APPENDIX D

Benefit-Cost Analysis

USDOT RAISE Grant Program

APRIL 14, 2022

CITY OF REPUBLIC

Highway MM: Corridor of Opportunity

BENEFIT-COST ANALYSIS SUPPLEMENTARY DOCUMENTATION

The purpose of this document is to describe methodologies, provide assumptions, and cite data sources used to prepare the BCA for the Highway MM: Corridor of Opportunity RAISE Grant application.

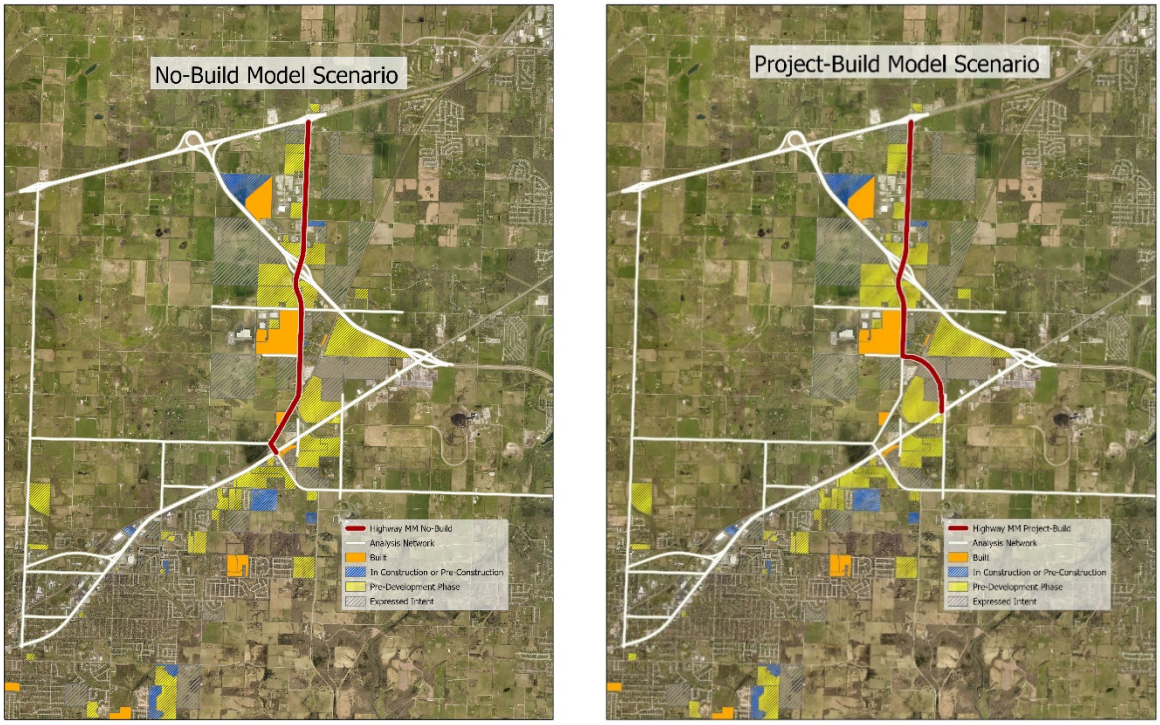
Table 1 Summary of Benefits, at 7% Discount Rate

Benefit-Cost Analysis Summary		
Benefits	NPV 7% Discount Rate	Undiscounted
Travel Time Savings	$ 36,891,298	$ 81,957,749
Safety	$ 28,456,899	$ 60,560,603
Emissions Reduction		
Air Pollutants	$ 12,761,524	$ 27,489,850
Green House Gases*	$ 12,798,558	$ 18,562,428
Railroad Crossing Operations & Maintenance Costs	$ 497,009	$ 940,000
Agglomeration Economics	$ 58,166,456	$ 103,350,153
Other Benefits - At-Grade Rail Seperation	$ 107,205	$ 207,684
Other Benefits - Mortality Reduction Benefit	$ 9,256	$ 17,473
Other Benefits - Pedestrian & Cycling Facilities	$ 893,347	$ 1,686,513
Total Benefits	$ 150,581,552	$ 294,772,454
Total Project Costs	$ 44,538,036	$ 58,572,215
BCA Ratio	**3.4**	**5.0**
*NPV 3% Discount Rate		

TRAVEL DEMAND FORECASTING

For comparative purposes, the OTO's Travel Demand Model (TDM) was updated to develop the "No-Build" and "Project Build" scenarios for the 2045 model year. Under this update, the OTO's 2045 existing conditions Visum model was modified to consider the recent improvements and travel behavior within the study area more accurately. Specifically, the OTO's consultant, Olsson, updated the scenario with known and anticipated future developments within the study area, as well as redefined some of the TAZ boundaries which are heavily influenced by the rapidly developing MM corridor and surrounding area. This "No-Build" scenario was used to run analyses to produce travel time, delay, and volumes for the roadways highlighted in the included maps.

Figure 1 Project Build and No-Build Scenario Maps



The model was then modified to incorporate the proposed Highway MM: Corridor of Opportunity improvements and run with the same analysis for the roadway network with the projects completed. Based on these data, 2045 daily traffic volumes for "No-Build" and "Project-Build" scenarios were determined for the two segments that comprise the Highway MM corridor project. The OTO Travel Demand Model traffic volumes were used as a factor in determining the benefits of reasonable outcomes resulting from the implementation of the project in accordance with the March 2022 Benefit-Cost Analysis Guidance for Discretionary Grant Programs.

TRAVEL DEMAND MODEL SCENARIO TRAFFIC VOLUMES

Table 2 Travel Demand Model Scenario Traffic Volumes

Corridor Segment	2020 AADT	No-Build 2045 AADT	Project-Build 2045 AADT
Hwy MM – I-44 to MO360	10,064	23,857	28,718
Hwy MM – MO360 to US60	7,830	18,630	26,333

TRAVEL TIME SAVINGS

The implementation of Highway MM: Corridor of Opportunity projects is expected to result in significant travel time savings along the corridor for existing and additional users after construction through 2045. These expectations are based on No-Build and Project-Build volume-

to-capacity ratios and corresponding levels of service to calculate peak and off-peak travel speeds and times for each scenario. Daily roadway capacity used for each scenario is developed from research completed by the Florida DOT based on the 2010 Highway Capacity Manual. Accordingly, a value of 8,450 vehicles per lane per day (vplpd) is used as the baseline for the No-Build two-lane rural arterial and 7,900 vplpd for the Project-Build suburban five-lane arterial placing the capacity values at 16,900 and 31,600, respectively. The following charts depict the percentage of free flow speed (PFFS) based on the Level of Service (LOS) for two-lane highways and a derived LOS for arterials based on volume-to-capacity ratios.

Table 3 Level of Service Criteria for Two-Lane Highways

	Class I Highways		Class II Highways	Class III Highways
LOS	ATS (mi/h)	PTSF (%)	PTSF (%)	PFFS (%)
A	> 55	<=35	<= 40	>91.7
B	>50 - 55	>35 - 50	>40 - 55	>83.3 – 91.7
C	>45 - 50	>50 - 65	>55 – 70	>75 – 83.3
D	>40 - 45	>65 - 80	>70 – 85	>66.7 – 75
E	>= 40	>80	>85	<=66.7
F	Demand Exceeds Capacity			

Source: https://www.smatstraffic.com/2021/07/26/level-of-service/ Highway Capacity Manual: Sixth Edition

Table 4 Level of Service Criteria for Arterials Based on Volume-to-Capacity Ratios

LOS	Description	V/C Ratio
A	Free flow conditions with unimpeded maneuverability. Stopped delay at signalized intersection is minimal.	0.0 to 0.6
B	Reasonably unimpeded operations with slightly restricted maneuverability. Stopped delays are not bothersome.	0.61 to 0.7
C	Stable operations with somewhat more restrictions in making mid-block lane changes than LOS B. Motorists will experience appreciable tension while driving.	0.71 to 0.8
D	Approaching unstable operations where small increases in volume produce substantial increases in delay and decreases in speed.	0.81 to 0.9
E	Operations with significant intersection approach delays and low average speeds.	0.91 to 1.0
F	Operations with extremely low speeds caused by intersection congestion, high delay, and adverse signal progression.	> 1.0

Source: https://ccag.ca.gov/wp-content/uploads/2014/07/cmp_2005_Appendix_B.pdf Transportation Research Board, Highway Capacity Manual, Special Report 209 (Washington, D.C., 1994

For No-Build and Project-Build scenarios, the base free flow speed along the corridor is conservatively estimated to be 95% of the posted speed limit. Regardless of whether the project is implemented, the City of Republic and MoDOT staff have indicated the posted speed limit will be reduced to 45 mph from 55 mph. In addition, the Project-Build scenario will shorten the Highway MM segment from MO 360 to US 60 to 1.884 miles from 2.193 miles. Using these parameters, it is possible to compare travel speeds for the No-Build and Project-Build scenarios and calculate annual travel time savings due to the implementation of the project.

Table 5 Parameters Utilized to Calculate Over $36.8 Million in 7% Discounted Benefits

Hwy MM to I-44/MO360	MoDOT 2020 Baseline	No-Build	Project-Build
AADT	10,064	23,857	28,718
Peak-Hr Volume (PM)	2,149	5,094	6,132
Peak-Hr Volume (AM)	1,140	2,702	3,253
Off-Peak Volume	6,775	16,060	19,333
Pct Commercial (%)	11.57	11.57	11.57
Roadway Capacity	16,900	16,900	31,600
V/C Ratio	0.59	1.41	0.91
LOS	A	F	E/D
LOS Speed Peak (mph)	42.75	28.12	32.07
LOS Speed Off-Peak (mph)	42.75	29.93	34.2
Route Length	1.64	1.64	1.64
Posted Speed Limit (mph)	45	45	45
Base Free Flow Speed (mph)	42.75	42.75	42.75
Avg Travel Time Peak (min)	2.31	3.51	3.08
Avg Travel Time Off-Peak (min)	2.31	3.3	2.89
Additional Users 2045	-	13,793	18,654
Additional Annual Users 2045 Peak	-	180	244
Additional Annual Users 2045 Off-Peak	-	371	502
Hwy MM-MO360/US60	**MoDOT 2020 Baseline**	**No-Build**	**Project-Build**
AADT	7,830	18,630	26,333
Peak-Hr Volume (PM)	1,979	4,709	6,656
Peak-Hr Volume (AM)	1,433	3,410	4,819
Off-Peak Volume	4,418	10,512	14,858
Pct Commercial (%)	15.9	15.9	15.9
Roadway Capacity	16,900	16,900	31,600
V/C Ratio	0.43	1.1	0.83
LOS	A	F	D/C
LOS Speed Peak (mph)	42.75	28.12	32.06
LOS Speed Off-Peak (mph)	42.75	29.93	35.48
Route Length	2.19	2.19	1.884
Posted Speed Limit (mph)	45	45	45
Base Free Flow Speed (mph)	42.75	42.75	42.75
Avg Travel Time Peak (min)	3.08	4.66	3.53
Avg Travel Time Off-Peak (min)	3.08	4.4	3.19
Additional Users 2045	-	10,800	18,503
Additional Annual Users 2045 Peak	-	188	322
Additional Annual Users 2045 Off-Peak	-	244	418

There is a positive Travel Time Savings of **$36,891,298** over the 20-year period.

SAFETY ANALYSIS

Data used to calculate safety benefits were provided by MoDOT. Crash statistics from 2/28/2016 to 2/28/2022 were exported from MoDOT's Datazone crash statistics map and used to calculate a baseline of annual averages for fatality, disabling & suspected serious injury, minor injury, and

property damage only crashes. All crashes within 250 ft of Hwy MM from Farm Road 140 to US 60 were selected for the analysis. MoDOT provided crash costs for each type of crash severity. The following Tables summarize the six years of crash history at specific locations of planned improvements in the Project-Build scenario and crash costs by severity type provided by MoDOT SW District staff. In the Project-Build scenario there is a positive discounted benefit of **$28,456,899** savings over the 20-year period.

CRASH HISTORY

Table 6 Crash History by Location

Location	Fatality	Disabling/Suspected Serious Injury	Minor Injury	PDO	Total
Hwy MM – I-44 to MO360	0	4	16	39	59
Hwy MM – MO360 to US60	1	3	20	47	71
Hwy MM & FR 160	0	0	2	1	3
FR 103 & US60 (New MM)	1	0	3	10	14
Hwy MM & US60 (Existing MM)	0	5	19	114	138

Source: https://modatazone.modot.org/index.php/safety

CRASH COSTS IN MISSOURI

Table 7 Missouri Crash Costs by Type

Severity Type	2018 – 2022 Cost*
Fatal	$9,962,900
Serious Injury	$577,700
Minor Injury	$150,300
Property Damage Only	$10,500

*MoDOT methodology was based on FHWA's Crash Costs for Highway Safety Report, January 2018.

MoDOT SW District staff provided Highway Safety Manual (HSM) safety performance function spreadsheets to calculate predicted and expected crash frequencies for rural two-lane highways and multi-lane urban and suburban arterials to reflect the No-Build and Project-Build scenarios using the baseline crash statistics for each roadway segment. The comparisons of expected crash frequencies from each scenario were used to create crash modification factors (CMF) for the expected safety performance of replacing a two-lane roadway with a five-lane road with a two-way left turn lane. The formula for developing the CMF and resulting spreadsheet output summaries are presented below.

$$\text{CMF} = \frac{\text{Expected crash frequency with treatment}}{\text{Expected crash frequency without treatment}}$$

Table 8 Summary Results for Two-Lane Roads

Project Element	Expected Crashes/Yr (Total)	Expected Fatality & Injury Crash/Yr	Expected PDO Crash/Yr
Hwy MM-I-44 to MO360	9.2	2.9	6.2
Hwy MM-MO360 to US60	11.3	3.6	7.7
Combined	20.5	6.6	13.9

HSM1 Extended Spreadsheet for Part C Chapter 10 v.9.1

Table 9 Summary Results for Urban and Suburban Arterials

Project Element	Expected Crashes/Yr (Total)	Expected Fatality & Injury Crash/Yr	Expected PDO Crash/Yr
Hwy MM-I-44 to MO360	6.6	2.0	4.6
Hwy MM-MO360 to US60	7.6	2.3	5.3
Combined	14.1	4.3	9.9

HSM1 Extended Spreadsheet for Part C Chapter 12 v.9

Applying the values for expected crash frequencies to the CMF formula for safety performance of the two scenarios resulted in the following factors for crash reduction for the Project-Build scenario. In addition, other applicable CMFs from the CMF clearinghouse for other proposed improvements are presented.

Table 10 CMF's Derived from Safety Performance Functions for Two-Lane Conversion to Five-Lane

Project Element	Fatal/Injury CMF	Minor Injury/PDO CMF
Hwy MM-I-44 to MO360	0.69	0.74
Hwy MM-MO360 to US60	0.64	0.69

Table 11 Applicable Crash Modification Factors

CMF Name	Clearinghouse ID	Severity	Urban/Rural	CMF
Convert all-way, stop-controlled intersection to roundabout	4933	Fatal, Serious Injury, Minor Injury	All	0.544
Collision Models for Multilane Highway Segments to Examine the Safety of Curbs	2375	All	Suburban	0.89

The baseline crash annual averages for severity type were grown to match the growth in forecast travel demand AADT for the 2045 Project-Build scenario from the MoDOT 2020 AADT. The CMFs were then applied to the grown annual averages for crashes by severity type resulting in reductions in annual averages based on the Project-Build implementation. Crash costs were applied to the difference between the baseline averages and the Project-Build crash averages to produce a monetary value for the annualized safety benefit.

EMISSIONS ANALYSIS

The emissions benefit calculation is based on the OTO 2045 Travel Demand Model for the No-Build and Project-Build scenarios for the complete analysis network, which includes roadways expected to be heavily influenced by the project. Based on the model runs, the travel time delay can be expected to reduce from 22.8 minutes per vehicle to 11.75 minutes per vehicle along the analysis network as shown in the "TDM Existing" and "TDM Project Build" tabs in the BCA workbook. The difference in annual vehicle hours of delay was used to calculate the savings in emissions from the No-Build and Project-Build Scenarios. Idle emissions rates in grams per hour were applied to the difference in vehicle hours of delay for the percentage of trucks vs passenger vehicles on the analysis network. The 2020 AADT by vehicle type was supplied by MoDOT. Emissions rates were derived from the EPA.

Table 12 Average Idle Emissions Rates (grams per hour)

Light Duty Gasoline Vehicles	
Volatile Organic Compounds (VOC)	2.683
Nitrogen Oxide (NOx)	3.515
Particulate Matter (PM2.5)	N/A
Sulfer Dioxide	N/A
Heavy Duty Diesel Vehicle	
Volatile Organic Compounds (VOC)	3.455
Nitrogen Oxide (NOx)	33.763
Particulate Matter (PM2.5)	1.1
Sulfer Dioxide	N/A

Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks, EPA, October 2008

Table 13 Unit Conversions

Grams per US Short Ton	907,185
Metric Ton to Short Ton	1.1

The monetized benefit of reduction in CO_2, like air pollutants, utilized the analysis network model runs, however idle emissions rates were unavailable for CO_2 and those emissions are calculated from fuel use. Supporting information for idling fuel use by vehicle type available from the Office of Energy Efficiency & Renewable Energy was utilized to calculate fuel savings in gallons for passenger cars and trucks on the analysis network comparing the No-Build and Project-Build vehicle hours of delay. Information from the EPA's Greenhouse Gases Equivalencies Calculator – Calculations and References webpage provided the grams of CO_2 emitted from burning a gallon of gasoline and diesel fuel – 8,887 and 10,180, respectively. The grams per gallon of fuel savings for passenger cars and trucks were converted to metric tons and monetized annually according to the damage costs in the Revised 2022 BCA guidance. The tables below document the parameters used in the calculation.

Idling Fuel Use Supporting Information

Table 14 Idling Fuel Use Supporting Data Parameters

Vehicle Type	Fuel Type	Engine Size (Liter)	Gross Vehicle Weight	Idling Fuel Use (Gal/Hr with No Load)
Compact Sedan	Gas	2	-	0.16
Large Sedan	Gas	4.6	-	0.39
Compact Sedan	Diesel	2	-	0.17
Medium Heavy Truck	Gas	5-7	19,700-26,000	0.84
Delivery Truck	Diesel	-	19,500	0.84
Tow Truck	Diesel	-	26,000	0.59
Medium Heavy Truck	Diesel	6-10	23,000-33,000	0.44
Transit Bus	Diesel	-	30,000	0.97
Combination Truck	Diesel	-	32,000	0.49
Bucket Truck	Diesel	-	37,000	0.9
Tractor Semi-Trailer	Diesel	-	80,000	0.64

https://www.energy.gov/eere/vehicles/fact-861-february-23-2015-idle-fuel-consumption-selected-gasoline-and-diesel-vehicles

Idling Fuel Use for passenger cars used the average gas use for Compact and Large Sedans (0.275) and the value for Combination Trucks (0.49) applied to the 2020 commercial percentage on the analysis network. The damage costs for CO_2, NOx, and $PM_{2.5}$ emissions were calculated based on the yearly value per metric ton in Table A-6 in the March 2022 US DOT BCA Guidance for Discretionary Grant Programs.

OPERATING & MAINTENANCE COSTS

Operating and Maintenance Costs for the Hwy MM corridor were provided by MoDOT. Baseline per lane-mile costs for patching, mowing, signing, snow removal, signals, and a 10-yr resurfacing cycle were calculated and applied to the existing No-Build lane-miles (7.6) to create a base year value. A three percent rate of inflation was applied year-over-year throughout the analysis period. The per lane-mile costs were then applied to the Project-Build lane-miles (14.09) and inflated at three percent year-over-year through the analysis period. The No-Build costs were subtracted from the Project-Build costs resulting in $3,111,122 added to the total project costs to be included in the denominator of the benefit-cost ratio.

Total Highway MM Costs	
2022 Present Worth (7% Discount)	
Highway MM Corridor 1-44 to US 60	$41,426,914
Operations and Maintenance	$3,111,122
Total Project Cost	**$44,538,036**

No-Build Mile Cost	$921,607
Project Build Mile Cost	$916,670

Operations and Maintenance Cost				
	Year	No-Build O&M	Build O&M	Net Difference Cost Present 7%
1	2022	$ 116,326		
2	2023	$ 123,410		
3	2024	$ 127,112	$ 214,063	$ 86,951
4	2025	$ 130,925	$ 227,100	$ 96,174
5	2026	$ 134,853	$ 233,913	$ 99,060
6	2027	$ 138,899	$ 248,158	$ 109,259
7	2028	$ 143,066	$ 255,603	$ 112,537
8	2029	$ 147,358	$ 263,271	$ 115,913
9	2030	$ 151,778	$ 271,169	$ 119,391
10	2031	$ 151,778	$ 279,304	$ 127,526
11	2032	$ 156,332	$ 287,683	$ 131,351
12	2033	$ 161,022	$ 296,314	$ 135,292
13	2034	$ 165,852	$ 305,203	$ 139,351
14	2035	$ 170,828	$ 314,359	$ 143,531
15	2036	$ 175,953	$ 323,790	$ 147,837
16	2037	$ 181,231	$ 333,504	$ 152,272
17	2038	$ 186,668	$ 343,509	$ 156,840
18	2039	$ 192,268	$ 353,814	$ 161,546
19	2040	$ 198,036	$ 364,428	$ 166,392
20	2041	$ 203,978	$ 375,361	$ 171,384
21	2042	$ 210,097	$ 386,622	$ 176,525
22	2043	$ 216,400	$ 398,221	$ 181,821
23	2044	$ 222,892	$ 410,167	$ 187,276
24	2045	$ 229,578	$ 422,472	$ 192,894
Total Costs		$ 4,036,640	$ 6,908,027	$ 3,111,122

PEDESTRIAN SAFETY

The BCA Guidance provides recommendations for pedestrian facilities. Benefits were quantified for the following project improvements, based on a conservative AADT along the sidewalk and trail additions and a 1% annual increase:

- US 60 to Farm Road 160 - 10’ Trail at 4567.2 feet
- US 60 to Farm Road 160 - 5’ Sidewalk at 4567.2 feet
- Farm Road 160 to US 360 - 5’ Sidewalk at 7810.44 feet
- US 360 to I-44 - 5’ Sidewalk at 7408.86 feet

The corridor currently does not have sidewalks available for pedestrians. A conservative estimate of 100 AADT along the trail, 50 AADT on the sidewalk, and 35 AADT from the corridor segment from US 360 to I-44 was assumed. The positive discounted benefit of **$726,107** is realized along the corridor.

Table 15 Value of Pedestrian and Cycling Facility Additions

Value Pedestrian & Cycling Facility Additions							
		Trail	Pedestrian Improvement US 60 to Farm Road 160	Pedestrian Improvement Farm Road 160 to US 360	Pedestrian Improvement US 360 to I-44	Total Present Value	Net Present 7%
0	2022	-	-	-	$ -		
1	2023	-	-	-	$ -		
2	2024 (Construction	-	-	-	$ -		
3	2025 (Construction)	-	-	-	$ -		
4	2026 (Construction)	-	-	-	$ -		
5	2027	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 64,055.50
6	2028	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 59,864.96
7	2029	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 55,948.56
8	2030	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 52,288.37
9	2031	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 48,867.64
10	2032	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 45,670.69
11	2033	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 42,682.89
12	2034	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 39,890.55
13	2035	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 37,280.89
14	2036	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 34,841.95
15	2037	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 32,562.57
16	2038	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 30,432.31
17	2039	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 28,441.41
18	2040	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 26,580.76
19	2041	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 24,841.83
20	2042	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 23,216.66
21	2043	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 21,697.82
22	2044	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 20,278.33
23	2045	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 18,951.71
24	2046	$31,572.5	$ 15,786.3	$ 13,498.2	$ 7,682.5	$ 68,539.39	$ 17,711.88
Present Value						**$ 1,370,788**	
Net Present Value (7% Discount)							**$ 726,107**

MORTALITY REDUCTION BENEFITS OF INDUCED ACTIVE TRANSPORATION VALUES

The BCA Guidance provides recommendations for Mortality Reduction Benefits of Induced Active Transportation Values. Benefits were quantified for the following segments utilizing the Pedestrian counts and multiplying by the allowable multipliers of 59% of overall induced trips and 89% of non-active transportation modes within the relevant age range.

Table 16 Mortality Reduction Benefit Criteria

Mortality Reduction Benefit Criteria			
Segment	Induced Walking Trips	Benefit	Total Value of New Trips
Trail	52.51	$ 7.08	$ 371.77
Sidewalk - US 60 to Farm Road 160	26.255	$ 7.08	$ 185.89
Sidewalk - Farm Road 160 - US 360	26.255	$ 7.08	$ 185.89
Sidewalk - US 360 to I-44	18.3785	$ 7.08	$ 130.12

RAILROAD SAFETY

The OTO utilized GradeDec.net, a highway-rail grade crossing investment analysis tool, developed and maintained by the Federal Railroad Administration to calculate the predicted crashes per rail crossing. The safety analysis within GradeDec.net is based on the USDOT Accident Prediction and Severity Model (APS) and Resource Allocation Method. Two rail crossings were examined in the GradeDec.net program, SS MM (Highway MM) and County Road 160 (Haile and Orr St./Farm Road 160) in the Republic area maintained by the BNSF railroad. The AADT for Highway 360 to US 60 was utilized for the SS MM segment and the default BNSF data of 350 AADT was utilized for County Road 160.

The SS MM crossing currently has a railroad crossing arm at the at-grade-railroad crossing. The factor of 5.4% yearly increase in AADT was applied to the SS MM crossing to match the predicted increase per the Traffic Demand Model.

The Project-Build is removing the two at-grade railroad crossing from I-44 to US 60. The average predicted accident rate of .0382 decreases to a **zero** chance of vehicular/train collision.

Table 17 Value of Safety Benefits for Highway MM At-Grade Crossing in Build Scenario

Value of Safety Benefits for Highway MM At-Grade Crossing in Build Scenerio							
Year	Calendar Year	Crash Probability	Fatal Accident Probability	Injury Accident Probability	Property Damage Probability	Value of Reduction in Fatalites, Injuries, Property	Savings Discount
0	2022	0.0308	0.0046	0.0092	0.0170		
1	2023	0.0311	0.0047	0.0093	0.0172		
2	2024 (Construction)	0.0315	0.0047	0.0094	0.0174		
3	2025 (Construction)	0.0319	0.0048	0.0095	0.0176		
4	2026 (Construction)	0.0322	0.0048	0.0096	0.0178		
5	2027	0.0325	0.0049	0.0097	0.0180	$ 5,043	$ 4,712.73
6	2028	0.0329	0.0049	0.0098	0.0182	$ 5,125	$ 4,476.00
7	2029	0.0333	0.0050	0.0099	0.0184	$ 5,203	$ 4,247.56
8	2030	0.0333	0.0050	0.0099	0.0184	$ 5,203	$ 3,969.68
9	2031	0.0340	0.0051	0.0101	0.0188	$ 5,367	$ 3,826.61
10	2032	0.0344	0.0051	0.0103	0.0190	$ 5,452	$ 3,632.77
11	2033	0.0347	0.0052	0.0104	0.0192	$ 5,533	$ 3,445.89
12	2034	0.0352	0.0053	0.0105	0.0194	$ 5,634	$ 3,279.03
13	2035	0.0356	0.0053	0.0106	0.0196	$ 5,720	$ 3,111.13
14	2036	0.0359	0.0054	0.0107	0.0198	$ 5,793	$ 2,944.99
15	2037	0.0363	0.0054	0.0108	0.0199	$ 5,885	$ 2,795.77
16	2038	0.0367	0.0055	0.0109	0.0203	$ 5,975	$ 2,652.91
17	2039	0.0371	0.0055	0.0111	0.0205	$ 6,078	$ 2,522.09
18	2040	0.0375	0.0056	0.0112	0.0207	$ 6,169	$ 2,392.33
19	2041	0.0378	0.0056	0.0113	0.0209	$ 6,251	$ 2,265.83
20	2042	0.0382	0.0057	0.0114	0.0211	$ 6,344	$ 2,149.00
21	2043	0.0386	0.0058	0.0115	0.0213	$ 6,441	$ 2,038.91
22	2044	0.0390	0.0058	0.0116	0.0216	$ 6,538	$ 1,934.21
23	2045	0.0394	0.0059	0.0118	0.0218	$ 6,635	$ 1,834.67
24	2046	0.0399	0.0060	0.0119	0.0220	$ 6,749	$ 1,744.13
Present Value						**$ 117,137**	
Net Present Value 7% Discount							**$ 59,976**

Table 18 Value of Removing Haile and Orr St. At-Grade Crossing in Build Scenario

Value of Haile and Orr St. At-Grade Crosssing in Build Scenerio							
Year	Calendar Year	Crash Probability	Fatal Accident Probability	Injury Accident Probability	Property Damage Probability	Value of Reduction in Crashes, Injuries, and Fatalities	Savings Discount
0	2022	0.0304	0.0045	0.0074	0.0185		
1	2023	0.0306	0.0046	0.0074	0.0186		
2	2024 (Construction)	0.0306	0.0046	0.0074	0.0186		
3	2025 (Construction)	0.0306	0.0046	0.0074	0.0186		
4	2026 (Construction)	0.0310	0.0046	0.0008	0.0189		
5	2027	0.0312	0.0047	0.0076	0.0190	$ 4,231.31	$ 3,954.50
6	2028	0.0313	0.0047	0.0076	0.0191	$ 4,258.39	$ 3,719.45
7	2029	0.0315	0.0047	0.0076	0.0192	$ 4,288.63	$ 3,500.80
8	2030	0.0316	0.0047	0.0077	0.0192	$ 4,322.36	$ 3,297.50
9	2031	0.0318	0.0047	0.0077	0.0193	$ 4,352.17	$ 3,103.03
10	2032	0.0319	0.0048	0.0077	0.0194	$ 4,387.37	$ 2,923.49
11	2033	0.0321	0.0048	0.0078	0.0195	$ 4,414.29	$ 2,749.00
12	2034	0.0323	0.0048	0.0078	0.0196	$ 4,444.97	$ 2,587.02
13	2035	0.0324	0.0048	0.0079	0.0197	$ 4,475.69	$ 2,434.48
14	2036	0.0326	0.0049	0.0079	0.0198	$ 4,510.72	$ 2,293.02
15	2037	0.0327	0.0049	0.0079	0.0199	$ 4,541.00	$ 2,157.40
16	2038	0.0329	0.0049	0.0080	0.0200	$ 4,568.33	$ 2,028.39
17	2039	0.0330	0.0049	0.0080	0.0201	$ 4,604.35	$ 1,910.64
18	2040	0.0332	0.0050	0.0080	0.0202	$ 4,635.52	$ 1,797.74
19	2041	0.0334	0.0050	0.0081	0.0203	$ 4,671.10	$ 1,693.02
20	2042	0.0335	0.0050	0.0081	0.0204	$ 4,701.86	$ 1,592.68
21	2043	0.0337	0.0050	0.0082	0.0205	$ 4,733.29	$ 1,498.44
22	2044	0.0338	0.0051	0.0082	0.0206	$ 4,769.19	$ 1,411.03
23	2045	0.0340	0.0051	0.0082	0.0207	$ 4,801.51	$ 1,327.66
24	2046	0.0342	0.0051	0.0083	0.0208	$ 4,834.62	$ 1,249.36
Present Value						**$ 90,547**	
Net Present Value 7% Discount							**$ 47,229**

Table 19 Total Two At-Grade Railroad Crossing Closures Benefits

Total Two At-Grade Railroad Crossing Closures	
Total At-Grade Separation Benefits	$ 207,684
Total At-Grade Separation Benefits Net Present Value 7%	$ 107,205

RAILROAD OPERATIONS AND MAINTENANCE

The railroad maintenance calculations were based on MoDOT maintenance cost of $8,500 per at-grade railroad crossing. BNSF maintenance cost was calculated at $25,000 for the crossing with lights and gate, and $5,000 for a passive crossing. Railroad maintenance was not factored in the roadway operations and maintenance section of the BCA. In the Project-Build scenario, all at-grade crossings are removed leaving a positive discounted benefit of **$497,009** savings over the 20-year period.

Table 20 Value of Reduced Operations and Maintenance Expenses

Value of Reduced Operations and Maintenance Expenses					
Year	Calendar Year	At-Grade Crossing Maintence BNSF	At-Grade Crossing Maintenance MoDOT	Total Operations and Maintenance Savings	Net Present Value 7%
0	2022	$30,000	$ 17,000	$ -	$ -
1	2023	$30,000	$ 17,000	$ -	$ -
2	2024 (Construction)	$30,000	$ 17,000	$ -	$ -
3	2025 (Construction)	$30,000	$ 17,000	$ -	$ -
4	2026 (Construction)	$30,000	$ 17,000	$ -	$ -
5	2027	$30,000	$ 17,000	$ 47,000	$ 43,925
6	2028	$30,000	$ 17,000	$ 47,000	$ 41,052
7	2029	$30,000	$ 17,000	$ 47,000	$ 38,366
8	2030	$30,000	$ 17,000	$ 47,000	$ 35,856
9	2031	$30,000	$ 17,000	$ 47,000	$ 33,510
10	2032	$30,000	$ 17,000	$ 47,000	$ 31,318
11	2033	$30,000	$ 17,000	$ 47,000	$ 29,269
12	2034	$30,000	$ 17,000	$ 47,000	$ 27,354
13	2035	$30,000	$ 17,000	$ 47,000	$ 25,565
14	2036	$30,000	$ 17,000	$ 47,000	$ 23,892
15	2037	$30,000	$ 17,000	$ 47,000	$ 22,329
16	2038	$30,000	$ 17,000	$ 47,000	$ 20,869
17	2039	$30,000	$ 17,000	$ 47,000	$ 19,503
18	2040	$30,000	$ 17,000	$ 47,000	$ 18,227
19	2041	$30,000	$ 17,000	$ 47,000	$ 17,035
20	2042	$30,000	$ 17,000	$ 47,000	$ 15,921
21	2043	$30,000	$ 17,000	$ 47,000	$ 14,879
22	2044	$30,000	$ 17,000	$ 47,000	$ 12,996
23	2045	$30,000	$ 17,000	$ 47,000	$ 12,996
24	2046	$30,000	$ 17,000	$ 47,000	$ 12,146
Total Value				**$ 940,000**	
Net Present Value (7% Discount)					**$497,009**

AGGLOMERATION ECONOMICS

The City of Republic has had 3,371 jobs created along this corridor in the past 10 years. The projection is another 2,000 jobs in the next 5 years based off planned development (City of Republic BUILD Department). The area is mostly developable land. Removing the road barrier will allow development on all the available developable land. The estimate is a total of an additional 3,000 jobs in the next 10 years. Current development has been planned based on the planned road projects in the Statewide Transportation Improvement Program and Transportation Improvement Program.

Table 21 Value of Job Creation

Value of Job Creation						
Year	Calendar Year	Estimate Jobs Per Year	Average Wage of Job	Full Time Hour	Total Annual Wage Growth	Net Present Value 7%
0	2022	0	$ 15.76		$ -	$ -
1	2023	0	$ 16.23		$ -	$ -
2	2024 (Construction)	0	$ 16.72		$ -	$ -
3	2025 (Construction)	0	$ 17.22		$ -	$ -
4	2026 (Construction)	0	$ 17.74		$ -	$ -
5	2027	500	$ 18.27	$ 33,280	$ 16,640,000	$ 15,551,402
6	2028	100	$ 18.64	$ 38,762	$ 3,876,197	$ 3,385,621
7	2029	100	$ 19.01	$ 39,537	$ 3,953,721	$ 3,227,414
8	2030	100	$ 19.39	$ 40,328	$ 4,032,795	$ 3,076,600
9	2031	100	$ 19.78	$ 41,135	$ 4,113,451	$ 2,932,834
10	2032	100	$ 20.17	$ 41,957	$ 4,195,720	$ 2,795,786
11	2033	100	$ 20.58	$ 42,796	$ 4,279,635	$ 2,665,141
12	2034	100	$ 20.99	$ 43,652	$ 4,365,227	$ 2,540,602
13	2035	100	$ 21.41	$ 44,525	$ 4,452,532	$ 2,421,882
14	2036	100	$ 21.83	$ 45,416	$ 4,541,583	$ 2,308,710
15	2037	100	$ 22.27	$ 46,324	$ 4,632,414	$ 2,200,827
16	2038	100	$ 22.72	$ 47,251	$ 4,725,063	$ 2,097,984
17	2039	100	$ 22.94	$ 47,723	$ 4,772,313	$ 1,980,340
18	2040	100	$ 23.17	$ 48,200	$ 4,820,036	$ 1,869,293
19	2041	100	$ 23.40	$ 48,682	$ 4,868,237	$ 1,764,473
20	2042	100	$ 23.64	$ 49,169	$ 4,916,919	$ 1,665,531
21	2043	100	$ 23.88	$ 49,661	$ 4,966,088	$ 1,572,136
22	2044	100	$ 24.11	$ 50,157	$ 5,015,749	$ 1,386,896
23	2045	100	$ 24.36	$ 50,659	$ 5,065,907	$ 1,400,765
24	2046	100	$ 24.60	$ 51,166	$ 5,116,566	$ 1,322,218
		2,400				
Total Value					**$ 103,350,153**	
Net Present Value (7% Discount)						**$58,166,456**

Table 22 Benefit Cost Analysis Input Tables

Travel Data		
	RTE MM - I-44/MO360	RTE MM - MO360/US60
Roadway AADT 2020	10,064	7,830
Roadway AADT 2045 Base Condition	23,857	18,630
Roadway AADT 2045 Build Scenario	28,718	26,333
Segment Length (Miles)	2	2
Segment Length (Miles) Build Scenario	2	2
Roadway VMT 2020	6,258,911	6,024,310
Roadway VMT 2045 Base Condition	14,332,907	14,912,624
Roadway VMT 2045 Build Scenario	17,253,634	18,108,123
VMT Growth Factor	1	1
VMT Growth No Build v. Build Scenario	0	0
AM Peak Volume 2020	1,140	1,433
PM Peak Volume 2020	2,149	1,979
Roadway Commercial % 2020	0	0
Combo-Semi Volume 2020	609	695
Single Unit Truck Volume 2020	481	466
Bus Volume 2020	75	87

Safety Data		
	RTE MM - I-44/MO360	RTE MM - MO360/US60
Crash Stats 2016 - 2022		
Fatalities Total	0	1
Disabling Injury Total	4	3
Minor Injury Total	16	20
Property Damage Only Total	39	47
Fatality Annual Avg	0	0.166666667
Disabling Injury Annual Avg	0.666667	0.5
Minor Injury Annual Avg	2.666666667	3.333333333
PDO Annual Avg	6.5	7.833333333

Value of Reduced Fatalities, Injuries, & PDO Crashes	
Type of Injury	**Value**
Fatality	$9,962,900
Disabling Injury	$577,700
Minor Injury	$150,300
PDO	$10,500
MoDOT 2018 - 2022 Crash Costs*	

Value of Travel Time Savings	
Travel Time Type	**Value**
In-Vehicle Travel	**Hourly Value**
Personal	$16.20
Business	$29.40
All Purposes	$17.80
Commercial Vehicle Operators	
Truck Drivers	$32.00
Bus Drivers	$33.60

Vehicle Operating Costs for Highway Passenger Vehicles	
Vehicle Type	**Value per Mile**
Light-Duty Vehicles	$0.43
Commercial Trucks	$0.93

At-Grade Railroad Crossing Safety		
Data Input	**Data Value**	**Reference**
Discount Rate	7%	
Operating Period	20 (Years)	
Operating Year	2027	
AADT Growth SS MM Crossing	5.40%	OTO Travel Demand Model 2045, Highway MM/ZZ Corridor Study
AADT Growth Haile and Orr St.	2.00%	
Injury Crash	$302,600	Benefit-Cost Analysis Guidance for Discretionary Grant Programs,
Fatal Crash	$12,837,400	
Property Damage Only	$4,600	
Serious Injury	$554,800	
Safety Formula	SB = Number of Yearly Crashes*100%*(Number of Accidents in base case, Number of accidents in alternative case 0), * Cost per accident type	GradeDec.Net Reference Manual Federal Railroad Administration * Benefit-Cost Analysis Guidance for Discretionary Grant Programs,