. The total economic competitiveness benefit associated with this project is $39.3 million discounted at a 7 percent rate

Table 13: Estimates of Economic Competitiveness Benefits, 2019 Dollars

	Over the Project Lifecycle	
	In Constant Dollars	Discounted at 7 Percent
Travel Time Savings	$127,576,445	$36,608,287
Vehicle Operating Cost Savings	$9,311,457	$2,713,610
Total	**$136,887,902**	**$39,321,898**

6.3 State of Good Repair

The state of good repair benefits are designed to capture benefits from maintaining infrastructure in good condition. This is captured through reduced maintenance costs and the residual value of assets. The residual value captures any useful life left on the assets constructed, and the reduced maintenance costs captures changes in maintenance costs between the No Build and Build Cases.

6.3.1 Methodology

The residual value of capital assets are calculated in line with US DOT BCA Guidance based upon an estimated useful life of 30 years. It is calculated based on the capital expenditure for the Project, depreciated linearly over its service life. Additionally, as land values are not expected to depreciate with time, the residual value for any land acquisition is the capital spent on acquiring the property for the Project.

The operations and maintenance cost savings are estimated based on the difference in costs between the No Build and Build cases. The estimates are subtracted to determine the incremental operations and maintenance costs. The pavement conditions in the No Build scenario are assumed to be in poor condition. The pavement conditions in the Build scenario are assumed to begin in good condition and then deteriorate based on the 14-year life cycle. Although the pavement conditions in the Build scenario are better than in No Build, the additional lane-miles from the Build scenario result in increasing annual maintenance costs.

6.3.2 Assumptions

The assumptions used in the estimation of state of good repair benefits are summarized in the table below.

Table 14: Assumptions Used in the Estimation of State of Good Repair Benefits

Variable Name	Unit	Value	Source
Operational Period of Analysis	years	20	USDOT BCA Guidance 2021
Depreciable Property Costs	$	$26,787,450	Capital cost of roadway structure expressed in 2019 dollars
Non-depreciable Property Costs	$	$2,931,862	Right-of-Way costs expressed in 2019 dollars
Expected Lifespan of Roadway Structure	years	30	Assumption
Annual Maintenance Cost - Good Road Condition	$/lane-mile	$112.22	Kentucky Transportation Cabinet; based on last paving cycle for route KY 54
Annual Maintenance Cost - Fair Road Condition	$/lane-mile	$177.54	
Annual Maintenance Cost - Poor Road Condition	$/lane-mile	$370.13	
Annual Resurface Cost	$/lane-mile	$8,055.60	
Annual Striping Cost	$/lane-mile	$295.40	
Lane Miles - No Build	$/year	9.16	Length of corridor multiplied by number of lanes
Lane Miles - Build	$/year	10.14	

6.3.3 Benefit Estimates

The table below shows estimates of state of good repair benefits. With a 7 percent discount rate, the estimated present value of benefits over the Project life cycle is $1.86 million dollars.

Table 15: Estimates of State of Good Repair Benefits, 2019 Dollars.

	Over the Project Lifecycle	
	In Constant Dollars	Discounted at 7 Percent
O&M Cost Savings	($153,324)	($48,042)
Residual Value	$11,861,012	$1,908,797
Total	**$11,707,688**	**$1,860,755**

7 Summary of Findings and Benefit-Cost Outcomes

The tables below summarize the BCA findings. Annual costs and benefits are computed over the lifecycle of the Project (28 years). As stated earlier, the benefits are accrued starting in the first full year of operations, assumed to be 2027. Benefits accrue over the assumed 20-year benefit period.

Table 16: Overall Results of the Benefit Cost Analysis, 2019 Dollars

Project Evaluation Metric	Undiscounted	Discounted at 7%*	Discounted at 3%
Total Benefits	$133,215,186	$35,895,131	$73,505,493
Total Costs	$41,564,036	$33,121,164	$37,564,239
Net Present Value	$91,651,150	$2,773,967	$35,941,254
Benefit / Cost Ratio	3.2	1.1	2.
Payback Period (years)	10.5 yrs	19.2 yrs	13.0 yrs
Internal Rate of Return (%)	7.50%		

**3 percent discount rate for the benefits from reduction in CO2 emissions, and 7 percent discount rate for everything else, as per USDOT BCA Guidance, February 2021.*

Considering all monetized benefits and costs, the estimated internal rate of return of the Project is 7.5 percent. The $33.1 million investment would result in $35.9 million in total benefits for a Net Present Value (NPV) of $2.8 million and a Benefit/Cost ratio (BCR) of 1.1.

Table 17: Estimates of Monetized Benefits, 2019 Dollars

Benefit Category	Undiscounted	Discounted at 7%*	Discounted at 3%
Travel Time Savings	$127,576,445	$36,608,287	$72,670,580
Vehicle Operating Costs Savings	$9,311,457	$2,713,610	$5,335,075
Accident Cost Savings	-$16,684,332	-$5,998,187	-$10,497,035
CAC Emission Cost Savings	$131,961	$39,202	$76,431
GHG Emission Cost Savings	$1,171,967	$671,463	$671,463
O&M Cost Savings	-$153,324	-$48,042	-$90,718
Residual Value	$11,861,012	$1,908,797	$5,339,698
Total	**$133,215,186**	**$35,895,131**	**$73,505,493**

**3 percent discount rate for the benefits from reduction in CO2 emissions, and 7 percent discount rate for everything else, as per USDOT BCA Guidance, February 2021.*

8 Sensitivity Analysis

The BCA outcomes presented in the previous sections rely on a large number of assumptions and long-term projections, both of which are subject to considerable uncertainty.

The primary purpose of the sensitivity analysis is to help identify the variables and model parameters whose variations have the greatest impact on the BCA outcomes: the "critical variables."

The sensitivity analysis can also be used to:

- Evaluate the impact of changes in individual critical variables – how much the 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 capital cost estimates, change in discount rate and change in traffic volumes in the Build scenario relative to the No Build Scenario. The changes in discount rate followed by the change in capital costs has the greatest impact on net present value.

The outcomes of the quantitative analysis for the Project using a 7 percent discount rate are summarized in **Table 18**. The table provides the percentage change in project NPV associated with variations in variables or parameters as indicated in the column headers. Overall, the sensitivity analysis demonstrates that even if the capital costs were to increase by 8 percent, the socio-economic benefits generated by the Project would still outweigh its costs.

Table 18: Sensitivity Analysis Results

Parameters	Change in Parameter Value	Current NPV	New NPV	Change in NPV	New B/C Ratio
Capital Costs	8% Reduction in Capital Costs	**$2.8 M**	$5.3 M	90%	1.17
	8% Increase in Capital Costs		$0.3 M	-90%	1.01
Change in Discount Rate	Applying a 3% discount rate for all impacts		$35.9 M	1196%	1.96
Change in Traffic Volumes for Build case	Build AADT is 1 percent higher than No Build AADT		$2.1 M	-26%	1.06