Benefit-Cost Analysis

Executive Summary

This memorandum summarizes the approach used for conducting the benefit-cost analysis (BCA) for widening Highway 10 in Little Rock, Arkansas. A project matrix, shown in Table 1, summarizes the components of this project. The project matrix describes the baseline conditions, proposed alternatives, and types of anticipated impacts.

Table 1. Project Matrix

Current Baseline	Change to Baseline	Type of Impacts	Economic Benefit
Highest congested principal arterial in Arkansas serving the states' largest metropolitan statistical area. High growth area with retail development, new schools, and multi-family dwellings.	Adding two travel lanes, Intersection improvements, and Safety features	Increased capacity; Reduced delay; Improved safety; Reduced emissions	Monetized value of reduced travel times, crash costs, and emissions

Project Benefits

Based on travel time cost savings during peak hours, crash reduction cost savings, vehicle emissions cost savings, and the project cost, the project benefit-cost ratio ranges from 1.65 to 3.59, depending on the discount rate applied (See Table 1).

Table 2. Summary of Benefit-Cost Analysis

Benefit/Cost Category	No Discount	Discounted at 3%	Discounted at 7%
Travel Time Benefits	$135,107,666	$85,970,338	$49,644,174
Safety Benefits	$51,319,000	$33,917,866	$20,738,323
Emissions Reduction Benefits	$2,124,039	$1,355,323	$793,113
Sum of Benefits	$188,550,704	$120,943,527	$71,175,610
Project Life Cycle Costs	$52,500,000	$48,124,181	$43,055,204
B/C Ratio	**3.59**	**2.51**	**1.65**

Baseline Conditions
The existing 2.13-mile segment of Highway 10 between Taylor Loop Road and Pleasant Ridge Road is a five-lane east-west principal arterial. The intersections of Highway 10 with Taylor Loop Road, Pinnacle Valley Road, a driveway to commercial development, Sam Peck Road, and Pleasant Ridge Road Five are currently signalized.

Proposed Alternative
The proposed project will widen Highway 10 from four travel lanes to six travel lanes, improve intersection operations, and provide improved safety.

Benefit-Cost Analysis
This Benefit-Cost Analysis Methodology Summary describes the method used to estimate the benefits and costs attributed to the implementation of the Highway 10 Widening project. USDOT TIGER Grant application guidelines were used in the calculation of project benefits.[1]

The benefits of the Highway 10 Widening project and intersection improvements were evaluated in the following areas:

- Travel Time Benefits
- Safety Benefits
- Emissions Reduction Benefits

Travel Time Benefits
Travel delay costs were estimated based upon congested weekday (260 days per year) peak hour travel conditions within the Highway 10 corridor. The daily peak hours were assumed to include two hours in the AM peak and two hours in the PM peak.

The traffic forecast assumes that peak hour traffic will grow at an average annual growth factor (AAGF) of 1.6% from 2020 to 2040. The recommended average hourly value of time by USDOT is $16.75 per hour for automobiles and $28.54 per hour for trucks in 2015 dollars. Based on an estimated peak hour truck percentage of 2% within the corridor, the average value of time is $16.98 per hour (2015$).

A travel time savings in off-peak hours is expected to result from the proposed improvements, but has not been recognized in this BCA. The cost savings, if considered, would increase the benefit-cost ratio and demonstrate that the proposed improvements are even more cost effective.

The net present value (NPV) of annual travel delay costs were calculated using the 3% and 7% discount rates as recommended by USDOT TIGER Grant guidelines. The NPV of travel delay costs to users, assuming that current conditions exist for the next 20 years, is estimated to be $135,107,666 with no discount rate applied, $85,670,338 at a 3% discount rate, and $49,644,174 at a 7% discount rate. Table 3 shows the travel time delay cost savings per year.

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1 US Department of Transportation (USDOT) (2015). "Benefit-Cost Analyses Guidance for TIGER Grant Applicants." Available at: https://www.transportation.gov/tiger/guidance#sthash.)MI0ixrq.dpuf

Table 3. Travel Time Delay Cost Savings (2015$)

Year	Calendar Year	Travel Time Reduction (hours)	Daily Time Cost Savings [Delay Reduction] (hours)	Total Value of Travel Time Savings ($2015)*[260 days]	NPV of Travel Time Delays (3%)	NPV of Travel Time Delays (7%)
0	2020	0	0	$0	$0	$0
1	2021	926	240,731	$4,088,936	$3,527,152	$2,915,355
2	2022	989	257,256	$4,369,615	$3,659,483	$2,911,659
3	2023	1,053	273,780	$4,650,293	$3,781,114	$2,895,969
4	2024	1,117	290,305	$4,930,971	$3,892,555	$2,869,871
5	2025	1,180	306,830	$5,211,651	$3,994,296	$2,834,793
6	2026	1,244	323,354	$5,492,329	$4,086,809	$2,792,022
7	2027	1,307	339,879	$5,773,008	$4,170,544	$2,742,714
8	2028	1,371	356,403	$6,053,687	$4,245,934	$2,687,909
9	2029	1,434	372,928	$6,334,365	$4,313,395	$2,628,536
10	2030	1,498	389,453	$6,615,044	$4,373,323	$2,565,428
11	2031	1,561	405,977	$6,895,723	$4,426,102	$2,499,327
12	2032	1,625	422,502	$7,176,401	$4,472,096	$2,430,895
13	2033	1,689	439,027	$7,457,080	$4,511,656	$2,360,721
14	2034	1,752	455,551	$7,737,759	$4,545,118	$2,289,324
15	2035	1,816	472,076	$8,018,437	$4,572,803	$2,217,165
16	2036	1,879	488,600	$8,299,116	$4,595,019	$2,144,649
17	2037	1,943	505,125	$8,579,795	$4,612,062	$2,072,133
18	2038	2,006	521,650	$8,860,473	$4,624,215	$1,999,925
19	2039	2,070	538,174	$9,141,152	$4,631,746	$1,928,298
20	2040	2,133	554,699	$9,421,831	$4,634,916	$1,857,482
Total Travel Time Delay Costs				**$135,107,666**	**$85,670,338**	**$49,644,174**

Safety Benefits

The most recent three years of crash data available for the corridor were analyzed to determine the crash types and corresponding crash related costs. The Crash Modification Factor (CMF) Clearinghouse[2] was referenced to determine the most appropriate CMF for highway cross-section improvements to widen from four travel lanes to six travel lanes. A search of the CMF Clearinghouse revealed four studies with four-star ratings, and CMFs ranging between 0.798 and 0.850. An average CMF of 0.82 was used to calculate a new crash rate. Crash severity was held constant for the cost determination.

Crash costs were calculated by determining a daily crash cost savings based on the three year average crash data and multiplying the daily crash savings by 365 days. Table 4 shows the fatal

[2] http://www.cmfclearinghouse.org/

and non-fatal crashes occurring in the corridor between 2011 and 2013. The crash costs by type of crash were determined by using the TIGER Benefit-Cost Analysis (BCA) Resource Guide (March 2015). When the distribution of crashes is applied to the costs per crash type, a total crash cost is determined. This results in a non-fatal average crash cost of $131,449 per year and a corresponding average cost of $9,542,210 per year for fatal crashes, in 2015 dollars.

Table 4. 2011-2013 Crashes

Type of Crash	2011	2012	2013	Total
Fatal Crashes	1	1	0	2
Non-Fatal Crashes	47	65	75	188
TOTAL	**48**	**66**	**76**	**190**

To quantify the benefits of the Highway 10 Widening project, the safety cost for the existing corridor was calculated and then the CMF of 0.82 was applied. The safety benefit from this project is the difference between the existing crash cost and the crash cost realized by improving Highway 10. For this analysis, the crash types and totals were held constant for future years. This means that the crash rates (crashes per million vehicle miles traveled) would be reduced in future years. This methodology yields lower total crash cost benefits and a lower benefit cost ratio than would be derived by holding the crash rates constant. This methodology was selected because it was more conservative.

Table 5 presents the safety benefits over the next 20 years using crash costs in 2015 dollars. The NPV of the reduction in crash costs is then calculated by applying 3% and 7% discount rates as recommended by USDOT TIGER Grant guidance. The NPV was determined to be $51,319,000 (No Discount), $33,917,866, (3% Discount), and $20,738,323 (7% Discount).

Table 5. Safety Benefits (2015)

	Safety Benefit (Non-Disc.)	Safety Benefit Disc. (3%)	Safety Benefit Disc. (7%)
2020	0	0	0
2021	$2,565,950	$2,213,411	$1,829,487
2022	$2,565,950	$2,148,943	$1,709,801
2023	$2,565,950	$2,086,352	$1,597,945
2024	$2,565,950	$2,025,585	$1,493,406
2025	$2,565,950	$1,966,587	$1,395,707
2026	$2,565,950	$1,909,308	$1,304,399
2027	$2,565,950	$1,853,697	$1,219,064
2028	$2,565,950	$1,799,706	$1,139,312
2029	$2,565,950	$1,747,287	$1,064,778
2030	$2,565,950	$1,696,395	$995,120
2031	$2,565,950	$1,646,986	$930,018
2032	$2,565,950	$1,599,015	$869,176
2033	$2,565,950	$1,552,442	$812,314
2034	$2,565,950	$1,507,225	$759,172
2035	$2,565,950	$1,463,325	$709,507
2036	$2,565,950	$1,420,704	$663,090
2037	$2,565,950	$1,379,325	$619,711
2038	$2,565,950	$1,339,150	$579,169
2039	$2,565,950	$1,300,146	$541,279
2040	$2,565,950	$1,262,277	$505,868
Total Economic Benefits of Safety Improvements	**$51,319,000**	**$33,917,866**	**$20,738,323**

Emissions Reductions Benefits

On-road emissions were calculated using the Motor Vehicle Emission Simulator (MOVES, version 2014a)[3] developed by the Environmental Protection Agency (EPA). Relevant inputs for MOVES runs were developed as follows:

- Source Type Population – The source type population for the project area was developed using a combination of data from the Pulaski County registration database (circa 2014) and traffic count data collected on the facility. Future populations were grown in proportion to the changes in projected traffic volumes reflected in the operations analysis. Given the limitations of the available data, the source types were limited to passenger

[3] U.S. Environmental Protection Agency (EPA). Motor Vehicle Emission Simulator (MOVES, version 2014a). Available at: https://www3.epa.gov/otaq/models/moves/

cars, passenger trucks, light commercial trucks, school buses, single-unit short-haul trucks and combination short-haul trucks.

- Age Distribution – Age distributions for each source type were developed using the model year data from the local registration database. Populations were aged to each MOVES scenario year using the Age Distribution Projection Tool developed by EPA.
- Fuel – The MOVES default fuel tables for Pulaski County were used for each scenario.
- Road Type Distribution – The facility in question is an urban principal arterial, so only the urban unrestricted road type was selected, and all VMT was assigned to that road type.
- Vehicle Type VMT – Yearly VMT by source type was calculated using the traffic volumes developed for the operations analyses, the source type populations described above and the length of the project area. Monthly VMT fractions were developed using seasonal traffic count adjustment factors developed by the Department. Daily VMT fractions are the MOVES defaults for those tables. Hourly VMT fractions (for the total traffic flow) were developed using the nearest classification counter on the facility (which is outside the project area, but expected to be reasonably representative of the project area).
- Average Speed Distribution – Average peak-hour speeds were calculated using the corridor travel times from the operations analysis. Linear interpolation and extrapolation were used to estimate average peak-hour speeds for missing years. It was assumed that average peak-hour speeds occur for 4 hours each day and that relatively free-flowing conditions occur for the remaining 20 hours each day. (This assumption is quite conservative given the relatively high traffic volumes that occur between the AM and PM peaking periods.) Average speed distributions assume that average speeds are relatively normally distributed with a standard deviation of 5.5 mph.[4] It was assumed that the average off-peak speed for the facility is the posted speed limit (45 mph).
- Meteorology Data – MOVES default fuel tables for Pulaski County were used for each scenario.

Build and no-build scenarios were evaluated in MOVES for the opening year (2021), an interim year (2031) and the design year (2040). For each scenario, atmospheric CO2, NOx, SO2, PM (as PM 2.5 and PM 10) and VOCs were estimated. Anticipated reductions in each emission type were calculated by taking the difference of build and no-build emissions for each modeling year. Reductions for intermediate years were calculated using separate polynomial interpolations for each emission type. Emissions reductions were monetized for each emission type and each year following the guidance set forth in the TIGER Benefit-Cost Analysis (BCA) Resource Guide (March 2015). Table 6 shows the monetized value of the air quality emissions benefits.

[4] Standard deviation based on speed data for local arterial network. Additional information available upon request.

Table 6. Air Quality Emissions Benefits (2015)

TOTAL Benefits of Emissions Reductions				
Year	Calendar Year	Undiscounted Benefits	3% NPV Emissions Benefits	7% NPV Emissions Benefits
0	2016	$ -	$ -	$ -
1	2017	$ -	$ -	$ -
2	2018	$ -	$ -	$ -
3	2019	$ -	$ -	$ -
4	2020	$ -	$ -	$ -
5	2021	$ 76,138	$ 65,677	$ 54,285
6	2022	$ 78,832	$ 66,021	$ 52,529
7	2023	$ 80,666	$ 65,589	$ 50,235
8	2024	$ 82,697	$ 65,282	$ 48,130
9	2025	$ 84,931	$ 65,093	$ 46,197
10	2026	$ 87,372	$ 65,013	$ 44,416
11	2027	$ 91,263	$ 65,930	$ 43,358
12	2028	$ 94,168	$ 66,047	$ 41,812
13	2029	$ 97,296	$ 66,254	$ 40,374
14	2030	$ 100,651	$ 66,542	$ 39,034
15	2031	$ 102,851	$ 66,016	$ 37,278
16	2032	$ 108,063	$ 67,341	$ 36,605
17	2033	$ 112,129	$ 67,840	$ 35,497
18	2034	$ 116,441	$ 68,397	$ 34,451
19	2035	$ 121,004	$ 69,007	$ 33,459
20	2036	$ 125,822	$ 69,665	$ 32,515
21	2037	$ 132,564	$ 71,260	$ 32,016
22	2038	$ 137,959	$ 72,000	$ 31,139
23	2039	$ 143,624	$ 72,773	$ 30,297
24	2040	$ 149,568	$ 73,578	$ 29,487

The discounted emissions account for a different way of discounting carbon.

Project Life Cycle Cost Analysis

Planning estimates of the project construction costs total $26,900,000. The preliminary engineering (PE) is estimated at $4,200,000. Construction engineering is estimated at $2,600,000. Right of Way (ROW) and Utilities are estimated at $14,900,000. Table 7 summarizes the project costs and Table 8 shows the project life cycle cost analysis for the proposed project. The project schedule mandates the project start year as 2018, and schedules the year of completion as 2020. The distribution of both the Construction and Construction Engineering payments are based on ROW acquisition beginning in 2018 and construction lasting through 2020.

Table 7. Project Cost Estimate (2015$)

Work Item	Amount	Year of Expenditure
Construction	$26,900,000	2019-2020
Construction Engineering	$2,700,000	2019-2020
Preliminary Engineering	$2,900,000	2018
Right of Way	$20,000,000	2018
Total	**$52,500,000**	

Table 8. Project Life Cycle Cost Analysis (2015$)

Year	Calendar Year	Initial Capital Cost	NPV of Annual Costs (3%)	NPV of Annual Costs (7%)
0	2016	$0	$0	$0
1	2017	0		
2	2018	$19,100,000	$18,003,582	$16,682,680
3	2019	$16,700,000	$15,282,866	$13,632,175
4	2020	$16,700,000	$14,837,734	$12,740,350
5-20	2021- 2036	$0	$0	$0
Total Project Costs		**$52,500,000**	**$48,124,181**	**$43,055,204**

Summary and Conclusions

This memorandum describes the methodology used for conducting the benefit-cost analysis for the Highway 10 Widening project. The economic benefits of implementing the project include cost savings for users due to reduced travel delays, reduced crash costs, and reduced vehicle emissions costs. The benefit-cost ratio of for the proposed action is 3.59 (No Discount), 2.51 (3% Discount) and 1.65 (7% Discount). Table 9 summarizes the benefit-cost analysis.

Table 9. Summary of Benefit-Cost Analysis (2015$)

Benefit/Cost Category	**No Discount**	**Discounted at 3%**	**Discounted at 7%**
Travel Time Benefits	$135,107,666	$85,970,338	$49,644,174
Safety Benefits	$51,319,000	$33,917,866	$20,738,323
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