5. Benefit-Cost Analysis Narrative

Overview

Rhode Island Department of Transportation (RIDOT) requests $25 million from the Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Grant Program to support **Right-Sizing Route 37: Improving Community Connectivity,** a surface transportation project that will leverage repairs on eight major bridges into a complete, multimodal, sustainable transportation investment. This $100 million project will complete a decade-long effort to restore Rhode Island Route 37 (RI-37), a critical urban freight corridor connecting interstates 95, 295, and US-1.

Broadly, this project seeks to complete a decade long effort to restore RI-37 to a state of good repair while making strategic improvements at critical intersections to make ready for future transit and complete streets enhancements. The specific technical aspects of this project include:

- **State of Good Repair:** Replace four bridges; rehabilitate one bridge and one culvert; decommission and remove two bridges; and eliminate a pair of loop ramps linking RI-37 and US-1, replacing them with a series of at-grade signalized intersections.
- **Environmental Sustainability:** With the removal of loop ramps connecting RI-37 to US-1, restore previously filled wetlands on the east side of US-1.
- **Safety:** Install at-grade signalized intersections to reduce arterial speeds and better manage traffic growth on US-1. Upgrade traffic signal equipment to implement adaptive signal control; install rumble strips along RI-37 to reduce roadway departure crashes; and install high-friction surface treatment and enhanced curve delineation along 17 ramps along the RI-37 corridor.
- **Transit Enhancements:** Install transit signal priority (TSP) at signalized intersections along US-1 and RI-2; provide queue jump lanes at the proposed intersection of RI-37 at US-1; replace the bridge carrying RI-37 over RI-2 and lengthen it to provide roadway width under the bridge to support future high-capacity transit expansion along RI-2, where Light Rail Transit (LRT) and Bus Rapid Transit (BRT) options are under development by RIPTA.
- **Pedestrian Facilities:** Enhance existing pedestrian crossings on US-1 and RI-2; install new crossings at the proposed RI-37 terminus at US-1 and on RI-2 at Chapel View Plaza.
- **Cycling Facilities:** Develop bike connectivity from the Washington Secondary Bike Path to Meshanticut Valley Parkway; install a shared use path along Meshanticut Valley Parkway and RI-2 providing bike connectivity to Chapel View Plaza.
- **Economic Competitiveness:** Remove loop ramps and reduce right-of-way to make several new parcels available and right-size the width of RI-37 to repurpose land use for development.

Taken together, these improvements will address immediate maintenance and safety issues while simultaneously advancing the long-term goals for robust transit and active transportation infrastructure along this critical corridor in the heart of Rhode Island.

Findings

Rightsizing Route 37 has a favorable benefit-cost ratio of 1.17, and a net present value of $14.05 million. It is therefore a cost-effective investment. The Benefit-Cost Analysis shows that this project generates safety, emissions, and travel time savings, in addition to foregone cost savings totaling $84 million over 30 years. While not easily quantified, the project also provides enhancements to pedestrian and cycling facilities, provides improvements that will be supportive of more reliable transit operations through the Study Area, and opens up opportunities for high-capacity transit enhancements that are currently under study. Complete calculations are included in Appendix A and the BCA spreadsheet.

Figure 5-1 Benefit-Cost Analysis Summary

Item	Value
Project Benefits Evaluation Period	30
Primary Discount Rate:	7%
Alternative Discount Rate:	3%
Present Value Benefit (7%):	$95,203,704.86
Present Value Cost (7%):	$76,109,662.78
Project Benefit-Cost Ratio (7%):	**1.17**
Net Present Value (NPV) (7%)	$14,054,611.78

(a) Spatial Extents

To accurately align the scope of benefits with the scope of the proposed project two different spatial extents were used in the evaluation of project benefits.

- Full Study Area Extents (Figure 5-2) – The Safety benefits were reviewed on a project-wide basis with Crash Modification Factors (CMFs) applied to the scope of crashes in the recent history specific to the given Safety Issue. Foregone cost benefits are applied by structure as appropriate.
- RI-37 at US-1 Interchange Sub-area (Figure 5-3) – Transitioning the RI-37 at US-1 interchange to an at-grade intersection has unique safety, travel time, and emissions benefits. This narrower study area, RI-37 at US-1 Interchange Sub-area, was modeled for each of those elements of the BCA.

Figure 5-2 Full Study Area Extents

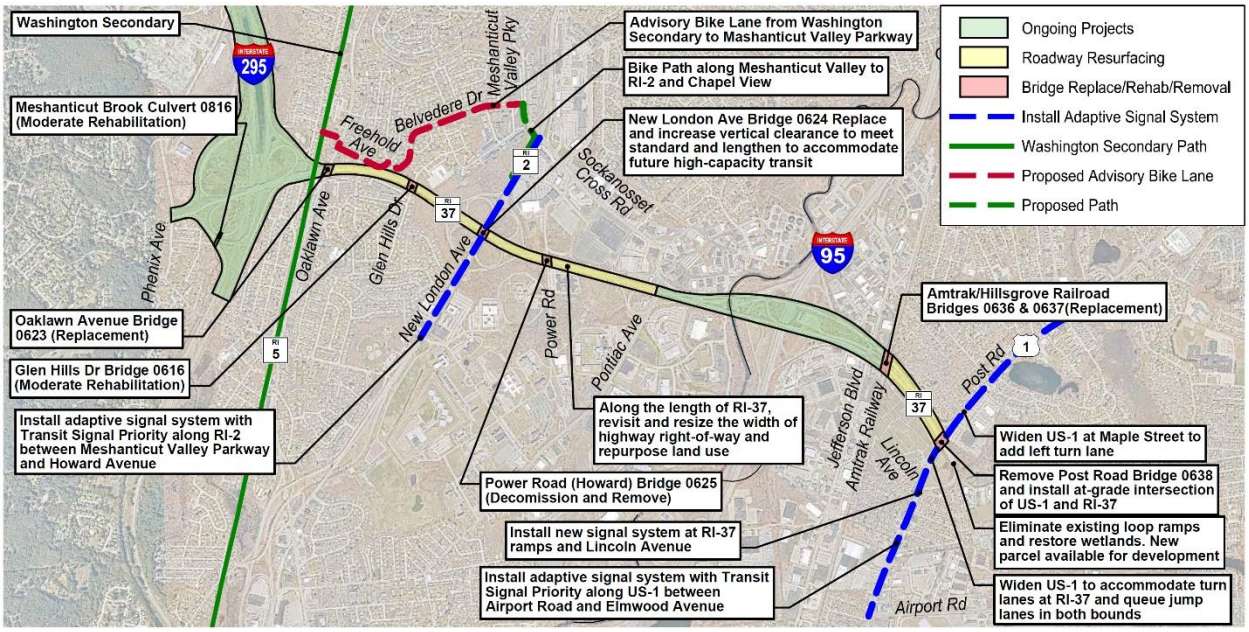


Figure 5-3 Route 37 at US-1 Interchange Sub-area

(b) Assumptions and Methodology

(i) Baseline

The assumptions and methodology used to produce this analysis are detailed in the attached BCA. In general, this analysis compares the proposed alternative to a baseline/no-build scenario in which all roadway geometry would remain unchanged. No facility expansions or enhancements are included in the baseline.

Each of these technical reviews is documented in Appendix A of this application with additional technical content for Safety (Appendix A-1), Travel Time (Appendix A-2), and Emissions (Appendix A-3).

Key assumptions for this analysis include:

- **Safety:** recent crash history is considered representative of the future crashes over the planning horizon, and a correlated to roadway volume.
- **Safety:** Application of Crash Modification Factors (CMFs) is the preferred methodology, however, in the case of the interchange reconstruction use of ISATe, the Highway Safety Manual (HSM) crash prediction model is an appropriate surrogate. The national default model was applied and outcomes applied to the relevant crash history.
- **Travel Time:** VISSIM Microsimulation software was used to model the 2023 Existing and future 2028 No Build, 2058 No Build, 2028 Build, and 2058 Build Conditions.
- **Travel Time:** The modeled travel time results are limited to the smaller sub-study area, not the wider project area. While speed reductions in the future No Build Condition may spill back on RI-37 EB and into the upstream interchange, those impacts are no included in this model.
- **Travel Time:** While the RI-37 study area supports a high volume of commuter, commercial, and freight traffic year-round and on all days of the week, this analysis conservatively assumes that benefits are only accrued on weekdays.
- **Emissions:** Emission factors for the study area were developed using the Motor Vehicle Emission Simulator model (MOVES3) developed by the US Environmental Protection Agency.
- **Emissions:** Emissions were analyzed for the first five years of operation (2028-2032) and the design year (2058). Analyses were conducted for the No Build and Build alternatives to determine the emissions reduction associated with the Project.
- **Emissions:** The emission factors represent the corresponding year of the traffic modeling. The factors were derived by calculating a seasonal average during the evening peak hour with a representative vehicle mix.
- **Foregone Costs:** This review emphasizes the importance of funding bridge decommissioning to eliminate the future routine maintenance needs to keep the structures open, ensuring safety of structures.

This project will generate significant benefits for **Safety, Travel Time Savings, Emissions, Foregone Costs, and Repurposed Right-of-Way.** The table below summarizes the primary project benefits. Calculations are documented in the Benefit-Cost Analysis Calculations spreadsheet.

Figure 5-4 Summary of Project Benefits

Parameter	Baseline Scenario (No RAISE Funding)	Preferred Action Scenario (With RAISE Funding)
Safety	• Project limited to structural maintenance, no substantive safety enhancements.	• RI-37 and US-1 at-grade intersection with appropriate intersection safety enhancements • High friction surface treatment • Rumble stripes with recessed pavement markers and enhanced curve delineation
Travel Time	• Within the RI-37 at US-1 interchange, existing traffic conditions continue to deteriorate increasing travel delay over time.	• Signalized at-grade intersection can better manage traffic in future years. Impact is negligible in the near-term, however and reduces travel delay in future years.
Emissions	• Within the RI-37 at US-1 interchange, emissions continue to grow as vehicle delays increase in the future as traffic operations deteriorate.	• Improved traffic management results in reductions in emissions primarily in future years.
Foregone Cost	• Bridge 636 – full replacement (incremental over 30 years) • Bridge 637 – full replacement (incremental over 30 years) • Bridge 625 – 2028 Full Replacement • Bridge 638 – 2025 Full Replacement • Bridge 625 - 30-year Maintenance (washing, joint & membrane replacements, coating & patching, steel repairs, minor rehabilitation) • Bridge 638 - 30-year Maintenance (washing, joint replacements, coating & patching, steel repairs, minor rehabilitation)	• Bridge 636– Full Replacement • Bridge 637 – Full Replacement • Bridge 625 – Decommission and Remove • Bridge 638 – Decommission and remove, install at-grade intersection.
Repurposed Right-of-Way	• No changes to the transportation footprint	• By eliminating Bridge 638 for RI-37 over US-1, the pair of supporting loop ramps is decommissioned and a parcel valued at approximately $3M is made available.

(ii) Data Sources

Key sources of data used to project outcomes include but are not limited to:

› 2022 RIDOT traffic count data;

› RIDOT crash data from January 1, 2015, to December 31, 2021 (complete 2022 data were not readily available for this application);

› Highway Safety Manual ISATe default model and results;

› VISSIM Microsimulation results;

› Motor Vehicle Emissions Simulator (MOVES3) model; and

› RIDOT Office of Bridge Engineering construction and maintenance costs in current dollars.

(iii) Key Input Parameters

In addition to the Data Sources listed, all key input parameters in this analysis are taken from USDOT's "Benefit-Cost Analysis Guidance for Discretionary Grant Programs," January 2023, unless otherwise noted. Safety benefit calculations utilize Crash Modification Factor Clearinghouse (CMF) inputs.

(c) Project Benefits

This project generates a range of quantified benefits to the state and local communities by directly addressing several baseline challenges with targeted interventions.

To ensure project benefits were not overstated and the highest standard of transparency was maintained, RIDOT and supporting consultants Vanasse Hangen Brustlin, Inc. (VHB) made several enhancements to the benefit-cost analysis preparation process. The enhancements were made in direct response to feedback from USDOT in debriefs of recently submitted grant applications, which included a critique that RIDOT's future BCAs would benefit from additional supporting documentation to improve transparency.

First, the team was deliberately conservative in its assumptions supporting the BCA. While the study area experiences heavy traffic year-round, the number of affected days for the travel time savings calculation was assumed to be 270, rather than a year-round 365-day calculation. Due to the presence of Garden City and Chapel View, the area does experience heavy weekend traffic, but the projections are deliberately more conservative for the purposes of this analysis.

Second, this benefit-cost analysis is accompanied by several supporting technical analysis appended to this narrative to elaborate on assumptions made, methodological considerations, data utilized, scenario assessments, analysis results, model calibrations, and more. They are:

- **Appendix A – Benefit Cost Analysis:** The calculations spreadsheet is reproduced here for easy reference. Each benefit and cost associated with the project is summarized and backup calculations are included. Each backup tab includes, at a minimum, a statement of the Assumptions, methodology, Baseline, Sources of Data, and Key Input Parameters, pursuant to the latest BCA guidance from USDOT (January 2023).
- **Appendix A-1 – Safety:** This technical memo explains and documents the strategies and methodologies deployed to estimate safety issues, accident counts, and proposed interventions throughout the Study Area. It identifies, explains, and justifies the use of selected Crash Modification Factors (CMFs) and supplies calculations utilized to arrive at data inputs for the master BCA spreadsheet.
- **Appendix A-2 – Travel Time:** This technical memo documents the methodologies and assumptions used in the development of the VISSIM microsimulation model for the project and provides documentation of the model results. Data collection, model calibration, and travel time segment comparisons are discussed.
- **Appendix A-3 – Emissions:** This technical memo documents the air quality study undertaken for the project, including a detailed mesoscale analysis over six selected years within the benefits period.
- **Appendix A-4 – Infrastructure Maintenance Plans:** RIDOT is committed to preserving and maintaining the state's infrastructure, and that commitment starts before a major rehabilitation project like this one even begins. This memo provides historical grounding for anticipated future maintenance costs on the roads and bridges in this project to ensure accurate figures are included over the analysis period in the BCA.

The baseline challenges of this project, proposed adjustments to the baseline, and anticipated benefits are summarized in **Error! Reference source not found.** below.

Figure 5-5 Summary of Baseline Challenges, Changes, and Impacts

Baseline Challenge	Change to Baseline	Impacts
Safety History of Lane/Roadway Departure crashes	Safety countermeasures geared toward mitigating lane/roadway departures crashes: High-friction surface treatment, improved curve delineation, and rumble strips.	High-friction surface treatment, curve delineation, and rumble strips yield substantial benefits of reducing 40 crashes annually.
Safety History of Lane/Roadway Departure crashes	Major reconfiguration of RI-37 at US-1 interchange.	The interchange reconfiguration is predicted to reduce fatal & injury crashes by about 4 annually but could increase property damage only crashes by six annually. Additionally, design elements, such as roadway alignment for speed control, are included in the proposed project, however, not represented in the Safety analysis.
Emissions Travel times and congestion are predicted to grow in future years.	Remove Post Road Bridge (#638) and construct an at-grade, signalized intersection.	In future years the proposed alternative can better manage higher traffic volume with a net reduction in greenhouse gas emissions valued at $1,116,388.18.
Travel Time Travel times and congestion are predicted to grow in future years.	Remove Post Road Bridge (#638) and construct an at-grade, signalized intersection.	In the near-term, the signalized intersection slows operations compared to the Existing Condition. In future years, the proposed alternative can better manage higher traffic volume with an average daily reduction in delay of 120 hours daily. *Note this reduction in delay is aggregated over the RI- 37 at US-1 sub-study area. Appendix A-1 details changes in travel time on specific facilities.*
Travel Time US-1 is congested with travel reliability challenges for personal vehicles and transit vehicles. This is one of the highest traveled roadways in the state by RIPTA riders carrying Route 1 and Route 20.	Install transit signal priority and queue jump lanes.	While not a quantified benefit in the Benefit-Cost Analysis, transit operations and reliability along US-1 improve with queue jump lanes and transit signal priority.
Foregone Costs Outsized asset portfolio	Decommission Post Road Bridge (#638) and Howard Bridge (#625)	Eliminates on average $266,000 in maintenance costs annually over 30 years.
Transit Facility Benefits Transit Facility benefits are not proposed due to right-of-way limitations	No change to baseline	No impacts as a result of this project. This project eliminates roadway constraints to future high-capacity transit improvements through RIPTA.
Pedestrian Facility Benefits Both US-1 and RI-2 are vehicle-focused corridors.	Enhanced signalized pedestrian crossings will be provided at intersections along US-1 and RI-2	The estimated number of existing pedestrians benefiting is 200 pedestrians annually.

Figure 5-5 Summary of Baseline Challenges, Changes, and Impacts

Baseline Challenge	Change to Baseline	Impacts
Cycling Facility Benefits Both US-1 and RI-2 are vehicle-focused corridors.	Bicycle connectivity will be established between the Washington Secondary Bike Path and Chapel View Shopping Plaza which provides commercial amenities including grocery store, bank, and medical offices.	While not a quantified benefit in the Benefit-Cost Analysis, new bike facilities and connectivity will induce bike trips not currently observed on RI-2.
Mortality Reduction Benefits Both US-1 and RI-2 are vehicle-focused corridors.	See Pedestrian Facility and Cycling Facility Benefits above.	While not a quantified benefit in the Benefit-Cost Analysis, new bike facilities and connectivity and improved pedestrian crossings will facilitate active transportation by area residents.

(d) Project Costs

The costs associated with this project are:

- The $100 million future eligible construction and design cost;
- Anticipated work zone costs totaling $0.84 million; and
- Lifecycle management costs over the service life of the proposed assets.

RIDOT has conservatively estimated that traffic delays will double during construction to avoid overstating the projected B-C ratio for both components.

Detailed budget information can be found in the Project Budget section of this application including a budget by phase and a separate budget by item type, tracked internally by RIDOT from a project's conception to completion.

Appendix A
Benefit-Cost Analysis

Project Benefit-Cost Analysis (BCA) Summary

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

This project will generate considerable safety, emissions, and time travel savings, which more than offset the cost of construction, work zone impacts, and long-term maintenance costs. The project's costs and benefits are summarized here, and reported in more detail in the "Project B&C Backup by Year" tab, which aggregates the annual benefits and costs from each area of this Benefit-Cost Analysis.

This project has a **favorable benefit-cost ratio of 1.17, and a net present value (NPV) of $14.05 million,** indicating that the **Right-Sizing Route 37 Project is a worthwhile and cost-effective investment.**

Table ES-1.1 summarizes the project's costs and benefits.
Table ES-1.2 shows the calculation of the project's benefits by year, discounted at both the primary (7%) and alternative (3%) discount rates.
Table ES-1.3 summarizes the project's costs by year, discounted at both the primary (7%) and alternative (3%) discount rates.

Table ES-1.1 Summary of Project Costs and Benefits

Item	Value
Project Benefits Evaluation Period	30
Primary Discount Rate:	7%
Alternative Discount Rate:	3%
Present Value Benefit (7%):	$ 95,203,704.86
Present Value Cost (7%):	$ 76,109,662.78
Project Benefit-Cost Ratio (7%):	**1.17**
Net Present Value (NPV) (7%)	$ 14,054,611.78
Alternative B-C Ratio (3%)	1.74
Alternative NPV (3%)	$ 71,390,034.68

Table ES-1.2 Project Benefits by Year

Table ES-1.3 Project Costs by Year

Year#	Year	Present Value (PV) Project Benefits	Project Benefits at 7% Discount Rate*	Project Benefits at 3% Discount Rate	Present Value (PV) Project Costs	Project Costs at 7% Discount Rate	Project Costs at 3% Discount Rate
1	2023	$ -	$ -	$ -	$ 610,000.00	$ 570,093.46	$ 592,233.01
2	2024	$ -	$ -	$ -	$ 2,415,000.00	$ 2,109,354.53	$ 2,276,369.12
3	2025	$ 25,927,991.00	$ 21,164,964.01	$ 23,727,784.71	$ 2,875,000.00	$ 2,346,856.40	$ 2,631,032.27
4	2026	$ -	$ -	$ -	$ 30,900,000.00	$ 23,573,462.05	$ 27,454,249.78
5	2027	$ -	$ -	$ -	$ 37,522,256.69	$ 26,752,850.44	$ 32,367,028.23
6	2028	$ 16,542,651.00	$ 11,023,066.86	$ 13,854,209.78	$ 24,822,256.69	$ 16,540,117.72	$ 20,788,249.19
7	2029	$ 8,751,677.26	$ 5,452,854.82	$ 7,115,914.49	$ 1,700,000.00	$ 1,058,674.56	$ 1,382,255.57
8	2030	$ 5,917,151.70	$ 3,446,999.06	$ 4,671,054.20	$ 413,064.00	$ 240,407.01	$ 326,076.54
9	2031	$ 6,082,886.82	$ 3,312,318.65	$ 4,662,026.24	$ 413,064.00	$ 224,679.45	$ 316,579.16
10	2032	$ 6,248,331.86	$ 3,180,382.53	$ 4,649,345.72	$ 413,064.00	$ 209,980.79	$ 307,358.41
11	2033	$ 6,413,794.97	$ 3,051,608.15	$ 4,633,461.95	$ 413,064.00	$ 196,243.73	$ 298,406.22
12	2034	$ 6,579,276.15	$ 2,926,146.08	$ 4,614,571.92	$ 413,064.00	$ 183,405.36	$ 289,714.78
13	2035	$ 6,744,775.40	$ 2,804,113.62	$ 4,592,863.85	$ 413,064.00	$ 171,406.87	$ 281,276.48
14	2036	$ 6,910,292.71	$ 2,685,598.54	$ 4,568,517.56	$ 413,064.00	$ 160,193.34	$ 273,083.97
15	2037	$ 7,076,133.39	$ 2,570,858.39	$ 4,541,900.76	$ 413,064.00	$ 149,713.40	$ 265,130.06
16	2038	$ 7,241,695.87	$ 2,459,539.62	$ 4,512,785.45	$ 413,064.00	$ 139,919.07	$ 257,407.83
17	2039	$ 7,407,276.42	$ 2,351,856.18	$ 4,481,524.05	$ 413,064.00	$ 130,765.48	$ 249,910.51
18	2040	$ 7,572,875.03	$ 2,247,808.32	$ 4,448,265.96	$ 413,064.00	$ 122,210.73	$ 242,631.57
19	2041	$ 7,738,491.71	$ 2,147,380.66	$ 4,413,153.69	$ 413,064.00	$ 114,215.64	$ 235,564.63
20	2042	$ 7,904,476.92	$ 2,050,738.30	$ 4,376,517.22	$ 413,064.00	$ 106,743.59	$ 228,703.52
21	2043	$ 8,070,138.77	$ 1,957,451.70	$ 4,338,097.25	$ 413,064.00	$ 99,760.36	$ 222,042.25
22	2044	$ 8,235,818.68	$ 1,867,664.86	$ 4,298,212.01	$ 413,064.00	$ 93,233.98	$ 215,575.00
23	2045	$ 8,401,516.66	$ 1,781,318.49	$ 4,256,979.16	$ 413,064.00	$ 87,134.56	$ 209,296.12
24	2046	$ 8,567,232.70	$ 1,698,346.08	$ 4,214,510.79	$ 413,064.00	$ 81,434.17	$ 203,200.12
25	2047	$ 8,733,362.45	$ 1,618,864.02	$ 4,171,102.54	$ 413,064.00	$ 76,106.70	$ 197,281.67
26	2048	$ 8,899,123.66	$ 1,542,415.59	$ 4,126,476.72	$ 413,064.00	$ 71,127.76	$ 191,535.60
27	2049	$ 9,064,902.94	$ 1,469,109.46	$ 4,080,920.10	$ 413,064.00	$ 66,474.54	$ 185,956.89
28	2050	$ 9,230,700.29	$ 1,398,861.00	$ 4,034,524.51	$ 413,064.00	$ 62,125.74	$ 180,540.67
29	2051	$ 9,396,515.70	$ 1,331,583.19	$ 3,987,377.26	$ 413,064.00	$ 58,061.44	$ 175,282.21
30	2052	$ 9,560,145.18	$ 1,266,279.27	$ 3,938,653.23	$ 413,064.00	$ 54,263.03	$ 170,176.90
31	2053	$ 9,725,951.56	$ 1,204,683.83	$ 3,890,255.60	$ 413,064.00	$ 50,713.11	$ 165,220.29
32	2054	$ 9,891,776.00	$ 1,145,790.32	$ 3,841,342.96	$ 413,064.00	$ 47,395.43	$ 160,408.05
33	2055	$ 10,057,618.52	$ 1,089,508.18	$ 3,791,986.16	$ 413,064.00	$ 44,294.79	$ 155,735.97
34	2056	$ 10,223,479.10	$ 1,035,747.11	$ 3,742,252.38	$ 413,064.00	$ 41,397.00	$ 151,199.97
35	2057	$ 10,389,357.74	$ 984,417.46	$ 3,692,205.26	$ 413,064.00	$ 38,688.79	$ 146,796.09
36	2058	$ 10,555,254.45	$ 935,430.51	$ 3,641,905.04	$ 413,064.00	$ 36,157.75	$ 142,520.47
Total		**$ 290,062,672.59**	**$ 95,203,704.86**	**$ 167,910,698.48**	**$ 112,823,369.38**	**$ 76,109,662.78**	**$ 93,936,029.13**

Project Benefit-Cost Analysis (BCA) Summary

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

This tab provides a summary of project costs and benefits by year.

Table ES-2.1 shows all project benefits by year.

Table ES-2.2 shows all project costs by year.

All estimates of project benefits and costs are derived from calculations presented in tabs 1 thru 12. All methodological assumptions and data sources are provided on the relevant sheets.

Table ES-2.1 Project Benefits by Year

Year #	Year	Safety Benefits	Emissions Benefits, NOT Including CO_2	Emissions Benefits, CO_2 Only	Travel Time Savings Benefits	Foregone Cost Savings	Repurpose ROW	Transit Facility Benefits	Pedestrian Facility Benefits	Cycling Facility Benefits	Mortality Reduction Benefits	TOTAL BENEFITS	TOTAL BENEFITS at 7% Discount Rate (CO_2 Discounted at 3% per NOFO)	TOTAL BENEFITS at 3% Discount Rate
1	2023											$ -	$ -	$ -
2	2024											$ -	$ -	$ -
3	2025					$ 25,927,991.00						$ 25,927,991.00	$ 21,164,964.01	$ 23,727,784.71
4	2026											$ -	$ -	$ -
5	2027											$ -	$ -	$ -
6	2028	$ -	$ -	$ -	$ -	$ 16,542,651.00		$ -	$ -	$ -	$ -	$ 16,542,651.00	$ 11,023,066.86	$ 13,854,209.78
7	2029	$ 5,292,586.71	$ 3,713.75	$ 14,448.07	$ (850,960.44)	$ 1,248,819.17	$ 3,000,000.00	$ -	$ 43,070.00	$ -	$ -	$ 8,751,677.26	$ 5,452,854.82	$ 7,115,914.49
8	2030	$ 5,292,586.71	$ 4,086.80	$ 15,250.20	$ (686,661.17)	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 5,917,151.70	$ 3,446,999.06	$ 4,671,054.20
9	2031	$ 5,292,586.71	$ 4,451.35	$ 16,321.50	$ (522,361.91)	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 6,082,886.82	$ 3,312,318.65	$ 4,662,026.24
10	2032	$ 5,292,586.71	$ 4,749.83	$ 17,168.80	$ (358,062.65)	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 6,248,331.86	$ 3,180,382.53	$ 4,649,345.72
11	2033	$ 5,292,586.71	$ 5,048.32	$ 18,034.17	$ (193,763.39)	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 6,413,794.97	$ 3,051,608.15	$ 4,633,461.95
12	2034	$ 5,292,586.71	$ 5,346.80	$ 18,917.60	$ (29,464.12)	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 6,579,276.15	$ 2,926,146.08	$ 4,614,571.92
13	2035	$ 5,292,586.71	$ 5,645.28	$ 19,819.10	$ 134,835.14	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 6,744,775.40	$ 2,804,113.62	$ 4,592,863.85
14	2036	$ 5,292,586.71	$ 5,943.77	$ 20,738.67	$ 299,134.40	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 6,910,292.71	$ 2,685,598.54	$ 4,568,517.56
15	2037	$ 5,292,586.71	$ 6,242.25	$ 21,981.60	$ 463,433.66	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 7,076,133.39	$ 2,570,858.39	$ 4,541,900.76
16	2038	$ 5,292,586.71	$ 6,540.73	$ 22,946.33	$ 627,732.93	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 7,241,695.87	$ 2,459,539.62	$ 4,512,785.45
17	2039	$ 5,292,586.71	$ 6,839.22	$ 23,929.13	$ 792,032.19	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 7,407,276.42	$ 2,351,856.18	$ 4,481,524.05
18	2040	$ 5,292,586.71	$ 7,137.70	$ 24,930.00	$ 956,331.45	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 7,572,875.03	$ 2,247,808.32	$ 4,448,265.96
19	2041	$ 5,292,586.71	$ 7,436.18	$ 25,948.93	$ 1,120,630.71	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 7,738,491.71	$ 2,147,380.66	$ 4,413,153.69
20	2042	$ 5,292,586.71	$ 7,734.67	$ 27,336.40	$ 1,284,929.98	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 7,904,476.92	$ 2,050,738.30	$ 4,376,517.22
21	2043	$ 5,292,586.71	$ 8,033.15	$ 28,400.50	$ 1,449,229.24	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 8,070,138.77	$ 1,957,451.70	$ 4,338,097.25
22	2044	$ 5,292,586.71	$ 8,331.63	$ 29,482.67	$ 1,613,528.50	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 8,235,818.68	$ 1,867,664.86	$ 4,298,212.01
23	2045	$ 5,292,586.71	$ 8,630.12	$ 30,582.90	$ 1,777,827.76	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 8,401,516.66	$ 1,781,318.49	$ 4,256,979.16
24	2046	$ 5,292,586.71	$ 8,928.60	$ 31,701.20	$ 1,942,127.03	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 8,567,232.70	$ 1,698,346.08	$ 4,214,510.79
25	2047	$ 5,292,586.71	$ 9,227.08	$ 33,233.20	$ 2,106,426.29	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 8,733,362.45	$ 1,618,864.02	$ 4,171,102.54
26	2048	$ 5,292,586.71	$ 9,525.57	$ 34,396.67	$ 2,270,725.55	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 8,899,123.66	$ 1,542,415.59	$ 4,126,476.72
27	2049	$ 5,292,586.71	$ 9,824.05	$ 35,578.20	$ 2,435,024.81	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 9,064,902.94	$ 1,469,109.46	$ 4,080,920.10
28	2050	$ 5,292,586.71	$ 10,122.53	$ 36,777.80	$ 2,599,324.08	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 9,230,700.29	$ 1,398,861.00	$ 4,034,524.51
29	2051	$ 5,292,586.71	$ 10,421.02	$ 37,995.47	$ 2,763,623.34	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 9,396,515.70	$ 1,331,583.19	$ 3,987,377.26
30	2052	$ 5,292,586.71	$ 10,719.50	$ 37,027.20	$ 2,927,922.60	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 9,560,145.18	$ 1,266,279.27	$ 3,938,653.23
31	2053	$ 5,292,586.71	$ 11,017.98	$ 38,235.83	$ 3,092,221.86	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 9,725,951.56	$ 1,204,683.83	$ 3,890,255.60
32	2054	$ 5,292,586.71	$ 11,316.47	$ 39,462.53	$ 3,256,521.13	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 9,891,776.00	$ 1,145,790.32	$ 3,841,342.96
33	2055	$ 5,292,586.71	$ 11,614.95	$ 40,707.30	$ 3,420,820.39	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 10,057,618.52	$ 1,089,508.18	$ 3,791,986.16
34	2056	$ 5,292,586.71	$ 11,913.43	$ 41,970.13	$ 3,585,119.65	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 10,223,479.10	$ 1,035,747.11	$ 3,742,252.38
35	2057	$ 5,292,586.71	$ 12,211.92	$ 43,251.03	$ 3,749,418.91	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 10,389,357.74	$ 984,417.46	$ 3,692,205.26
36	2058	$ 5,292,586.71	$ 12,510.40	$ 44,550.00	$ 3,913,718.18	$ 1,248,819.17		$ -	$ 43,070.00	$ -	$ -	$ 10,555,254.45	$ 935,430.51	$ 3,641,905.04
Present Value Benefits		**$ 158,777,601.30**	**$ 245,265.05**	**$ 871,123.13**	**$ 45,941,366.11**	**$ 79,935,217.00**	**$ 3,000,000.00**	**$ -**	**$ 1,292,100.00**	**$ -**	**$ -**	**$ 290,062,672.59**	**$ 95,203,704.86**	**$ 167,910,698.48**

Project Benefit-Cost Analysis (BCA) Summary

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Table ES-2.2 Project Costs by Year

Year #	Year	Work Zone Closure Costs	Bridge Rehab Work Zone	Future Eligible Project Costs	Lifecycle Management Costs	TOTAL COSTS	TOTAL COSTS at 7% Discount Rate	TOTAL COSTS at 3% Discount Rate
1	2023	$ -	$ -	$ 610,000.00		$ 610,000.00	$ 570,093.46	$ 592,233.01
2	2024	$ -	$ -	$ 2,415,000.00		$ 2,415,000.00	$ 2,109,354.53	$ 2,276,369.12
3	2025	$ -	$ -	$ 2,875,000.00		$ 2,875,000.00	$ 2,346,856.40	$ 2,631,032.27
4	2026	$ -	$ -	$ 30,900,000.00		$ 30,900,000.00	$ 23,573,462.05	$ 27,454,249.78
5	2027		$ 422,256.69	$ 37,100,000.00		$ 37,522,256.69	$ 26,752,850.44	$ 32,367,028.23
6	2028		$ 422,256.69	$ 24,400,000.00	$ -	$ 24,822,256.69	$ 16,540,117.72	$ 20,788,249.19
7	2029			$ 1,700,000.00	$ -	$ 1,700,000.00	$ 1,058,674.56	$ 1,382,255.57
8	2030			$ -	$ 413,064.00	$ 413,064.00	$ 240,407.01	$ 326,076.54
9	2031			$ -	$ 413,064.00	$ 413,064.00	$ 224,679.45	$ 316,579.16
10	2032			$ -	$ 413,064.00	$ 413,064.00	$ 209,980.79	$ 307,358.41
11	2033			$ -	$ 413,064.00	$ 413,064.00	$ 196,243.73	$ 298,406.22
12	2034			$ -	$ 413,064.00	$ 413,064.00	$ 183,405.36	$ 289,714.78
13	2035			$ -	$ 413,064.00	$ 413,064.00	$ 171,406.87	$ 281,276.48
14	2036			$ -	$ 413,064.00	$ 413,064.00	$ 160,193.34	$ 273,083.97
15	2037			$ -	$ 413,064.00	$ 413,064.00	$ 149,713.40	$ 265,130.06
16	2038			$ -	$ 413,064.00	$ 413,064.00	$ 139,919.07	$ 257,407.83
17	2039			$ -	$ 413,064.00	$ 413,064.00	$ 130,765.48	$ 249,910.51
18	2040			$ -	$ 413,064.00	$ 413,064.00	$ 122,210.73	$ 242,631.57
19	2041			$ -	$ 413,064.00	$ 413,064.00	$ 114,215.64	$ 235,564.63
20	2042			$ -	$ 413,064.00	$ 413,064.00	$ 106,743.59	$ 228,703.52
21	2043			$ -	$ 413,064.00	$ 413,064.00	$ 99,760.36	$ 222,042.25
22	2044			$ -	$ 413,064.00	$ 413,064.00	$ 93,233.98	$ 215,575.00
23	2045			$ -	$ 413,064.00	$ 413,064.00	$ 87,134.56	$ 209,296.12
24	2046			$ -	$ 413,064.00	$ 413,064.00	$ 81,434.17	$ 203,200.12
25	2047			$ -	$ 413,064.00	$ 413,064.00	$ 76,106.70	$ 197,281.67
26	2048			$ -	$ 413,064.00	$ 413,064.00	$ 71,127.76	$ 191,535.60
27	2049			$ -	$ 413,064.00	$ 413,064.00	$ 66,474.54	$ 185,956.89
28	2050			$ -	$ 413,064.00	$ 413,064.00	$ 62,125.74	$ 180,540.67
29	2051			$ -	$ 413,064.00	$ 413,064.00	$ 58,061.44	$ 175,282.21
30	2052			$ -	$ 413,064.00	$ 413,064.00	$ 54,263.03	$ 170,176.90
31	2053			$ -	$ 413,064.00	$ 413,064.00	$ 50,713.11	$ 165,220.29
32	2054			$ -	$ 413,064.00	$ 413,064.00	$ 47,395.43	$ 160,408.05
33	2055			$ -	$ 413,064.00	$ 413,064.00	$ 44,294.79	$ 155,735.97
34	2056			$ -	$ 413,064.00	$ 413,064.00	$ 41,397.00	$ 151,199.97
35	2057			$ -	$ 413,064.00	$ 413,064.00	$ 38,688.79	$ 146,796.09
36	2058			$ -	$ 413,064.00	$ 413,064.00	$ 36,157.75	$ 142,520.47
Present Value Costs		**$ -**	**$ 844,513.38**	**$ 100,000,000.00**	**$ 11,978,856.00**	**$ 112,823,369.38**	**$ 76,109,662.78**	**$ 93,936,029.13**

1. Safety Benefits Summary

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

This review considers the safety impacts associated with roadway improvement proposed in conjunction with the Right-Sizing Route 37 project.
Safety Issue 1 – Route 37 Rumble strips - Rumble strips are proposed along Route 37 on the inside and outside shoulders to prevent lane departure crashes.
Safety Issue 2 - High-Friction Surface Treatment– Seventeen ramps along Route 37 spread over 3 interchanges will have high-friction surface treatment (HFST) implemented. The HFST will improve friction and reduce the likelihood of roadway departure crashes along the ramps.
Safety Issue 3 – Route 37 at Post Road Interchange Improvements – The Route 37 at Post Road interchange will be reconstructed as an at-grade intersection. The trumpet interchange will be replaced with at-grade intersections connecting Route 37 and Post Road. These improvements will result in the "right-sizing" of the intersection, including removal of one structure and two ramps. Safety improvements include advanced warning systems to alert vehicles that the freeway is terminating, the use of adaptive signal controls, and retroreflective signal backplates to increase visibility of the traffic signals. Although not quantified below for a safety benefit, Wrong Way Detection Systems will be installed at this interchange to mitigate wrong-way maneuvers onto Route 37 from Post Road.

The is analysis used the Highway Safety Manual method for selecting crash countermeasures by applying estimating crash reductions to historic crashes. Crash data was collected from the RIDOT Crash Database for the study area between January 1, 2015 and December 31, 2021. The analysis assumes that crashes experienced over the 7-year period are consistent throughout the 30-year planning horizon. This analysis used the Highway Safety Manual method for selecting crash countermeasures and applying available crash reductions to historic crashes. Additionally predictive modeling approach was used to estimate the impacts of Safety Issue 3, which is explained in the Appendix to this RAISE grant submission.

From the U.S. Department of Transportation's "Benefit-Cost Analysis Guidance for Discretionary Grant Programs," (January 2023) the monetized values for injuries by severity were obtained to determine a monetary benefit.

After considering both safety challenges and opportunities, the net benefit is a crash savings of approximately 38 crashes per year with a total estimated annual safety benefit attributable to this project is expected to average **$5,292,587 per year.**

The assumptions, methodology, a description of the baseline scenario, source of data, and key input parameters are documented in Tab 1B.

A full review of the Safety analysis is attached to this BCA narrative with detailed methodology, assumptions, inputs, and outcomes.

Table 1-1. Safety Issue 1: Rumble Strips (w/ recessed pavement markers)
Countermeasure(s): CMF 3518 (FI) and 3410 (All), PDO Calculated as Difference between FI and All

Crash Severity	No-Build Predicted Crashes	Crash Reduction Factor	Predicted Annual Crash Reduction	Value of Injuries	Annual Savings
O - No Injury	58.751	(0.109)	(6.40)	$ 4,000.00	$ (25,615.44)
C - Possible Injury	30.987	0.200	6.197	$ 78,500.00	$ 486,495.90
B - Non-Incapacitating	3.877	0.200	0.775	$ 153,700.00	$ 119,178.98
A - Incapacitating	1.422	0.200	0.284	$ 564,300.00	$ 160,486.92
K - Killed	0.256	0.200	0.051	$ 11,800,000.00	$ 604,160.00
U - Injured (Severity Unknown)	-		-	$ 213,900.00	$ -
# Accidents Reported (Unknown if Injured)	-		-	$ 162,600.00	$ -
Injury Crash	-		-	$ 307,800.00	$ -
Fatal Crash	-		-	$ 13,046,800.00	$ -
Total	**95.29**	**0.01**	**0.90**		**$ 1,344,706.36**

Table 1-2. Safety Issue 2: High Friction Surface Treatment & Enhanced Curve Delineation w/Barrier or Guardrail (17 Ramps)
Countermeasure(s): CMF 10319 (FI) and 10318 (All), PDO Calculated as Difference between FI and All

Crash Severity	No-Build Predicted Crashes	Crash Reduction Factor	Predicted Annual Crash Reduction	Value of Injuries	Annual Savings
O - No Injury	50.57	0.45	22.76	$ 4,000.00	$ 91,020.60
C - Possible Injury	27.26	0.51	13.90	$ 78,500.00	$ 1,091,474.21
B - Non-Incapacitating	3.41	0.51	1.74	$ 153,700.00	$ 267,064.51
A - Incapacitating	1.26	0.51	0.64	$ 564,300.00	$ 362,043.59
K - Killed	0.23	0.51	0.11	$ 11,800,000.00	$ 1,354,050.00
U - Injured (Severity Unknown)	-		-	$ 213,900.00	$ -
# Accidents Reported (Unknown if Injured)	-		-	$ 162,600.00	$ -
Injury Crash	-		-	$ 307,800.00	$ -
Fatal Crash	-		-	$ 13,046,800.00	$ -
Total	**82.72**	**0.47**	**39.15**		**$ 3,165,652.91**

Table 1-3. Safety Issue 3: Freeway Termination at Full-Access Arterial; Remove Horizontal Curve Ramps
Countermeasure(s): Surrogate CMF calculated using differences in predicted crashes for the build and no build.

Crash Severity	No-Build Predicted Crashes	Crash Reduction Factor	Predicted Annual Crash Reduction	Value of Injuries	Annual Savings
O - No Injury	100.30	(0.06)	(6.02)	$ 4,000.00	$ (24,072.00)
C - Possible Injury	21.45	0.17	3.65	$ 78,500.00	$ 286,308.97
B - Non-Incapacitating	2.68	0.17	0.46	$ 153,700.00	$ 70,072.75
A - Incapacitating	0.99	0.17	0.17	$ 564,300.00	$ 94,655.12
K - Killed	0.18	0.17	0.03	$ 11,800,000.00	$ 355,262.60
U - Injured (Severity Unknown)	-		-	$ 213,900.00	$ -
# Accidents Reported (Unknown if Injured)	-		-	$ 162,600.00	$ -
Injury Crash	-		-	$ 307,800.00	$ -
Fatal Crash	-		-	$ 13,046,800.00	$ -
Total	**125.60**	**-0.01**	**-1.72**		**$ 782,227.44**

Table 1-6. Safety Benefits Summary

Total Crashs	Number of Crashes per Year	Crash Reduction Factor	Predicted Annual Crash Reduction	Annual Savings	30-Year Total
-	303.61	0.13	38.34	$ 5,292,586.71	158,777,601.30

1B. Safety Benefits Backup, All Years

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Assumptions	The analysis assumes that reviewed recent historic crashes are consistent throughout the 30 year planning horizon.
Methodology	The is analysis used the Highway Safety Manual method for selecting crash countermeasures by applying estimating crash reductions to historic crashes. For Safety Issue 3 ISATe predictive modeling which implements the Highway Safety Manual was used to predict impacts related to extensive changes in the roadway network.
Baseline	The Existing Conditions model represents crashes between 2015 and 2021.
Sources of Data	RIDOT Crash Data 2015-2021; FHWA CMF Clearinghouse
Key Input Parameters	The model required crash frequency and severity derived from the RIDOT crash reports as well as Crash Modification Factors (form the FHWA Crash Modification Factor Clearinghouse) determined to be most appropriate to existing conditions.

Table 1B-1. Safety Benefits by Year

Year	Traffic Count	Estimated Total Crashes, No Build Scenario (Crashes/Yr)	Estimated Total Crashes, Preferred Action Scenario	Predicted Crash Reduction, Preferred Action Scenario (Crashes/Yr)	Realized Safety Benefit ($/Year)
2023	59,238.93	303.61	265.27	38.34	$ -
2024	59,392.20	303.61	265.27	38.34	$ -
2025	59,545.47	303.61	265.27	38.34	$ -
2026	59,698.73	303.61	265.27	38.34	$ -
2027	59,852.00	303.61	265.27	38.34	$ -
2028	59,852.00	303.61	265.27	38.34	$ -
2029	60,158.53	303.61	265.27	38.34	$ 5,292,586.71
2030	60,311.80	303.61	265.27	38.34	$ 5,292,586.71
2031	60,465.07	303.61	265.27	38.34	$ 5,292,586.71
2032	60,618.33	303.61	265.27	38.34	$ 5,292,586.71
2033	60,771.60	303.61	265.27	38.34	$ 5,292,586.71
2034	60,924.87	303.61	265.27	38.34	$ 5,292,586.71
2035	61,078.13	303.61	265.27	38.34	$ 5,292,586.71
2036	61,231.40	303.61	265.27	38.34	$ 5,292,586.71
2037	61,384.67	303.61	265.27	38.34	$ 5,292,586.71
2038	61,537.93	303.61	265.27	38.34	$ 5,292,586.71
2039	61,691.20	303.61	265.27	38.34	$ 5,292,586.71
2040	61,844.47	303.61	265.27	38.34	$ 5,292,586.71
2041	61,997.73	303.61	265.27	38.34	$ 5,292,586.71
2042	62,151.00	303.61	265.27	38.34	$ 5,292,586.71
2043	62,304.27	303.61	265.27	38.34	$ 5,292,586.71
2044	62,457.53	303.61	265.27	38.34	$ 5,292,586.71
2045	62,610.80	303.61	265.27	38.34	$ 5,292,586.71
2046	62,764.07	303.61	265.27	38.34	$ 5,292,586.71
2047	62,917.33	303.61	265.27	38.34	$ 5,292,586.71
2048	63,070.60	303.61	265.27	38.34	$ 5,292,586.71
2049	63,223.87	303.61	265.27	38.34	$ 5,292,586.71
2050	63,377.13	303.61	265.27	38.34	$ 5,292,586.71
2051	63,530.40	303.61	265.27	38.34	$ 5,292,586.71
2052	63,683.67	303.61	265.27	38.34	$ 5,292,586.71
2053	63,836.93	303.61	265.27	38.34	$ 5,292,586.71
2054	63,990.20	303.61	265.27	38.34	$ 5,292,586.71
2055	64,143.47	303.61	265.27	38.34	$ 5,292,586.71
2056	64,296.73	303.61	265.27	38.34	$ 5,292,586.71
2057	64,450.00	303.61	265.27	38.34	$ 5,292,586.71
2058	64,603.27	303.61	265.27	38.34	$ 5,292,586.71
	2,229,006	**10,930**	**9,549.80**	**$ 1,380.27**	**$ 158,777,601.30**

2. Emissions Benefits Summary

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

This project will benefit local air quality by improving transportation operations and reducing vehicle delay in the corridor. Improvements in air quality will benefit the area by reducing local pollutant concentrations and regional emissions reductions.
An air quality study of the Project was conducted using traffic data developed with VISSIM to calculate Travel Time Savings. Emission factors for the study area were developed using the Motor Vehicle Emission Simulator model (MOVES3) developed by the US Environmental Protection Agency (EPA). Emissions were analyzed for the first year of operations (2028) and design year (2053) for Baseline and Proposed Action alternatives.
The Preferred Alternative will result in emission costs savings for all years of analysis. Reduced congestion across the network reduces the emissions sufficiently to counteract the expected increase in VMT resulting in an emissions benefit. This project will reduce emissions by a projected **361** tons per year, a net savings of **$1,116,388** over 30 years.

The assumptions, methodology, a description of the baseline scenario, source of data, and key input parameters are documented in Tab 2B.

A full review of the Emissions analysis is attached to this BCA narrative with detailed methodology, assumptions, inputs, and outcomes.

Table 2-1. Projected Emissions Reduction by Year, Selected Years (Metric Tons/Year)

Year	NO_X	SOx	$PM_{2.5}$	CO_2	PM_{10}	VOC	Total
2028	0.18	0.00	-	224.00	(0.11)	0.12	224.19
2029	0.18	0.00	0.00	233.03	(0.06)	0.18	233.34
2030	0.18	0.00	0.00	242.07	(0.01)	0.25	242.49
2031	0.18	0.00	0.00	251.10	0.04	0.31	251.63
2032	0.18	0.00	0.00	260.13	0.09	0.37	260.78
							-
2058	0.16	0.01	0.01	495.00	1.42	2.01	498.61
Average	**0.17**	**0.01**	**0.00**	**359.50**	**0.66**	**1.07**	**361.40**

Table 2-2. Projected Monetary Benefit from Emissions Reductions by Year, Selected Years

Year	NO_X	SOx	$PM_{2.5}$	CO_2	PM_{10}	VOC	Total
2028	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2029	$ 3,263.87	$ 156.75	$ 293.13	$ 14,448.07	$ -	$ -	$ 18,161.82
2030	$ 3,323.20	$ 168.00	$ 595.60	$ 15,250.20	$ -	$ -	$ 19,337.00
2031	$ 3,364.20	$ 179.55	$ 907.60	$ 16,321.50	$ -	$ -	$ 20,772.85
2032	$ 3,351.60	$ 188.10	$ 1,210.13	$ 17,168.80	$ -	$ -	$ 21,918.63
2058	$ 3,024.00	$ 410.40	$ 9,076.00	$ 44,550.00	$ -	$ -	$ 57,060.40
Average	**$ 3,200.73**	**$ 286.13**	**$ 4,688.64**	**$ 29,037.44**	**$ -**	**$ -**	**$ 37,212.94**

Table 2-3. Emissions Benefits Summary

Year	NOX	SOx	PM2.5	CO2	PM10	VOC	30-Year Total
2028 to 2058	$ 96,021.87	$ 8,584.05	$ 140,659.13	$ 871,123.13	$ -	$ -	$ 1,116,388.18

2B. Emissions Benefits Backup, All Years

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Assumptions	The analysis relies on assumption made b the traffic analysis which assumes that traffic patterns remain consistent through this study area, however, traffic volumes will continue to grow at a rate of approximately 0.25% annually over the 30-year planning horizon for this analysis.
Methodology	An air quality study of the Project was conducted using traffic data developed in the transportation analysis. Emission factors for the study area were developed using the Motor Vehicle Emission Simulator model (MOVES3) developed by the US Environmental Protection Agency. Emissions were analyzed for the first five years of operation (2028-2032) and the design year (2058). Analyses were conducted for the No Build and Build alternatives to determine the emissions reduction associated with the Project. The emission factors represent the corresponding year of the traffic modeling. The factors were derived by calculating a seasonal average during the evening peak hour with a representative vehicle mix. Oxides of Nitrogen (NOX), Sulfur Dioxide (SO2), Particulate Matter (PM2.5) and Carbon Dioxide (CO2) were studied based on the latest grant application guidance. Volatile Organic Compounds (VOC) and Particulate Matter 10 (PM10) emissions savings were included for informational purposes, but cost savings were not quantified per the latest grant application guidance. Emissions reductions are scaled linearly by year between the opening and design years.
Baseline	The baseline model represents a 2028 No Build Mesoscale Air Quality Analysis
Sources of Data	Output from VISSIM microsimulation model
Key Input Parameters	Average speed; Vehicle Miles Traveled; Vehicle Hours Traveled

Table 2B-1. Mesoscale Air Quality Analysis - Air Pollutants by Year, No-Build Scenario

Year	NOX	SOx	PM2.5	CO2	PM10	VOC	Total
2023							-
2024							-
2025							-
2026							-
2027							-
2028	4.15	0.10	0.28	6,939.00	1.27	2.90	**6,947.70**
2029	4.09	0.10	0.28	6,922.83	1.28	2.88	**6,931.45**
2030	4.02	0.10	0.28	6,906.67	1.28	2.85	**6,915.21**
2031	3.96	0.10	0.28	6,890.50	1.29	2.83	**6,898.96**
2032	3.90	0.10	0.27	6,874.33	1.30	2.80	**6,882.71**
2033	3.84	0.10	0.27	6,858.17	1.31	2.78	**6,866.46**
2034	3.77	0.10	0.27	6,842.00	1.31	2.76	**6,850.22**
2035	3.71	0.10	0.27	6,825.83	1.32	2.73	**6,833.97**
2036	3.65	0.10	0.27	6,809.67	1.33	2.71	**6,817.72**
2037	3.59	0.10	0.27	6,793.50	1.34	2.68	**6,801.47**
2038	3.52	0.10	0.27	6,777.33	1.34	2.66	**6,785.23**
2039	3.46	0.10	0.27	6,761.17	1.35	2.64	**6,768.98**
2040	3.40	0.10	0.26	6,745.00	1.36	2.61	**6,752.73**
2041	3.34	0.10	0.26	6,728.83	1.37	2.59	**6,736.48**
2042	3.27	0.10	0.26	6,712.67	1.37	2.56	**6,720.24**
2043	3.21	0.10	0.26	6,696.50	1.38	2.54	**6,703.99**
2044	3.15	0.10	0.26	6,680.33	1.39	2.52	**6,687.74**
2045	3.08	0.10	0.26	6,664.17	1.39	2.49	**6,671.49**
2046	3.02	0.10	0.26	6,648.00	1.40	2.47	**6,655.24**
2047	2.96	0.10	0.25	6,631.83	1.41	2.44	**6,639.00**
2048	2.90	0.10	0.25	6,615.67	1.42	2.42	**6,622.75**
2049	2.83	0.10	0.25	6,599.50	1.42	2.40	**6,606.50**
2050	2.77	0.10	0.25	6,583.33	1.43	2.37	**6,590.25**
2051	2.71	0.10	0.25	6,567.17	1.44	2.35	**6,574.01**
2052	2.65	0.10	0.25	6,551.00	1.45	2.32	**6,557.76**
2053	2.58	0.10	0.25	6,534.83	1.45	2.30	**6,541.51**
2054	2.52	0.09	0.25	6,518.67	1.46	2.28	**6,525.26**
2055	2.46	0.09	0.24	6,502.50	1.47	2.25	**6,509.02**
2056	2.40	0.09	0.24	6,486.33	1.48	2.23	**6,492.77**
2057	2.33	0.09	0.24	6,470.17	1.48	2.20	**6,476.52**
2058	2.27	0.09	0.24	6,454.00	1.49	2.18	**6,460.27**
Total	**99.51**	**3.02**	**8.06**	**207,591.50**	**42.78**	**78.74**	**207,823.61**

2B. Emissions Benefits Backup, All Years

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Table 2B-2. Mesoscale Air Quality Analysis - Air Pollutants by Year, Preferred Action Scenario

Year	NOX	SOx	PM2.5	CO2	PM10	VOC	Total
2023							-
2024							-
2025							-
2026							-
2027							-
2028	3.97	0.10	0.28	6,715.00	1.38	2.78	6,723.51
2029	3.91	0.10	0.28	6,689.80	1.34	2.69	6,698.11
2030	3.85	0.10	0.28	6,664.60	1.29	2.61	6,672.72
2031	3.78	0.10	0.28	6,639.40	1.25	2.52	6,647.32
2032	3.72	0.10	0.27	6,614.20	1.21	2.43	6,621.93
2033	3.66	0.10	0.27	6,589.00	1.16	2.35	6,596.53
2034	3.60	0.10	0.27	6,563.80	1.12	2.26	6,571.14
2035	3.54	0.10	0.27	6,538.60	1.07	2.17	6,545.74
2036	3.47	0.09	0.27	6,513.40	1.03	2.08	6,520.35
2037	3.41	0.09	0.27	6,488.20	0.99	2.00	6,494.96
2038	3.35	0.09	0.26	6,463.00	0.94	1.91	6,469.56
2039	3.29	0.09	0.26	6,437.80	0.90	1.82	6,444.17
2040	3.23	0.09	0.26	6,412.60	0.86	1.74	6,418.77
2041	3.16	0.09	0.26	6,387.40	0.81	1.65	6,393.38
2042	3.10	0.09	0.26	6,362.20	0.77	1.56	6,367.98
2043	3.04	0.09	0.26	6,337.00	0.73	1.48	6,342.59
2044	2.98	0.09	0.25	6,311.80	0.68	1.39	6,317.19
2045	2.92	0.09	0.25	6,286.60	0.64	1.30	6,291.80
2046	2.85	0.09	0.25	6,261.40	0.59	1.21	6,266.40
2047	2.79	0.09	0.25	6,236.20	0.55	1.13	6,241.01
2048	2.73	0.09	0.25	6,211.00	0.51	1.04	6,215.61
2049	2.67	0.09	0.25	6,185.80	0.46	0.95	6,190.22
2050	2.61	0.09	0.24	6,160.60	0.42	0.87	6,164.82
2051	2.54	0.09	0.24	6,135.40	0.38	0.78	6,139.43
2052	2.48	0.09	0.24	6,110.20	0.33	0.69	6,114.03
2053	2.42	0.09	0.24	6,085.00	0.29	0.60	6,088.64
2054	2.36	0.09	0.24	6,059.80	0.24	0.52	6,063.24
2055	2.30	0.09	0.24	6,034.60	0.20	0.43	6,037.85
2056	2.23	0.09	0.23	6,009.40	0.16	0.34	6,012.46
2057	2.17	0.09	0.23	5,984.20	0.11	0.26	5,987.06
2058	2.11	0.09	0.23	5,959.00	0.07	0.17	5,961.67
Total	**94.24**	**2.85**	**7.91**	**196,447.00**	**22.48**	**45.73**	**196,620.20**

Table 2B-3. Mesoscale Air Quality Analysis - Estimated Reduction in Air Pollutants by Year, Preferred Action Scenario

Year	NOX	SOx	PM2.5	CO2	PM10	VOC	Total
2023	-	-	-	-	-	-	-
2024	-	-	-	-	-	-	-
2025	-	-	-	-	-	-	-
2026	-	-	-	-	-	-	-
2027	-	-	-	-	-	-	-
2028	0.18	0.00	-	224.00	(0.11)	0.12	224.19
2029	0.18	0.00	0.00	233.03	(0.06)	0.18	233.34
2030	0.18	0.00	0.00	242.07	(0.01)	0.25	242.49
2031	0.18	0.00	0.00	251.10	0.04	0.31	251.63
2032	0.18	0.00	0.00	260.13	0.09	0.37	260.78
2033	0.18	0.00	0.00	269.17	0.15	0.44	269.93
2034	0.18	0.00	0.00	278.20	0.20	0.50	279.08
2035	0.18	0.00	0.00	287.23	0.25	0.56	288.22
2036	0.17	0.00	0.00	296.27	0.30	0.62	297.37
2037	0.17	0.00	0.00	305.30	0.35	0.69	306.52
2038	0.17	0.00	0.00	314.33	0.40	0.75	315.66
2039	0.17	0.00	0.00	323.37	0.45	0.81	324.81
2040	0.17	0.00	0.00	332.40	0.50	0.88	333.96
2041	0.17	0.01	0.00	341.43	0.55	0.94	343.11
2042	0.17	0.01	0.00	350.47	0.60	1.00	352.25
2043	0.17	0.01	0.00	359.50	0.66	1.07	361.40
2044	0.17	0.01	0.01	368.53	0.71	1.13	370.55
2045	0.17	0.01	0.01	377.57	0.76	1.19	379.69
2046	0.17	0.01	0.01	386.60	0.81	1.25	388.84
2047	0.17	0.01	0.01	395.63	0.86	1.32	397.99
2048	0.17	0.01	0.01	404.67	0.91	1.38	407.14
2049	0.17	0.01	0.01	413.70	0.96	1.44	416.28
2050	0.17	0.01	0.01	422.73	1.01	1.51	425.43
2051	0.16	0.01	0.01	431.77	1.06	1.57	434.58
2052	0.16	0.01	0.01	440.80	1.11	1.63	443.72
2053	0.16	0.01	0.01	449.83	1.17	1.70	452.87
2054	0.16	0.01	0.01	458.87	1.22	1.76	462.02
2055	0.16	0.01	0.01	467.90	1.27	1.82	471.17
2056	0.16	0.01	0.01	476.93	1.32	1.88	480.31
2057	0.16	0.01	0.01	485.97	1.37	1.95	489.46
2058	0.16	0.01	0.01	495.00	1.42	2.01	498.61
Total	**5.27**	**0.17**	**0.15**	**11,144.50**	**20.31**	**33.02**	**11,203.42**

2B. Emissions Benefits Backup, All Years

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Table 2B-4. Mesoscale Air Quality Analysis - Estimated Reduction in Air Pollutants by Year, Preferred Action Scenario

Year	NOX	SOx	PM2.5	CO2	PM10	VOC	Total
2023	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2024	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2025	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2026	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2027	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2028	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2029	$ 3,263.87	$ 156.75	$ 293.13	$ 14,448.07	$ -	$ -	$ 18,161.82
2030	$ 3,323.20	$ 168.00	$ 595.60	$ 15,250.20	$ -	$ -	$ 19,337.00
2031	$ 3,364.20	$ 179.55	$ 907.60	$ 16,321.50	$ -	$ -	$ 20,772.85
2032	$ 3,351.60	$ 188.10	$ 1,210.13	$ 17,168.80	$ -	$ -	$ 21,918.63
2033	$ 3,339.00	$ 196.65	$ 1,512.67	$ 18,034.17	$ -	$ -	$ 23,082.48
2034	$ 3,326.40	$ 205.20	$ 1,815.20	$ 18,917.60	$ -	$ -	$ 24,264.40
2035	$ 3,313.80	$ 213.75	$ 2,117.73	$ 19,819.10	$ -	$ -	$ 25,464.38
2036	$ 3,301.20	$ 222.30	$ 2,420.27	$ 20,738.67	$ -	$ -	$ 26,682.43
2037	$ 3,288.60	$ 230.85	$ 2,722.80	$ 21,981.60	$ -	$ -	$ 28,223.85
2038	$ 3,276.00	$ 239.40	$ 3,025.33	$ 22,946.33	$ -	$ -	$ 29,487.07
2039	$ 3,263.40	$ 247.95	$ 3,327.87	$ 23,929.13	$ -	$ -	$ 30,768.35
2040	$ 3,250.80	$ 256.50	$ 3,630.40	$ 24,930.00	$ -	$ -	$ 32,067.70
2041	$ 3,238.20	$ 265.05	$ 3,932.93	$ 25,948.93	$ -	$ -	$ 33,385.12
2042	$ 3,225.60	$ 273.60	$ 4,235.47	$ 27,336.40	$ -	$ -	$ 35,071.07
2043	$ 3,213.00	$ 282.15	$ 4,538.00	$ 28,400.50	$ -	$ -	$ 36,433.65
2044	$ 3,200.40	$ 290.70	$ 4,840.53	$ 29,482.67	$ -	$ -	$ 37,814.30
2045	$ 3,187.80	$ 299.25	$ 5,143.07	$ 30,582.90	$ -	$ -	$ 39,213.02
2046	$ 3,175.20	$ 307.80	$ 5,445.60	$ 31,701.20	$ -	$ -	$ 40,629.80
2047	$ 3,162.60	$ 316.35	$ 5,748.13	$ 33,233.20	$ -	$ -	$ 42,460.28
2048	$ 3,150.00	$ 324.90	$ 6,050.67	$ 34,396.67	$ -	$ -	$ 43,922.23
2049	$ 3,137.40	$ 333.45	$ 6,353.20	$ 35,578.20	$ -	$ -	$ 45,402.25
2050	$ 3,124.80	$ 342.00	$ 6,655.73	$ 36,777.80	$ -	$ -	$ 46,900.33
2051	$ 3,112.20	$ 350.55	$ 6,958.27	$ 37,995.47	$ -	$ -	$ 48,416.48
2052	$ 3,099.60	$ 359.10	$ 7,260.80	$ 37,027.20	$ -	$ -	$ 47,746.70
2053	$ 3,087.00	$ 367.65	$ 7,563.33	$ 38,235.83	$ -	$ -	$ 49,253.82
2054	$ 3,074.40	$ 376.20	$ 7,865.87	$ 39,462.53	$ -	$ -	$ 50,779.00
2055	$ 3,061.80	$ 384.75	$ 8,168.40	$ 40,707.30	$ -	$ -	$ 52,322.25
2056	$ 3,049.20	$ 393.30	$ 8,470.93	$ 41,970.13	$ -	$ -	$ 53,883.57
2057	$ 3,036.60	$ 401.85	$ 8,773.47	$ 43,251.03	$ -	$ -	$ 55,462.95
2058	$ 3,024.00	$ 410.40	$ 9,076.00	$ 44,550.00	$ -	$ -	$ 57,060.40
Total	**$ 96,021.87**	**$ 8,584.05**	**$ 140,659.13**	**$ 871,123.13**	**$ -**	**$ -**	**$ 1,116,388.18**

3. Travel Time Savings Summary

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**
Date: **February 28, 2023**

This project will reduce travel times by 121 hours daily by improving traffic management on Route 37 at Post Road. Signal enhancements will improve traffic movements through the area, reducing delay times, congestion, and greenhouse gas emissions.

This project will generate an estimated $1.5 million in travel time savings benefits annually and, over 30 years, travel time savings total $45.9 million.

Assumptions, methodology, a description of the baseline scenario, source of data, and key input parameters are documented in Tabs 3B, 3C, and 3D.

A full review of the travel time analysis is attached to this BCA narrative with detailed methodology, assumptions, inputs, and outcomes.

Table 3-1. Travel Time Savings Benefits Summary, Opening Year (2028)

Scenario	Total Traffic in Network (Veh/Day)	Vehicle Miles Traveled (VMT/Day)	Vehicle Hours Traveled (VHT/Day)	Average Speed (MPH)	Average Delay (Hrs/Veh/Day)	Travel Time Savings Benefit ($/Day)	Annual Benefit ($/Year)
2028 No-Build	59,252.00	47,168.63	1,667.48	30.18	0.01	$ -	-
2028 Preferred Action	59,852.00	41,856.87	1,646.51	25.89	0.01	$ (4,364.55)	(1,593,060.79)

Table 3-2. Travel Time Savings Benefits Summary, Design Year (2058)

Scenario	Total Traffic in Network (Veh/Day)	Vehicle Miles Traveled (VMT/Day)	Vehicle Hours Traveled (VHT/Day)	Average Speed (MPH)	Average Delay (Hrs/Veh/Day)	Travel Time Savings Benefit ($/Day)	Annual Benefit ($/Year)
2058 No-Build	63,396.00	49,848.67	2,393.58	26.01	0.01	$ -	-
2058 Preferred Action	64,450.00	45,072.71	1,806.09	25.49	0.01	$ 13,861.61	5,059,488.46

Table 3-3. Travel Time Savings Change Rates, 2028-2058

Scenario	Total Traffic in Network (Veh/Day)	Vehicle Miles Traveled (VMT/Day)	Vehicle Hours Traveled (VHT/Day)	Average Speed (MPH)	Average Delay (Hrs/Veh/Day)	Travel Time Savings Benefit ($/Day)	Annual Benefit ($/Year)
Annual Change No-Build	138.13	89.33	24.20	(0.14)	0.00	$ -	-
Annual Change Preferred Action	153.27	107.19	5.32	(0.01)	0.00	$ 729.05	266,101.97

Table 3.4 Travel Time Savings Summary

Scenario	Total Traffic in Network (Avg. Veh/Day)	Vehicle Miles Traveled (Avg. VMT/Day)	Vehicle Hours Traveled (Avg. VHT/Day)	Average Speed (MPH)	Total Delay (Avg. Hours/Day)	Travel Time Savings Benefit (Avg. $/Year)	30-Year Total
No-Build, 2028-2058	61,112.96	48,372.17	1,993.55	28.31	719.01	0 $	-
Preferred Action, 2028-2058	61,916.84	43,301.02	1,718.17	25.71	597.27	$ 1,531,378.87	$ 45,941,366.11
Total	**803.88**	**(5,071.15)**	**(275.38)**	**(2.60)**	**(121.73)**	**$ 1,531,378.87**	**$ 45,941,366.11**

3B. Travel Time Savings Backup, 2028 (Opening Year)

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Assumptions	The analysis assumes that traffic patterns remain consistent through this study area, however, traffic volumes will continue to grow at a rate of approximately 0.25% annually over the 30-year planning horizon for this analysis. Upcoming potential area development remains speculative, however, is anticipated to be covered within the steady, modest growth rate. Growth in delay times and volumes are assumed to be linear between the opening year and design year. While the Route 37 corridor is busy year-round and throughout the week supporting commuter, commercial, and freight travel, benefits for reductions in delays were applied only for weekdays (270 days per year). Given the nature of this corridor that was a conservative assumption to limit accrued benefits.
Methodology	VISSIM microscopic traffic modelling software was used to project travel times through the study area for five different scenarios (2023 Existing, 2028 No-Build, 2028 Preferred Action - Opening Year, 2058 No-Build, and 2058 Preferred Action). Each scenarios was run for a 15-hour period from 6:00am-8:00pm for 10 iterations (random seeds) each. Model outputs included vehicles in the network, vehicle miles traveled, vehicle hours traveled, average speed, and average delay. In this tab (3B), 2028 travel time impacts are profiled for existing, no-action, and preferred action scenarios. In Tab 3C, no-action and preferred action scenarios are profiled for the design year (2058). In Tab 3D, those inputs were then extended to annual impacts. 2028 impacts are calculated as a baeline benefits year, but benefits are not captured in that year as the project is expected to complete in late 2028.
Baseline	The Existing Condtion model represents a 2023 condition.
Sources of Data	Historic and 2022 turning movement counts and traffic volume data adjusted to represent a 2023 Existing Condition.
Key Input Parameters	The model outputs were monetized using the value of travel time savings and assumed vehicle occupancy rates provided by the Benefit Cost Analysis Guidance for Discretionary Grant Programs (January 2023).

Table 3B-1. Project Limit Network MOEs Summary - Existing 2022 Conditions

Time	Total Vehicles in Network	VMT: Total Path Distance (mi)	VHT: Total Time in Network (hr)	Average Speed (mph)	Total Delay (hr)	Average Delay (hr/veh)
6:00 AM	1,257	989	28	35	2	0.002
7:00 AM	4,697	3,799	128	30	29	0.006
8:00 AM	3,004	2,372	71	34	9	0.003
9:00 AM	4,491	3,623	117	31	22	0.005
10:00 AM	3,362	2,737	82	33	11	0.003
11:00 AM	3,350	2,720	82	33	11	0.003
12:00 PM	3,481	2,849	87	33	12	0.003
1:00 PM	3,693	2,926	92	32	15	0.004
2:00 PM	4,079	3,177	101	31	17	0.004
3:00 PM	4,724	3,736	124	30	25	0.005
4:00 PM	5,229	4,167	151	28	40	0.008
5:00 PM	5,361	4,224	186	23	74	0.014
6:00 PM	5,123	4,041	187	23	79	0.015
7:00 PM	3,834	3,036	101	30	20	0.005
8:00 PM	2,745	2,178	67	33	9	0.003
Total	**58,430.00**	**46,576.15**	**1,602.44**	**30.63**	**374.70**	**0.006**

Table 3B-2. Delays by Vehicle Type, Existing 2022 Conditions

Time	Car Traffic Share	Truck Traffic Share	Car Traffic	Car Delay (hrs)	Truck Traffic	Truck Delay (hrs)
6:00 AM	97%	3%	1,213	2.32	44	0.08
7:00 AM	96%	4%	4,531	27.96	166	1.03
8:00 AM	97%	3%	2,920	8.83	84	0.25
9:00 AM	95%	5%	4,274	21.40	217	1.09
10:00 AM	98%	2%	3,301	10.72	61	0.20
11:00 AM	98%	2%	3,280	10.31	70	0.22
12:00 PM	96%	4%	3,356	11.56	125	0.43
1:00 PM	97%	3%	3,579	14.35	114	0.46
2:00 PM	98%	2%	4,004	16.98	75	0.32
3:00 PM	98%	2%	4,620	24.35	104	0.55
4:00 PM	100%	0%	5,224	39.92	5	0.04
5:00 PM	99%	1%	5,313	73.04	48	0.66
6:00 PM	99%	1%	5,084	78.40	39	0.60
7:00 PM	99%	1%	3,780	19.56	54	0.28
8:00 PM	100%	0%	2,745	8.78	0	-
Total	**98%**	**2%**	**57,223.31**	**368.50**	**1,206.69**	**6.20**

3B. Travel Time Savings Backup, 2028 (Opening Year)

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Table 3B-3. Project Limits Network MOEs Summary, Projected 2028 No-Action Conditions

Time	Total Vehicles in Network	VMT: Total Path Distance (mi)	VHT: Total Time in Network (hr)	Average Speed (mph)	Total Delay (hr)	Average Delay (hr/veh)
6:00 AM	1,272	1,001	28	35	3	0.002
7:00 AM	4,751	3,847	130	30	30	0.006
8:00 AM	3,052	2,402	72	33	10	0.003
9:00 AM	4,556	3,672	119	31	23	0.005
10:00 AM	3,406	2,773	84	33	11	0.003
11:00 AM	3,393	2,756	83	33	11	0.003
12:00 PM	3,523	2,885	88	33	12	0.003
1:00 PM	3,740	2,962	94	32	15	0.004
2:00 PM	4,139	3,218	103	31	18	0.004
3:00 PM	4,786	3,784	126	30	26	0.005
4:00 PM	5,301	4,222	155	27	43	0.008
5:00 PM	5,437	4,262	199	22	86	0.016
6:00 PM	5,207	4,093	215	20	106	0.020
7:00 PM	3,902	3,085	105	30	23	0.006
8:00 PM	2,787	2,207	68	33	9	0.003
Total	**59,252.00**	**47,168.63**	**1,667.48**	**30.18**	**424.18**	**0.006**

Table 3B-4. Delays by Vehicle Type, Projected 2028 No-Action Conditions

Time	Car Traffic Share	Truck Traffic Share	Car Traffic	Car Delay (hrs)	Truck Traffic	Truck Delay (hrs)
6:00 AM	97%	3%	**1,228**	**2.42**	**44**	**0.09**
7:00 AM	96%	4%	**4,583**	**28.68**	**168**	**1.05**
8:00 AM	97%	3%	**2,967**	**9.35**	**85**	**0.27**
9:00 AM	95%	5%	**4,336**	**22.16**	**220**	**1.13**
10:00 AM	98%	2%	**3,344**	**10.83**	**62**	**0.20**
11:00 AM	98%	2%	**3,322**	**10.46**	**71**	**0.22**
12:00 PM	96%	4%	**3,396**	**11.86**	**127**	**0.44**
1:00 PM	97%	3%	**3,625**	**14.58**	**115**	**0.46**
2:00 PM	98%	2%	**4,062**	**17.65**	**77**	**0.33**
3:00 PM	98%	2%	**4,681**	**25.07**	**105**	**0.56**
4:00 PM	100%	0%	**5,296**	**42.83**	**5**	**0.04**
5:00 PM	99%	1%	**5,388**	**84.85**	**49**	**0.77**
6:00 PM	99%	1%	**5,168**	**104.82**	**39**	**0.80**
7:00 PM	99%	1%	**3,847**	**22.79**	**55**	**0.33**
8:00 PM	100%	0%	**2,787**	**9.12**	**0**	**-**
Total			**58,028.91**	**417.48**	**1,223.09**	**6.70**

Table 3B-5. Project Limits Network MOEs Summary - Projected 2028 (Opening Year) Proposed Action Conditions

Time	Total Vehicles Traveling Within the Network	VMT: Total Path Distance (mi)	VHT: Total Time Within the Network (hr)	Average Speed (mph)	Total Delay: All Vehicles (hr)	Average Delay: Per Vehicle (hr/veh)
6:00 AM	1,281	908	31	29	8	0.006
7:00 AM	3,004	2,108	77	27	23	0.008
8:00 AM	4,853	3,429	134	26	46	0.009
9:00 AM	4,661	3,284	126	26	41	0.009
10:00 AM	3,458	2,445	89	27	26	0.008
11:00 AM	3,453	2,439	88	28	25	0.007
12:00 PM	3,573	2,529	93	27	27	0.008
1:00 PM	3,778	2,644	103	26	34	0.009
2:00 PM	4,186	2,888	115	25	40	0.010
3:00 PM	4,850	3,370	139	24	51	0.011
4:00 PM	5,365	3,750	157	24	60	0.011
5:00 PM	5,497	3,827	161	24	62	0.011
6:00 PM	5,167	3,581	150	24	57	0.011
7:00 PM	3,899	2,704	108	25	37	0.010
8:00 PM	2,827	1,951	75	26	24	0.009
Total	**59,852.00**	**41,856.87**	**1,646.51**	**25.89**	**563.06**	**0.009**

3B. Travel Time Savings Backup, 2028 (Opening Year)

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Table 3B-6. Project Limits Network MOEs Summary - Projected 2028 (Opening Year) Proposed Action Delays

Time	Car Traffic Share	Truck Traffic Share	Car Traffic	Car Delay (hrs)	Truck Traffic	Truck Delay (hrs)
6:00 AM	97%	3%	1,237	7.62	44	0.27
7:00 AM	96%	4%	2,898	21.85	106	0.80
8:00 AM	97%	3%	4,717	44.72	136	1.29
9:00 AM	95%	5%	4,436	39.47	225	2.01
10:00 AM	98%	2%	3,395	25.64	63	0.47
11:00 AM	98%	2%	3,381	24.67	72	0.53
12:00 PM	96%	4%	3,444	26.41	129	0.99
1:00 PM	97%	3%	3,662	33.35	116	1.06
2:00 PM	98%	2%	4,109	39.60	77	0.75
3:00 PM	98%	2%	4,743	50.04	107	1.13
4:00 PM	100%	0%	5,360	59.65	5	0.06
5:00 PM	99%	1%	5,448	61.52	49	0.56
6:00 PM	99%	1%	5,128	56.67	39	0.43
7:00 PM	99%	1%	3,844	36.77	55	0.53
8:00 PM	100%	0%	2,827	24.22	0	-
Total			58,627.25	552.20	1,224.75	10.86

Table 3B-7. Travel Time Savings Benefits Summary - Projected 2028 Conditions

Time	Car Delay Savings (hrs)	Truck Delay Savings (hrs)	Car Savings Benefits (Daily)	Truck Savings Benefits (Daily)	Total Benefits, Low (270 Days)	Total Benefits, High (365 Days)
6:00 AM	(5.19)	(0.19)	$ (163.00)	$ (6.03)	$ (45,638.37)	$ (61,696.32)
7:00 AM	6.82	0.25	$ 214.23	$ 8.11	$ 60,030.83	$ 81,152.79
8:00 AM	(35.38)	(1.02)	$ (1,110.64)	$ (33.00)	$ (308,780.57)	$ (417,425.58)
9:00 AM	(17.31)	(0.88)	$ (543.40)	$ (28.49)	$ (154,410.27)	$ (208,739.81)
10:00 AM	(14.81)	(0.27)	$ (465.06)	$ (8.85)	$ (127,955.01)	$ (172,976.22)
11:00 AM	(14.21)	(0.30)	$ (445.99)	$ (9.83)	$ (123,071.64)	$ (166,374.63)
12:00 PM	(14.55)	(0.54)	$ (456.78)	$ (17.61)	$ (128,086.94)	$ (173,154.56)
1:00 PM	(18.76)	(0.60)	$ (589.07)	$ (19.30)	$ (164,258.72)	$ (222,053.45)
2:00 PM	(21.95)	(0.41)	$ (689.18)	$ (13.40)	$ (189,698.51)	$ (256,444.28)
3:00 PM	(24.97)	(0.56)	$ (783.96)	$ (18.21)	$ (216,586.21)	$ (292,792.46)
4:00 PM	(16.81)	(0.02)	$ (527.92)	$ (0.51)	$ (142,677.04)	$ (192,878.22)
5:00 PM	23.33	0.21	$ 732.60	$ 6.87	$ 199,656.94	$ 269,906.60
6:00 PM	48.15	0.37	$ 1,511.74	$ 11.91	$ 411,384.02	$ 556,130.25
7:00 PM	(13.99)	(0.20)	$ (439.14)	$ (6.52)	$ (120,329.41)	$ (162,667.53)
8:00 PM	(15.10)	-	$ (474.10)	$ -	$ (128,007.64)	$ (173,047.36)
Total			$ (4,229.67)	$ (134.88)	$ (1,178,428.53)	$ (1,593,060.79)

3C. Travel Time Savings Backup, 2058 (Last Year of Analysis)

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Table 3C-1. Project Limit Network MOEs Summary - Projected 2058 No-Action Conditions

Time	Total Vehicles in Network	VMT: Total Path Distance (mi)	VHT: Total Time in Network (hr)	Average Speed (mph)	Total Delay (hr)	Average Delay (hr/veh)
6:00 AM	1,371	1,079	31	35	3	0.002
7:00 AM	5,112	4,103	160	26	53	0.010
8:00 AM	3,329	2,629	82	32	14	0.004
9:00 AM	4,889	3,939	134	29	32	0.007
10:00 AM	3,673	2,989	93	32	14	0.004
11:00 AM	3,656	2,967	91	33	14	0.004
12:00 PM	3,785	3,102	97	32	16	0.004
1:00 PM	4,030	3,197	102	31	17	0.004
2:00 PM	4,449	3,455	113	31	22	0.005
3:00 PM	5,104	3,981	171	25	66	0.013
4:00 PM	5,476	4,199	256	18	144	0.026
5:00 PM	5,517	4,154	329	13	218	0.040
6:00 PM	5,328	4,019	339	12	232	0.044
7:00 PM	4,543	3,590	271	14	175	0.039
8:00 PM	3,134	2,446	125	27	60	0.019
Total	**63,396.00**	**49,848.67**	**2,393.58**	**26.01**	**1,080.70**	**0.015**

Table 3C-2. Delays by Vehicle Type, Projected 2058 No-Action Conditions

Time	Car Traffic Share	Truck Traffic Share	Car Traffic	Car Delay (hrs)	Truck Traffic	Truck Delay (hrs)
6:00 AM	97%	3%	**1,323.54**	**2.62**	**47.46**	**0.09**
7:00 AM	96%	4%	**4,931.11**	**51.13**	**180.89**	**1.88**
8:00 AM	97%	3%	**3,235.85**	**13.51**	**93.15**	**0.39**
9:00 AM	95%	5%	**4,652.61**	**30.42**	**236.39**	**1.55**
10:00 AM	98%	2%	**3,606.49**	**14.22**	**66.51**	**0.26**
11:00 AM	98%	2%	**3,579.54**	**13.50**	**76.46**	**0.29**
12:00 PM	96%	4%	**3,648.66**	**15.48**	**136.34**	**0.58**
1:00 PM	97%	3%	**3,906.00**	**16.78**	**124.00**	**0.53**
2:00 PM	98%	2%	**4,366.71**	**21.15**	**82.29**	**0.40**
3:00 PM	98%	2%	**4,991.65**	**64.06**	**112.35**	**1.44**
4:00 PM	100%	0%	**5,470.83**	**144.03**	**5.17**	**0.14**
5:00 PM	99%	1%	**5,467.35**	**216.53**	**49.65**	**1.97**
6:00 PM	99%	1%	**5,287.64**	**230.57**	**40.36**	**1.76**
7:00 PM	99%	1%	**4,478.56**	**172.83**	**64.44**	**2.49**
8:00 PM	100%	0%	**3,134.00**	**60.11**	-	-
Total			**62,080.54**	**1,066.95**	**1,315.46**	**13.76**

Table 3C-3. Project Limits Network MOEs Summary - Projected 2058 Proposed Action Conditions

Time	Total Vehicles Traveling Within the Network	VMT: Total Path Distance (mi)	VHT: Total Time Within the Network (hr)	Average Speed (mph)	Total Delay: All Vehicles (hr)	Average Delay: Per Vehicle (hr/veh)
6:00 AM	1,381	977	34	29	9	0.006
7:00 AM	3,238	2,280	84	27	25	0.008
8:00 AM	5,214	3,688	147	25	52	0.010
9:00 AM	5,028	3,534	139	25	48	0.010
10:00 AM	3,720	2,632	97	27	29	0.008
11:00 AM	3,702	2,623	96	27	29	0.008
12:00 PM	3,845	2,724	100	27	30	0.008
1:00 PM	4,070	2,851	113	25	39	0.009
2:00 PM	4,509	3,108	125	25	44	0.010
3:00 PM	5,214	3,619	153	24	59	0.011
4:00 PM	5,789	4,040	175	23	70	0.012
5:00 PM	5,919	4,118	180	23	73	0.012
6:00 PM	5,555	3,858	165	23	65	0.012
7:00 PM	4,216	2,917	118	25	42	0.010
8:00 PM	3,050	2,105	81	26	27	0.009
Total	**64,450.00**	**45,072.71**	**1,806.09**	**25.49**	**639.24**	**0.009**

3C. Travel Time Savings Backup, 2058 (Last Year of Analysis)

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Table 3C-4. Project Limits Network MOEs Summary - Projected 2058 Delays, Proposed Action

Time	Car Traffic Share	Truck Traffic Share	Car Traffic	Car Delay (hrs)	Truck Traffic	Truck Delay (hrs)
6:00 AM	97%	3%	1,333.20	8.33	47.80	0.30
7:00 AM	96%	4%	3,123.42	24.32	114.58	0.89
8:00 AM	97%	3%	5,068.10	50.33	145.90	1.45
9:00 AM	95%	5%	4,784.89	45.93	243.11	2.33
10:00 AM	98%	2%	3,652.64	28.61	67.36	0.53
11:00 AM	98%	2%	3,624.58	28.01	77.42	0.60
12:00 PM	96%	4%	3,706.50	28.94	138.50	1.08
1:00 PM	97%	3%	3,944.77	37.44	125.23	1.19
2:00 PM	98%	2%	4,425.60	43.29	83.40	0.82
3:00 PM	98%	2%	5,099.23	57.83	114.77	1.30
4:00 PM	100%	0%	5,783.54	69.55	5.46	0.07
5:00 PM	99%	1%	5,865.73	71.87	53.27	0.65
6:00 PM	99%	1%	5,512.92	64.59	42.08	0.49
7:00 PM	99%	1%	4,156.20	41.28	59.80	0.59
8:00 PM	100%	0%	3,050.00	26.62	-	-
Total			63,131.30	626.95	1,318.70	12.29

Table 4C-7. Travel Time Savings Benefits Summary - Projected 2058 Conditions

Time	Car Delay Savings (hrs)	Truck Delay Savings (hrs)	Car Savings Benefits (Daily)	Truck Savings Benefits (Daily)	Total Benefits, Low (270 Days)	Total Benefits, High (365 Days)
6:00 AM	(5.70)	(0.20)	$ (179.04)	$ (6.62)	$ (50,128.34)	$ (67,766.08)
7:00 AM	26.81	0.98	$ 841.67	$ 31.86	$ 235,855.02	$ 318,841.05
8:00 AM	(36.81)	(1.06)	$ (1,155.81)	$ (34.34)	$ (321,340.42)	$ (434,404.64)
9:00 AM	(15.52)	(0.79)	$ (487.16)	$ (25.54)	$ (138,429.37)	$ (187,136.01)
10:00 AM	(14.39)	(0.27)	$ (451.90)	$ (8.60)	$ (124,336.05)	$ (168,083.92)
11:00 AM	(14.51)	(0.31)	$ (455.60)	$ (10.04)	$ (125,722.36)	$ (169,958.00)
12:00 PM	(13.46)	(0.50)	$ (422.57)	$ (16.30)	$ (118,494.86)	$ (160,187.50)
1:00 PM	(20.67)	(0.66)	$ (648.80)	$ (21.26)	$ (180,915.14)	$ (244,570.47)
2:00 PM	(22.14)	(0.42)	$ (695.16)	$ (13.52)	$ (191,344.73)	$ (258,669.73)
3:00 PM	6.23	0.14	$ 195.60	$ 4.54	$ 54,038.35	$ 73,051.84
4:00 PM	74.48	0.07	$ 2,338.46	$ 2.28	$ 631,999.59	$ 854,369.81
5:00 PM	144.66	1.31	$ 4,541.73	$ 42.57	$ 1,237,760.19	$ 1,673,268.41
6:00 PM	165.98	1.27	$ 5,211.16	$ 41.05	$ 1,418,098.31	$ 1,917,058.82
7:00 PM	131.55	1.89	$ 4,130.29	$ 61.33	$ 1,131,736.34	$ 1,529,939.86
8:00 PM	33.49	-	$ 1,051.33	$ -	$ 283,858.78	$ 383,735.02
Total	440.00	1.46	$ 13,814.20	$ 47.41	$ 3,742,635.30	$ 5,059,488.46

3D. Travel Time Savings Backup 3, All Years

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Table 3D-1. Daily Project Limits Network MOEs Summary, No-Action Scenario by Year

Year	Total Traffic in Network (Veh/Day)	Vehicle Miles Traveled (VMT/Day)	Vehicle Hours Traveled (VHT/Day)	Average Speed (MPH)	Total Delay (hrs/day)	Average Delay (Hrs/Veh/Day)
2023	58,699	46,811.29	1,570.67	30.74	336.64	0.0048
2024	58,838	46,900.63	1,594.87	30.60	358.53	0.0052
2025	58,976	46,989.96	1,619.07	30.46	380.41	0.0055
2026	59,114	47,079.30	1,643.28	30.32	402.30	0.0059
2027	59,252	47,168.63	1,667.48	30.18	424.18	0.0062
2028	59,252	47,168.63	1,667.48	30.18	424.18	0.0062
2029	59,528	47,347.30	1,715.89	29.90	467.95	0.0069
2030	59,666	47,436.63	1,740.09	29.76	489.83	0.0073
2031	59,805	47,525.97	1,764.29	29.62	511.72	0.0076
2032	59,943	47,615.30	1,788.50	29.49	533.60	0.0080
2033	60,081	47,704.64	1,812.70	29.35	555.48	0.0083
2034	60,219	47,793.97	1,836.90	29.21	577.37	0.0087
2035	60,357	47,883.31	1,861.11	29.07	599.25	0.0090
2036	60,495	47,972.64	1,885.31	28.93	621.14	0.0094
2037	60,633	48,061.98	1,909.51	28.79	643.02	0.0097
2038	60,771	48,151.31	1,933.72	28.65	664.91	0.0101
2039	60,910	48,240.65	1,957.92	28.51	686.79	0.0104
2040	61,048	48,329.98	1,982.12	28.37	708.67	0.0108
2041	61,186	48,419.32	2,006.32	28.23	730.56	0.0111
2042	61,324	48,508.65	2,030.53	28.09	752.44	0.0115
2043	61,462	48,597.98	2,054.73	27.95	774.33	0.0118
2044	61,600	48,687.32	2,078.93	27.82	796.21	0.0122
2045	61,738	48,776.65	2,103.14	27.68	818.09	0.0125
2046	61,877	48,865.99	2,127.34	27.54	839.98	0.0129
2047	62,015	48,955.32	2,151.54	27.40	861.86	0.0132
2048	62,153	49,044.66	2,175.75	27.26	883.75	0.0136
2049	62,291	49,133.99	2,199.95	27.12	905.63	0.0139
2050	62,429	49,223.33	2,224.15	26.98	927.51	0.0143
2051	62,567	49,312.66	2,248.36	26.84	949.40	0.0146
2052	62,705	49,402.00	2,272.56	26.70	971.28	0.0150
2053	62,843	49,491.33	2,296.76	26.56	993.17	0.0153
2054	62,982	49,580.67	2,320.97	26.42	1,015.05	0.0157
2055	63,120	49,670.00	2,345.17	26.28	1,036.93	0.0160
2056	63,258	49,759.34	2,369.37	26.15	1,058.82	0.0163
2057	63,396	49,848.67	2,393.58	26.01	1,080.70	0.0167
2058	63,534	49,938.00	2,417.78	25.87	1,102.59	0.0170
Average	**61,113**	**48,372.17**	**1,993.55**	**28.31**	**719.01**	**0.0109**

Table 3D-2. Daily Project Limits Network MOEs Summary, Preferred Action Scenario by Year

Year	Total Traffic in Network (Veh/Day)	Vehicle Miles Traveled (VMT/Day)	Vehicle Hours Traveled (VHT/Day)	Average Speed (MPH)	Total Delay (hrs/day)	Average Delay (Hrs/Veh/Day)
2023	59,239	41,428.09	1,625.23	25.94	552.91	0.0090
2024	59,392	41,535.29	1,630.55	25.93	555.45	0.0090
2025	59,545	41,642.48	1,635.87	25.91	557.99	0.0090
2026	59,699	41,749.68	1,641.19	25.90	560.52	0.0090
2027	59,852	41,856.87	1,646.51	25.89	563.06	0.0090
2028	59,852	41,856.87	1,646.51	25.89	563.06	0.0090
2029	60,159	42,071.26	1,657.14	25.86	568.14	0.0091
2030	60,312	42,178.45	1,662.46	25.85	570.68	0.0091
2031	60,465	42,285.65	1,667.78	25.83	573.22	0.0091
2032	60,618	42,392.84	1,673.10	25.82	575.76	0.0091
2033	60,772	42,500.04	1,678.42	25.81	578.30	0.0091
2034	60,925	42,607.23	1,683.74	25.79	580.84	0.0092
2035	61,078	42,714.43	1,689.06	25.78	583.38	0.0092
2036	61,231	42,821.62	1,694.38	25.77	585.92	0.0092
2037	61,385	42,928.82	1,699.70	25.75	588.46	0.0092
2038	61,538	43,036.01	1,705.02	25.74	590.99	0.0092
2039	61,691	43,143.21	1,710.34	25.73	593.53	0.0092
2040	61,844	43,250.40	1,715.66	25.71	596.07	0.0093
2041	61,998	43,357.60	1,720.98	25.70	598.61	0.0093
2042	62,151	43,464.79	1,726.30	25.69	601.15	0.0093
2043	62,304	43,571.98	1,731.62	25.67	603.69	0.0093
2044	62,458	43,679.18	1,736.94	25.66	606.23	0.0093
2045	62,611	43,786.37	1,742.26	25.65	608.77	0.0094
2046	62,764	43,893.57	1,747.58	25.63	611.31	0.0094
2047	62,917	44,000.76	1,752.90	25.62	613.85	0.0094
2048	63,071	44,107.96	1,758.22	25.61	616.39	0.0094
2049	63,224	44,215.15	1,763.54	25.59	618.93	0.0094
2050	63,377	44,322.35	1,768.86	25.58	621.47	0.0094
2051	63,530	44,429.54	1,774.18	25.57	624.00	0.0095
2052	63,684	44,536.74	1,779.50	25.55	626.54	0.0095
2053	63,837	44,643.93	1,784.81	25.54	629.08	0.0095
2054	63,990	44,751.13	1,790.13	25.53	631.62	0.0095
2055	64,143	44,858.32	1,795.45	25.52	634.16	0.0095
2056	64,297	44,965.52	1,800.77	25.50	636.70	0.0096
2057	64,450	45,072.71	1,806.09	25.49	639.24	0.0096
2058	64,603	45,179.90	1,811.41	25.48	641.78	0.0096
Average	**61,917**	**43,301.02**	**1,718.17**	**25.71**	**597.27**	**0.0093**

Table 3D-3. Tavel Time Savings Benefits Summary, Preferred Action Scenario, All Years

3D. Travel Time Savings Backup 3, All Years

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Year	Car Delay Savings (Hrs/Day)	Truck Delay Savings (Hrs/Day)	Car Savings Benefits ($/Day)	Truck Savings Benefits ($/Day)	Annual Benefits, Low (270 Days)	Annual Benefits, High (365 Days)
2023						
2024						
2025						
2026						
2027						
2028					$ -	$ -
2029	(94.18)	(6.01)	$ (2,956.93)	$ (194.78)	$ (850,960.44)	$ (1,150,372.44)
2030	(76.00)	(4.85)	$ (2,386.02)	$ (157.17)	$ (686,661.17)	$ (928,264.18)
2031	(57.81)	(3.69)	$ (1,815.11)	$ (119.56)	$ (522,361.91)	$ (706,155.92)
2032	(39.63)	(2.53)	$ (1,244.20)	$ (81.96)	$ (358,062.65)	$ (484,047.65)
2033	(21.45)	(1.37)	$ (673.29)	$ (44.35)	$ (193,763.39)	$ (261,939.39)
2034	(3.26)	(0.21)	$ (102.38)	$ (6.74)	$ (29,464.12)	$ (39,831.13)
2035	14.92	0.95	$ 468.53	$ 30.86	$ 134,835.14	$ 182,277.13
2036	33.11	2.11	$ 1,039.44	$ 68.47	$ 299,134.40	$ 404,385.39
2037	51.29	3.27	$ 1,610.35	$ 106.08	$ 463,433.66	$ 626,493.66
2038	69.48	4.43	$ 2,181.26	$ 143.68	$ 627,732.93	$ 848,601.92
2039	87.66	5.60	$ 2,752.16	$ 181.29	$ 792,032.19	$ 1,070,710.18
2040	105.84	6.76	$ 3,323.07	$ 218.89	$ 956,331.45	$ 1,292,818.44
2041	124.03	7.92	$ 3,893.98	$ 256.50	$ 1,120,630.71	$ 1,514,926.71
2042	142.21	9.08	$ 4,464.89	$ 294.11	$ 1,284,929.98	$ 1,737,034.97
2043	160.40	10.24	$ 5,035.80	$ 331.71	$ 1,449,229.24	$ 1,959,143.23
2044	178.58	11.40	$ 5,606.71	$ 369.32	$ 1,613,528.50	$ 2,181,251.49
2045	196.76	12.56	$ 6,177.62	$ 406.93	$ 1,777,827.76	$ 2,403,359.76
2046	214.95	13.72	$ 6,748.53	$ 444.53	$ 1,942,127.03	$ 2,625,468.02
2047	233.13	14.88	$ 7,319.44	$ 482.14	$ 2,106,426.29	$ 2,847,576.28
2048	251.32	16.04	$ 7,890.35	$ 519.75	$ 2,270,725.55	$ 3,069,684.54
2049	269.50	17.20	$ 8,461.26	$ 557.35	$ 2,435,024.81	$ 3,291,792.80
2050	287.69	18.36	$ 9,032.17	$ 594.96	$ 2,599,324.08	$ 3,513,901.07
2051	305.87	19.52	$ 9,603.08	$ 632.56	$ 2,763,623.34	$ 3,736,009.33
2052	324.05	20.68	$ 10,173.99	$ 670.17	$ 2,927,922.60	$ 3,958,117.59
2053	342.24	21.84	$ 10,744.90	$ 707.78	$ 3,092,221.86	$ 4,180,225.85
2054	360.42	23.01	$ 11,315.81	$ 745.38	$ 3,256,521.13	$ 4,402,334.12
2055	378.61	24.17	$ 11,886.72	$ 782.99	$ 3,420,820.39	$ 4,624,442.38
2056	396.79	25.33	$ 12,457.63	$ 820.60	$ 3,585,119.65	$ 4,846,550.64
2057	414.97	26.49	$ 13,028.53	$ 858.20	$ 3,749,418.91	$ 5,068,658.90
2058	433.16	27.65	$ 13,599.44	$ 895.81	$ 3,913,718.18	$ 5,290,767.17
Total			**$ 159,637.72**	**$ 10,515.49**	**$ 45,941,366.11**	**$ 62,105,920.86**

4. Foregone Cost Savings

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Without the requested RAISE grant funding support, RIDOT will not be able to execute the preferred alternative presented in this application on the more accelerated/preferred timeline, and therefore cannot guarantee that the key components of this project will be completed within the next 30 years. RIDOT will have to take a fiscally constrained approach to addressing maintenance incrementally. Therefore, in the no action alternative, RIDOT will be forced to plan for incremental maintenance and delayed bridge replacement/rehabilitations.

Table 1 below outlines the costs foregone by the project which are otherwise spread over the 30 year planning horizon. These are primarily maintenance costs, however, due to the already very poor condition of bridges 636 and 637 and the ongoing challenges of construction work over Amtrak the replacement of those bridges maybe be performed incrementally over several projects to avoid substantial weight restrictions or closures. Basic maintenance for bridges #616, 623, 624, and 818 are comparable and also documented as part of the Lifecycle Management Costs. For simplicity, these costs are averaged over 30 years in the calculations of the overall benefit-cost ratio for this project.

Table 2 breaks down the cost into individual rehabilitation projects that would be needed over the planning horizon.

Table 4-1. Foregone Cost Savings Summary - Annual Costs Anticipated Over 30 years

Expense	Annual Average	30-Year Total
Bridge 636 & 637 Full Replacement	$ 835,015.17	$ 25,050,455.00
Bridges 818, 616, 623, 624 Annual Maintenance	$ 155,876.67	$ 4,676,300.00
Bridge 625 Annual Maintenance	$ 101,625.33	$ 3,048,760.00
Bridge 638 Annual Maintenance	$ 156,302.00	$ 4,689,060.00
	$ -	$ -
	$ -	$ -
	$ -	$ -
Total	**$ 1,248,819.17**	**$ 37,464,575.00**

Table 4-2. Foregone Cost Savings Summary - One Time Replacement Costs for Bridges Eliminated

Expense	Year	Total
Bridge 625 Full Replacement	2028	$ 16,542,651.00
Bridge 638 Full Replacement	2025	$ 25,927,991.00
		$ -
Total		**$ 42,470,642.00**

4B. Foregone Cost Savings Backup

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**
Date: **February 28, 2023**

Assumptions	Without the requested RAISE grant funding support, RIDOT will not be able to execute the preferred alternative presented in this application on the more accelerated/preferred timeline, and therefore cannot guarantee that the key components of this project will be completed within the next 30 years. RIDOT will have to take a fiscally constrained approach to addressing maintenance incrementally. Therefore, in the no action alternative, RIDOT will be forced to plan for incremental maintenance and delayed bridge replacement/rehabilitations.
Methodology	Based on historic bridge data and best practices, the existing bridge deterioration is projected to future years. Similarly, based on historic information, future unit cost projections are applied to the projected deterioration.
Baseline	Cost estimation based on 2022 bridge inspection reports.
Sources of Data	2022 RIDOT Bridge Inspection Reports, RIDOT weighted average unit price database.
Key Input Parameters	RIDOT historic cost estimates

Bridge 638 - Post Road (2025 Full Replacement)

Cost Type	Square Feet/Each	Unit Cost/EA/SF	Iterations	Total Cost
Bridge Replacement	1.00	$ 13,716,800.00	1	$ 13,716,800.00
				$ -
Subtotal Foregone Cost Before EC&M				**$ 13,716,800.00**
Engineering, Contingencies, and Mobilizations (30%)				$ 4,115,040.00
Other Costs				$ 8,096,151.00
Subtotal Foregone Cost				**$ 25,927,991.00**

Bridge 638 - Post Road (30 Year Maintenance)

Cost Type	Square Feet/Each	Unit Cost/EA/SF	Iterations	Total Cost
Bridge Washing	1.00	$ 17,700.00	15	$ 265,500.00
Joint Replacement, RC Protective Coating, RC Patching	1.00	$ 137,600.00	1	$ 137,600.00
Joint Replacement, RC Protective Coating, RC Patching, Steel Repairs	1.00	$ 301,800.00	1	$ 301,800.00
Minor Rehab	1.00	$ 1,640,300.00	1	$ 1,640,300.00
Subtotal Foregone Cost Before EC&M				**$ 2,345,200.00**
Engineering, Contingencies, and Mobilizations (30%)				$ 703,560.00
Subtotal Foregone Cost				**$ 4,689,060.00**

Bridge 625 - Howard Road (2028 Full Replacement)

Cost Type	Square Feet/Each	Unit Cost/EA/SF	Iterations	Total Cost
Bridge Replacement per RIDOT Maintenance Plan	1.00	$ 1.00	1	$ 8,755,000.00
				$ -
Subtotal Foregone Cost Before EC&M				**$ 8,755,000.00**
Engineering, Contingencies, and Mobilizations (30%)				$ 2,626,500.00
Other Costs - RIDOT Green sheet				$ 5,161,151.00
Subtotal Foregone Cost				**$ 16,542,651.00**

Bridge 625 - Howard Road (30 Year Maintenance)

Cost Type	Square Feet/Each	Unit Cost/EA/SF	Iterations	Total Cost
Bridge Washing	1.00	$ 17,700.00	15	$ 265,500.00
Minor Rehab	1.00	$ 1,640,300.00	1	$ 1,640,300.00
Joint Replacement, RC Protective Coating, RC Patching	1.00	$ 137,600.00	1	$ 137,600.00
Replace Membrane & Overlay, Minor Deck Repairs	1.00	$ 301,800.00	1	$ 301,800.00
				$ -
Subtotal Foregone Cost Before EC&M				**$ 2,345,200.00**
Engineering, Contingencies, and Mobilizations (30%)				$ 703,560.00
Subtotal Foregone Cost				**$ 3,048,760.00**

Bridges 637 & 638 - Hillsgrove RR North & South (Full Replacement over 30 years)

Cost Type	Square Feet/Each	Unit Cost/EA/SF	Iterations	Total Cost
Bridge Replacement - 636	1.00	$ 6,510,000.00	1	$ 6,510,000.00
Bridge Replacement - 637	1.00	$ 6,769,000.00	1	$ 6,769,000.00
Subtotal Foregone Cost Before EC&M				**$ 13,279,000.00**
Engineering, Contingencies, and Mobilizations (30%)				$ 3,983,700.00
Other Costs - RIDOT Green Sheet				$ 7,787,755.00
Subtotal Foregone Cost				**$ 25,050,455.00**

5. Repurposing Right-Of-Way

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

With the reconfiguration of the Route 37/Post Road interchange, over 9 acres of land will be made available for development. Because an official land use assessment has not been performed at this time, this analysis is based on the fair market value on recent sold commercial properties along Post Road and Airport Road in Warwick, Rhode Island. Both Post Road and Airport Road have similar traffic volumes and adjacent land uses to that of the subject parcel. A comparison of nearby properties assessed land values (Table 5-1) suggests an average valuation of $1.7M per acre. To be conservative, the lower $1.0M per acre valuation was used. This assessment also reduced the available land from 9 acres to 3 acres to account for potential zoning and environmental regulations that may limit the amount of development on the subject parcel.

Table 5-1. Nearby Property Comparison

Property	Last Sale Date	Assessed Land Value	Acres	Land Value Per Acre
1176 Post Road Warwick, RI	2/28/2022	$ 1,050,000.00	1.01	$ 1,039,603.96
1795 Post Road Warwick, RI	1/9/2020	$ 950,000.00	0.38	$ 2,500,000.00
2313 Post Road Warwick, RI	12/3/2021	$ 1,883,000.00	0.63	$ 2,988,888.89
40 Airport Road, Warwick, RI	1/18/2022	$ 1,925,000.00	1.73	$ 1,112,716.76
63 Airport Road, Warwick, RI	1/9/2020	$ 655,000.00	0.62	$ 1,056,451.61
Total	**$221,410.00**			**$8,697,661.23**
			Average	**$1,739,532.25**
			Minimum	**$1,039,603.96**
			Maximum	**$2,988,888.89**
Post Road Interchange Land			3.00	$3,118,811.88
			Say	**$3,000,000.00**

6. Pedestrian Facility Improvement Benefits

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Minor sidewalk widening and signalized crossing installation are proposed as part of this project. Observationally, 10-15 pedestrians traverse Post Road and New London Avenue each during a typical evening peak period. If this is assumed to represent 10% of daily pedestrians (typical automobile K-factor in Rhode Island) then that equates to 100 pedestrians daily on each corridor.

Results of this estimation are summarized below in Table 6-1.

The assumptions, methodology, a description of the baseline scenario, source of data, and key input parameters are documented in Tab 2B.

Table 6-1. Pedestrian Facility Benefits Summary

Improvement	Annual Users Affected	Annual Benefit	30-Year Total	Notes
Sidewalk Improvements	73,000	$ 8,030.00	$ 240,900.00	
At-Grade Improvements for Existing Users	73,000	$ 35,040.00	$ 1,051,200.00	
At-Grade Improvements for Additional Users	-	$ -	$ -	
Total	**146,000**	**$ 43,070.00**	**$ 1,292,100.00**	

6B. Pedestrian Facility Improvement Benefits

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Assumptions	Minor sidewalk widening and signalized crossing installation are proposed as part of this project.
Methodology	Estimate pedestrian activity based on local knowledge, observations, and trends.
Baseline	Observationally, 10-15 pedestrians traverse Post Road and New London Avenue each during a typical evening peak period. If this is assumed to represent 10% of daily pedestrians (typical automobile K-factor in Rhode Island) then that equates to 100 pedestrians daily on each corridor.
Sources of Data	Based on a conservative estimate of daily users based on existing observations extrapolated daily.
Key Input Parameters	Assume Rhode Island K-factor of 10%, monetization rates based on the U.S. Department of Transportation's "Benefit-Cost Analysis Guidance for Discretionary Grant Programs" (January 2023).

Table 6B-1. Sidewalk Improvement Benefits Summary

Improvement Type - Sidewalk Improvements	Additional Sidewalk Width (ft)	Sidewalk Length Widened (mi)	# Daily Users	Benefit per Mile Walked per Day
Expanded Sidewalk (per ft added width)	2	0.5	200	$ 22.00
Total Per Year			**73,000**	**$ 8,030.00**

Table 6B-2. At-Grade Crossing Improvements Benefits Summary for Existing Users

Improvement Type - At-Grade Crossing Improvements for Existing Users	Value per Use	# Existing Daily Users	Benefit per Signalized Pedestrian Crossing Use per Day
Marked-Crosswalks on Roadway, Volume >10k/day	$ 0.18		$ -
Signal and Pedestrian Crossing on Roadway, Volume >13k/day	$ 0.48	200	$ 96.00
Total Per Year		**73,000**	**$ 35,040.00**

Table 6B-3. At-Grade Crossing Improvements Benefits Summary for Additional Users

Improvement Type - At-Grade Crossing Improvements for Additional Users	Value per Use	# Additional Daily Users	Benefit per Signalized Pedestrian Crossing Use per Day
Marked-Crosswalks on Roadway, Volume >10k/day	$ 0.18		$ -
Signal and Pedestrian Crossing on Roadway, Volume >13k/day	$ 0.48		$ -
Total Per Year		**-**	**$ -**

10. Future Eligible Project Costs (With RAISE)

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Assumptions	RIDOT is requesting $25.0 million (25.00%) in RAISE funding to support this project. The remaining $75.00 million (75%) will be derived from federal formula program funds ($55.00 million, 55%), and state funds ($20.00 million, 20%) specifically Rhode Island Capital Plan (RICAP) funds appropriated by the state as match for federal projects. Apart from the requested RAISE funding, no funding for this project requires satisfying any unique conditions. If RIDOT were to receive a RAISE award that differs from the request in this application, the Department would make every effort to identify alternative sources of funding to make up the gap and ensure that award execution and obligation would proceed on the timeline outlined in this application. If this project does not receive any RAISE funding, RIDOT would reevaluate the project's funding sources in the context of the ten-year plan to determine the best path forward. These calculations also assume that the project will begin construction in federal fiscal year (FFY) 2026.
Methodology	RIDOT and VHB developed a cost estimate based on the items identified in inspection reports, field reviews, and additional prioritization of preventative work to reduce further maintenance costs. Quantity-level estimates were developed and revised as shown below.
Baseline	The baseline assumption is that RIDOT will complete the project as described in the attached RAISE Application Narrative components.
Sources of Data	RIDOT WAUP data; bridge inspection data; historical average soft costs
Key Input Parameters	2% future inflation rate; RIDOT blue book cost escalation policies

Table 10-1. Summary of Future Eligible Project Costs by Phase and Task

Phase	Task	Federal Fiscal Year (FFY)	Expected Cost ($)	Contingency ($)	Total ($)
Design	Preliminary Engineering	2023	$ 550,000.00	$ 60,000.00	$ 610,000.00
Design	Design, Year 1	2024	$ 2,100,000.00	$ 315,000.00	$ 2,415,000.00
Design	Design, Year 2	2025	$ 2,500,000.00	$ 375,000.00	$ 2,875,000.00
Construction	Construction, Year 1	2026	$ 28,200,000.00	$ 2,700,000.00	$ 30,900,000.00
Construction	Construction, Year 2	2027	$ 33,750,000.00	$ 3,350,000.00	$ 37,100,000.00
Construction	Construction, Year 3	2028	$ 21,900,000.00	$ 2,500,000.00	$ 24,400,000.00
Other	Punchlist & Closeout	2029	$ 1,500,000.00	$ 200,000.00	$ 1,700,000.00
Total			**$ 90,500,000.00**	**$ 9,500,000.00**	**$ 100,000,000.00**

Table 10-2. Total Future Eligible Cost Summation

Phase	Item	Percentage Share	Current-Year Dollars	Project-Year Dollars (Assume 2026 NTP)	SAY (Final Estimate)
Design	Consultant - Design	5.07%	$ 4,850,000.00	$ 5,000,000.00	$ 5,000,000.00
Design	RIDOT In-House Staff	0.24%	$ 233,700.00	$ 243,163.26	$ 300,000.00
Design	RIDOT Planning Staff	0.14%	$ 136,300.00	$ 141,845.23	$ 200,000.00
Design	ROW Easements / Acquis	0.21%	$ 204,500.00	$ 212,767.85	$ 300,000.00
Design	Utility - Design	0.02%	$ 19,500.00	$ 20,263.60	$ 100,000.00
Construction	Contractor	69.99%	$ 67,000,000.00	$ 69,200,000.00	$ 69,200,000.00
Construction	Utility - Construction	0.65%	$ 623,200.00	$ 648,435.35	$ 700,000.00
Construction	Police Detail	2.03%	$ 1,940,000.00	$ 2,026,360.47	$ 2,100,000.00
Construction	Consultant - Construction	1.02%	$ 975,000.00	$ 1,013,180.23	$ 1,100,000.00
Construction	RIDOT Construction Staff	7.31%	$ 7,000,000.00	$ 7,250,000.00	$ 7,300,000.00
Construction	RIDOT Materials Staff / Su	1.12%	$ 1,070,000.00	$ 1,114,498.26	$ 1,200,000.00
Construction	3rd Party Consultant	1.27%	$ 1,215,000.00	$ 1,266,475.29	$ 1,300,000.00
Construction	Contingency	9.40%	$ 9,000,000.00	$ 9,500,000.00	$ 9,500,000.00
Other	RIDOT Project Manager	0.63%	$ 603,000.00	$ 628,171.74	$ 700,000.00
Other	RIDOT Other Labor	0.28%	$ 272,000.00	$ 283,690.47	$ 300,000.00
Other	Misc.	0.61%	$ 585,000.00	$ 607,908.14	$ 700,000.00
	TOTAL--Future Eligible Project Costs		**$ 95,727,200.00**	**$ 99,156,759.88**	**$ 100,000,000.00**

11. Work Zone Impact Costs (With RAISE)

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Assumptions	It is estimated that approximately 59,000 vehicles will be directly impacted by bridge work zone impacts from this project.
Methodology	To be conservative, RIDOT is calculating the anticipated work zone impact using 200% of the projected 2028 weighted average delay. In other words, this benefit-cost analysis assumes that for the duration of the construction period, typical DELAY times through the corridor will increase by 100% for all vehicles traveling through the immediate area. The construction timeframe for the preferred action scenario is estimated at fewer than 60 days spread over multiple weekends. Conservatively, this estimate uses 60 days. The vast majority of construction work will be completed offline.
Baseline	Existing conditions and alignments within the project limits
Sources of Data	Traffic analysis presented in Section 4 of this BCA
Key Input Parameters	The expense of additional travel time for all affected vehicles is calculate below. From the U.S. Department of Transportation's "Benefit-Cost Analysis Guidance for Discretionary Grant Programs," All Purpose private vehicle travel monetized value is $18.80 and for Commercial Vehicle operators (an average of truck drivers and bus drivers) is $32.40.

Table 11-1. Preferred Action Scenario Bridge Rehab Work Zone Impact

Daily Traffic:	59,252.00	vehicles
Percentage of daily cars:	98%	
Percentage of daily trucks:	2%	
Cost of Additional Travel Time (cars):	$18.80	dollars
Cost of Additional Travel Time (commercial):	$32.40	dollars
Additional commuting time:	0.0125	hours/day
Length of work zone impacts	60	days

Total Bridge Rehab Work Zone Impact $ 844,513.38

With Proposed Improvements (Preferred Action Scenario--With Grant)

Table 11-2. Projected Impact by Year

Year	Cost
2022	
2023	
2024	
2025	
2026	$ 422,256.69
2027	$ 422,256.69

12. Lifecycle Management Costs (With RAISE)

Project Name: **Right-Sizing Route 37: Improving Community Connectivity**

Date: **February 28, 2023**

Assumptions	Assumes that two bridges are demolished. Pricing to routine maintenance of remaining bridges following project construction.
Methodology	Based on historic deterioration, proposed improvement, and future projections.Detailed backup information is included in the attached Bridge Maintenance Plan and Corridor Maintenance Plan attached to the BCA Narrative submission.
Baseline	Cost estimation based on 2022 bridge inspection reports and historic pricing.
Sources of Data	2022 RIDOT Bridge Inspection Reports, RIDOT weighted average unit price database.
Key Input Parameters	RIDOT historic cost estimates, see Bridge Maintenance Plan and Corridor Maintenance Plan

Table 12-1. Future Bridge Maintenance Costs, Preferred Action Scenario

Bridge ID	Description / Task	Unit Cost	Iterations	30 Year Maintenance Cost	30-Year Cost ($)
624	Maintenance	$ 1.00	1	$ 2,097,900.00	$ 2,097,900.00
623	Maintenance	$ 1.00	1	$ 1,700,900.00	$ 1,700,900.00
636	Maintenance	$ 1.00	1	$ 1,337,400.00	$ 1,337,400.00
637	Maintenance	$ 1.00	1	$ 1,387,900.00	$ 1,387,900.00
816	Maintenance	$ 1.00	1	$ 110,000.00	$ 110,000.00
616	Maintenance	$ 1.00	1	$ 767,500.00	$ 767,500.00
					$ -
					$ -
					$ -
					$ -
					$ -
					$ -
Total					**$ 7,401,600.00**

Table 12-2. Future Bridge Maintenance Costs, Preferred Action Scenario

Bridge ID	Description/Task	Units/Square Yard/Each	Unit Cost/EA/SY	Iterations	Total Cost
	High Friction Surface Treatment	25,000	$ 30.00	3	$ 2,250,000.00
					$ -
					$ -
Subtotal Foregone Cost Before EC&M					**$ 2,250,000.00**
Engineering, Contingencies, and Mobilizations (30%)					$ 675,000.00
Subtotal Foregone Cost, Pavement Reconstruction					**$ 2,925,000.00**

Table 12-3. Future Eligible Costs Summary

Item	Description	Cost Over 30 Years
Bridge Maintenance	30-Year Lifecycle Maintenance	$ 7,401,600.00
Pavement Maintenance	30-Year Lifecycle Maintenance	$ 2,925,000.00
Total		**$ 10,326,600.00**

A-1
Safety

Memorandum

To: Ken White, Ph.D.
Assistant Director for Administrative Services
Division of Planning
Rhode Island Department of Transportation
Two Capitol Hill, Room 318
Providence, Rhode Island

Date: February 23, 2023

Project #: 73337.04

From: Jeff Gooch, PE
Kristin Caouette, PE
Sam Arnold, PE
Pete Pavao, PE

Re: Right-Sizing Route 37 Safety Impacts

Introduction

The Rhode Island Department of Transportation (RIDOT) is responding to a Notice of Funding Opportunity (NOFO) for grant funding through the Rebuilding American Infrastructure with Sustainability and Equity (RAISE) discretionary grant program to request a construction grant for **Right-sizing Route 37 Improve Community Connections**. RIDOT requested support from VHB for preparation of the NOFO application, including estimation of the traffic, safety, noise, environmental, and other impacts, as well as costs, of the proposed design. This memorandum summarizes the expected safety effects of the proposed design.

Key safety aspects of the construction projects include:

- **Safety Issue 1 – Route 37 Rumble strips** - Rumble strips are proposed along Route 37 on the inside and outside shoulders to prevent lane departure crashes.
- **Safety Issue 2 - High-Friction Surface Treatment**– Seventeen ramps along Route 37 spread over 3 interchanges will have high-friction surface treatment (HFST) implemented. The HFST will improve friction and reduce the likelihood of roadway departure crashes along the ramps.
- **Safety Issue 3 – Route 37 at Post Road Interchange Improvements** – The Route 37 at Post Road interchange will be reconstructed as an at-grade intersection. The trumpet interchange will be replaced with at-grade intersections connecting Route 37 and Post Road. These improvements will result in the "right-sizing" of the intersection, including removal of one structure and two ramps. Safety improvements include advanced warning systems to alert vehicles that the freeway is terminating, the use of adaptive signal controls, and retroreflective signal backplates to increase visibility of the traffic signals. Although not quantified below for a safety benefit, Wrong Way Detection Systems will be installed at this interchange to mitigate wrong-way maneuvers onto Route 37 from Post Road.

Methodology

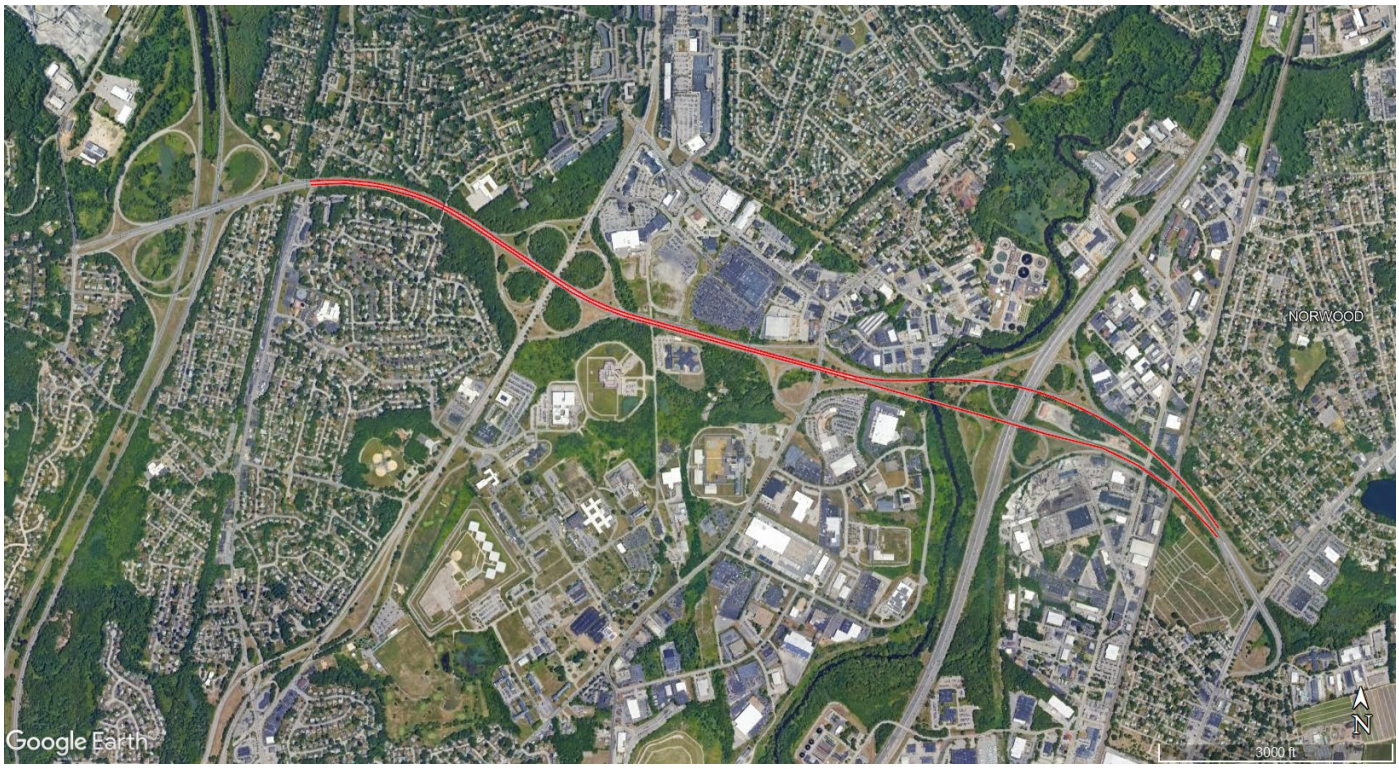
Guided by the U.S. Department of Transportation's "Benefit-Cost Analysis Guidance for Discretionary Grant Programs," (January 2023) Crash Modification Factors (CMFs) for selected countermeasures were applied to the crash history by severity and by crash type. The monetized values for injuries by severity were obtained to determine a monetary benefit.

Reconstruction of Route 37 at Post Road interchange is a substantial change in the transportation network that is not easily summarized using crash modification factors. In order to predict the change in crashes due to that change in roadway network, crash prediction models were used to quantifying data-driven safety impacts.

Safety Issue 1 - Route 37 Rumble Strips

The RIDOT grant application also includes a proposal to include rumble strips along Route 37 inside and outside shoulders. Figure 1 shows the extent of the proposed rumble strip installation in red.

Figure 1: Proposed length of rumble strip installation



Source: Google Earth, 2023©

The analysis used the Highway Safety Manual (HSM) method for selecting crash countermeasures by applying estimated crash reductions to historic crashes. Crash data was collected from the RIDOT Crash Database for the study area between January 1, 2015 and December 31, 2021. The analysis assumes that crashes experienced over the 7-year period are consistent throughout the 30-year planning horizon.

For the analysis of this safety issue, VHB used the annual traffic growth rate - 0.25 percent - to grow the observed crash frequency to the design year (expected) no build crash frequency. The factor is calculated from the midpoint of the study period (2019) to the opening design year of 2028, so the growth factor would equal $(1 + 0.0025)^{(2028-2019)} = 1.023$.

VHB identified CMFs for shoulder rumble strips on freeways and expressways, which were applied to the project future crash frequency – Table 1 summarizes those CMFs. Note that no CMF was identified for PDO crashes, so the reduction in PDO crashes was calculated using the difference between the reduction in all severity crashes and reduction in FI

crashes specific to this crash history. Table 1 shows the calculated crash reduction expected for the rumble strips. The results show that the rumble strips are expected to reduce injury crashes by 20 percent and all injury crashes by 1 percent; therefore, this implies an increase in PDO crashes.

Table1: Summary of CMFs for the Safety Issue 1

	CMF	CRF	Justification
Fatal & Injury			
CMF ID: 3518	0.80	0.20	Highly rated CMF for urban expressways
Property Damage Only			
Calculated	1.109*	-0.109*	CMF calculated based on CMF ID 3518 and 3410 specific to the study area crash history. Indicates an increase in PDO crashes
All Severity			
CMF ID: 3410	0.99	0.01	Adequately rated CMF for urban expressways.

"Highly rated" is defined by the CMF Clearinghouse as 4-star quality based on transportation safety research.
"Adequately rated" is defined by the CMF Clearinghouse as 3-star quality based on transportation safety research.
*This value is calculated based on available FI and All Crash CMFs and the study area specific crash history.

The resulting expected change is a reduction of 7.3 FI crashes, an increase of 6.4 PDO crashes, and a total reduction of 0.95 crashes, summarized in Table 2.

Table 21: Crash Reduction for Route 37 Rumble Strips

KABCO Category	Annualized Crashes, 2015-2021	Growth Factor to Design Year	Expected Annual Crashes, Design Year	CMF	Reduced Crashes, Design Year
K Crashes	0.25	1.023	0.256	0.80	0.051
A Crashes	1.39	1.023	1.422	0.80	0.284
B Crashes	3.79	1.023	3.877	0.80	0.775
C Crashes	30.29	1.023	30.987	0.80	6.197
Subtotal Fatal & Injury Crashes					**7.308**
O Crashes	57.43	1.023	58.751	1.109*	-6.355
Subtotal Property Damage Only Crashes					**-6.355**
All Crashes	**93.15**	**1.023**	**95.292**	**0.99**	**0.953**

Note: Negative values for Reduced Crashes indicates an increase in crashes.
*This value is calculated based on available FI and All Crash CMFs and the study area specific crash history.

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Safety Issue 2 - High-Friction Surface Treatment (HFST)

RIDOT is proposing the installation of HFST for all ramps along the Route 37 study corridor (17 locations). The HFST will improve pavement friction, support speed reduction and vehicle control, and reduce the likelihood of roadway departure crashes along the ramps. Figure 2 shows the proposed ramp HFST installation.

Figure 2: Proposed HFST ramp locations along the Route 37 corridor

Source: Google Earth, 2023©

As with the rumble strips, VHB used the projected change in traffic volume to grow the observed crash frequency for 2015 through 2021 to the design year 2028, calculating an expected crash frequency. VHB identified highly rated CMFs for HFST to apply to the design year crash frequency. Table 3 summarizes the selected CMFs. Again, with no PDO CMF, the change in PDO crashes was calculated using the difference between the reduction in crashes of all severities and the reduction in crashes of FI severity.

The results summarized in Table 3 show that HFST is expected to reduce fatal and injury crashes by 51 percent and total crashes by 47.1 percent, resulting in a 45 percent reduction in PDO crashes.

Table 32: Summary of CMFs for Safety Issue 2

	CMF	CRF	Justification
Fatal & Injury			
CMF ID: 10319	0.49	0.51	Highly rated CMF for all sites.
Property Damage Only			
Calculated	0.55*	0.45	CMF calculated based on CMF ID 10318 and 10319 specific to the study area crash history. Indicates an increase in PDO crashes
All Severity			
CMF ID: 10318	0.529	0.471	Highest rated CMF for all sites.

"Highest rated" is defined by the CMF Clearinghouse as 5-star quality based on transportation safety research.
"Highly rated" is defined by the CMF Clearinghouse as 4-star quality based on transportation safety research.
"Adequately rated" is defined by the CMF Clearinghouse as 3-star quality based on transportation safety research.
*This value is calculated based on available FI and All Crash CMFs and the study area specific crash history.

In terms of crashes, HFST can reduce 16.4 FI crashes per year and 22.8 PDO crashes per year, summarized in Table 4.

Table 4. Crash Reduction for Ramp HFST

KABCO Category	Annual Crashes, 2015-2021	Growth Factor to Design Year	Expected Annual Crashes, Design Year	CMF	Reduced Crashes, Design Year
K Crashes	0.22	1.023	0.225	0.49	0.11
A Crashes	1.23	1.023	1.258	0.49	0.64
B Crashes	3.33	1.023	3.407	0.49	1.74
C Crashes	26.65	1.023	27.263	0.49	13.90
Subtotal Fatal & Injury Crashes					**16.40**
O Crashes	49.43	1.023	50.567	0.55	22.76
Subtotal Property Damage Only Crashes					**22.76**
All Crashes	**80.86**	**1.023**	**82.72**	**0.529**	**39.15**

Safety Issue 3 - Route 37 at Post Road Interchange Improvements

The existing terminal of Route 37 at Post Road is a trumpet interchange in which vehicles have free flow access to and from Route 37 using ramps tied to Post Road (see Figure 3). The area of influence for the proposed improvement is outlined in red.

Figure 3: Existing Conditions at the Route 37 and Post Road interchange in Warwick, RI.

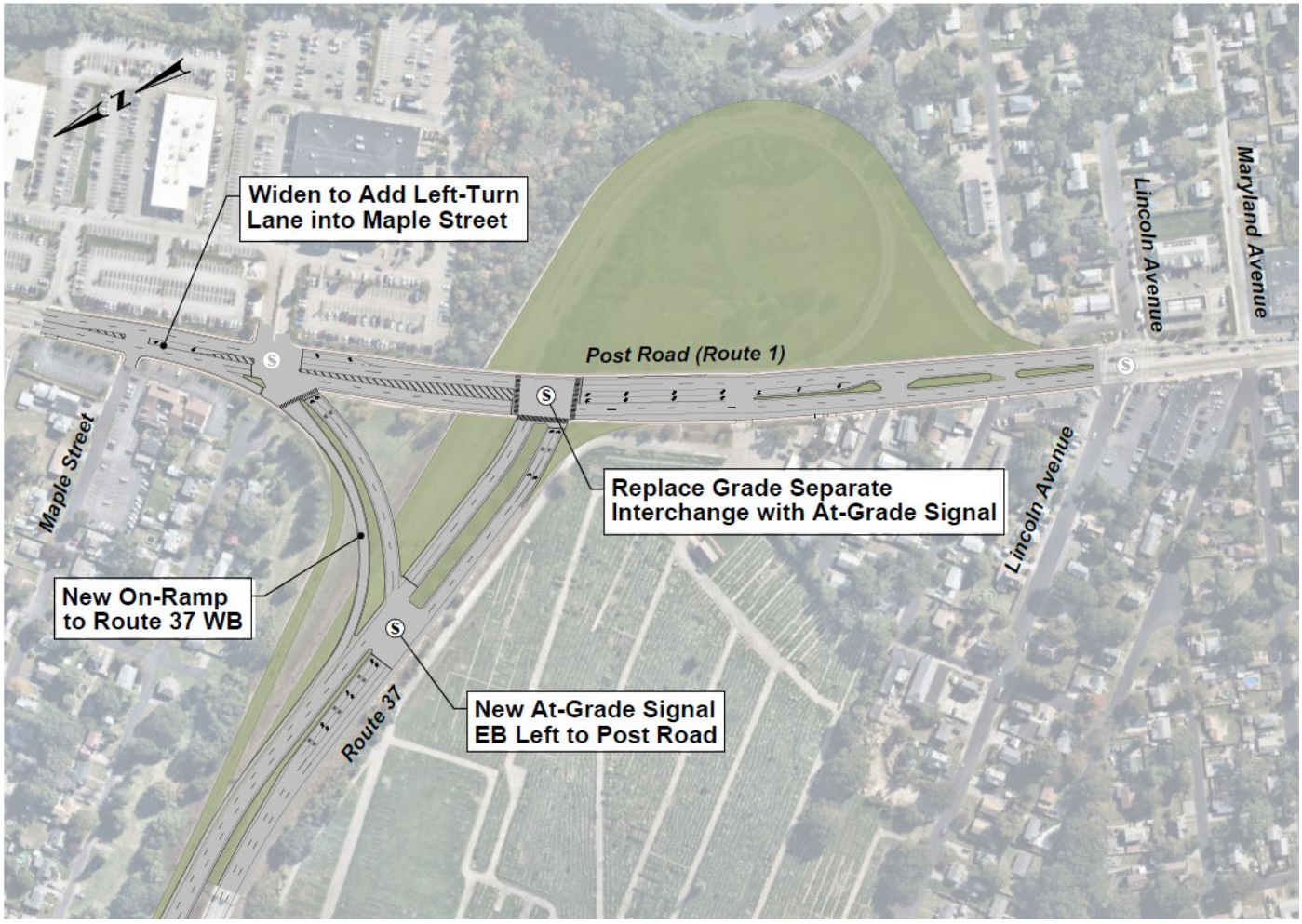
Source: Google Earth, 2023©

Proposed Improvements

Figure 2 shows RIDOT's proposed improvements for the terminal. The trumpet interchange will be replaced with at-grade intersections connecting Route 37 and Post Road. One intersection will be created on Route 37 in advance of Post Road to manage traffic diverging to Post Road northbound and southbound and merging from Post Road northbound and southbound. A second new signal located on Post Road controls traffic traveling between Route 37 and Post Road to/from the south.

Memorandum

Figure 4: Proposed Safety Issue 1 Improvements



Safety Analysis Methodology

Ideally, the safety analysis would include the application of CMFs to an expected future crash frequency as described for Safety Issue 1 and 2. Unfortunately, this is not feasible because:

- CMFs are not available for the proposed redesign of the interchange.
- RIDOT does not have calibrated crash prediction models (CPMs) which could be used for EB.

As a result, VHB proposed a modified approach to estimating safety performance using default Highway Safety Manual (HSM) CPMs.

VHB applied the CPMs to predict Fatal & Injury (FI) and Property Damage Only (PDO) crashes for existing conditions under current volumes and design year volumes. Additionally, VHB applied the HSM CPMs to predict crashes for the proposed design with design year volumes.

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VHB proposed estimating design year safety performance ($C_{Obs,future}$) by taking the observed crash frequency during the study period ($C_{Annual,Observed}$) and growing it to the design year using the ratio of predicted crashes under existing conditions for the design year ($N_{Pr,Design}$) to the study years ($N_{Pr,Study}$). Figure 5 describes this calculation.

Figure 5: Calculating expected no-build crash frequency in the design year.

$$C_{exp,future} = C_{annual,observed} * {N_{Pr,Design}}/{N_{Pr,Study}}$$

VHB would then calculate a surrogate CMF ($CMF_{Surrogate}$) using the ratio of predicted design year crashes ($N_{PR,Build}$) for the proposed design to the predicted design year crashes for the existing design ($N_{PR,Design}$). Figure 6 describes the proposed calculation.

Figure 6: Calculate the surrogate CMF for the proposed design.

$$CMF_{Surrogate} = {N_{PR,Build}}/{N_{PR,Design}}$$

Finally, VHB would estimate the change in safety performance ($C_{Reduced,Design}$) by applying the surrogate CMF to the grown design year crashes, as shown in Figure 7.

Figure 7: Calculation of expected crash reduction in the design year.

$$C_{Reduced,Design} = C_{obs,future} - C_{obs,future} * CMF_{Surrogate}$$

The next section describes the analysis performed following this methodology.

Safety Analysis Results

Existing Crash Frequency

VHB reviewed RIDOT crash data for this project location for the years 2015 through 2019 in support of prior conceptual design efforts. Table 1 summarizes those crashes by KABCO severity level[1] and crash type. Note there were no fatal crashes in the study area during the study period.

[1] https://safety.fhwa.dot.gov/hsi0p/spm/conversion0_tbl/pdfs/kabco_ctable_by_state.pdf

Table 5: Summary of Study Area Crashes - Safety Issue 3, 2015-2019

Crash Type	A Severity	B Severity	C Severity	ABC Severity	O Severity	Total
Angle	0	0	3	3	22	**25**
Collision with Roadside Object	1	2	13	16	33	**49**
Collision with Vulnerable User	0	0	2	2	0	**2**
Head On	0	0	2	2	3	**5**
Rear End	1	6	73	80	331	**411**
Sideswipe – Opposite Direction	0	0	1	1	2	**3**
Sideswipe – Same Direction	1	0	6	7	53	**60**
Total	**3**	**8**	**100**	**111**	**444**	**555**

The project area experienced 555 crashes during that time period, an average frequency of 111 per year, 22.2 of which are fatal and injury (FI, or ABC) and 88.8 of which are property damage only (PDO, or O).

Predicted Crash Frequency, No Build

VHB applied the proposed methodology using the applicable HSM spreadsheet tools, including the Enhanced Interchange Safety Analysis Tool (ISATe)[2] and the HSM Chapter 12 Urban and Suburban Arterials Spreadsheet[3], downloaded in January 2023. VHB followed HSM guidance when segmenting the area. The ramps, the starting segment on Route 37, and the existing intersection of the southbound Post Road to northbound Route 37 and the car dealership were modeled using the relevant ramp, mainline, and ramp terminal CPMs in ISATe. The remaining segments and intersections in the study area along Post Road were modeled using the Chapter 12 spreadsheet CPMs. Table 6 summarizes the predicted crashes for the Existing Condition and No-Build conditions.

Table 6: Summary of Annual Predicted Crashes for No-Build Conditions

Sites	Predicted FI Crashes (Existing)	Predicted PDO Crashes (Existing)	Predicted FI Crashes (No-Build)	Predicted PDO Crashes (No-Build)
Freeway Segments	0.3	0.6	0.3	0.7
Freeway Ramps	3.2	4.5	3.6	5.0
Freeway Ramp Terminals	4.9	8.1	5.7	8.7
Arterial Segments	1.0	2.4	1.2	2.9
Arterial Intersections	2.1	3.7	2.4	4.3
Total	**11.5**	**19.2**	**13.1**	**21.6**

The results in Table 7 suggest FI crashes are expected to increase by a factor of 1.14 from the study period to the design year, while PDO crashes are expected to increase by a factor of 1.13. VHB used those results and the equation

[2] https://www.highwaysafetymanual.org/Documents/ISATe_Documents.zip
[3] https://www.highwaysafetymanual.org/Documents/HSM_CPM_UrbanSuburbanArterials_v3.2.xlsx

in Figure 6 to grow the observed crash frequency during the study period (2015-2019) to the expected no build crash frequency in the design year.

Table7: Calculation of Expected No Build Crashes in the Design Year

Crash Severity	HIstoric Crash Frequency	Growth Factor	Expected Crashes in Design Year
FI	22.2	1.14	25.3
PDO	88.8	1.13	100.3
All	111	N/A	125.6

Predicted Crash Frequency, Build

By converting the terminal from an interchange to a series of intersections, RIDOT is removing the freeway characteristics of the project area. As such, VHB modeled the proposed condition entirely using the HSM Chapter 12 CPM spreadsheet. Table 8 summarizes the predicted crashes for the proposed conditions under the design volumes.

Table 8: Summary of Predicted Crashes for the Design Year Proposed Conditions

Sites	FI, Design Year	PDO, Design Year
Arterial Segments	1.9	4.9
Arterial Intersections	11.0	22.7
Total	**12.9**	**27.6**

The results summarized in Table 8 do not include adaptive signal controls, retroflective sheeting for backplates, and intersection warning signage for the two new intersections and the Post Road/Auto Dealership intersection. Table 9 summarizes the CMFs for the additional intersection safety improvements. For the backplates, the only CMF available was for all severities, so this was applied equally to FI crashes and PDO crashes. For the intersection warning sign, the only CMFs available were for FI crashes and all severity crashes. As such, these CMFs were applied to those severities, and the resulting change in PDO crashes was calculated using the difference between the reduction in all severity crashes and FI severity crashes.

Table 9: Summary of Additional CMFs for Safety Issue 3 Intersections.

Countermeasure	Adaptive Signal Control	Retroreflective Sheeting for Backplates	Intersection Warning Signs
FI CMF	0.958	N/A	0.82
FI CMF Clearinghouse ID	11236	N/A	4201
FI CMF Justification	Highly rated CMF for urban and suburban intersections.	N/A	Highly rated CMF for intersections in any area.
PDO CMF	0.943	N/A	N/A
PDO CMF Clearinghouse ID	11237	N/A	N/A

PDO CMF Justification	Highly rated CMF for urban and suburban intersections.	N/A	N/A
All CMF	N/A	0.85	0.814
All CMF Clearinghouse ID	N/A	1410	4198
All CMF Justification	N/A	Highly rated CMF for urban intersections.	Highly rated CMF for intersections in any area.

VHB applied the CMFs for adaptive signal control and sheeting to the three signalized intersections created or modified in the design, while applying the warning sign CMF to the proposed intersection of Route 37 and the new two-way ramp connecting to Post Road. Table 10 summarizes the updated predicted crash results with the proposed CMFs applied.

Table10: Summary of Predicted Crashes for the Proposed Conditions with Proposed CMFs Applied.

Sites	FI, Design Year	PDO, Design Year
Arterial Segments	1.9	4.9
Arterial Intersections	9.0	18.0
Total	**10.9**	**22.9**

VHB applied the equation in Figure 6 and the results from Table 6 and Table 10 to calculate surrogate CMFs for FI and PDO crashes (see Table 11). Based on these results, VHB expects the proposed RIDOT improvements to reduce FI crashes by 17 percent and increase PDO crashes by 6 percent.

Table 11: Calculation of Surrogate CMFs.

Crash Types	Predicted Crashes, No Build, Design Year	Predicted Crashes, Build, Design Year	Surrogate CMF
FI Crashes	13.6	12.6	0.83
PDO Crashes	22.4	25.1	1.06

Finally, VHB used the results in Table 6 and Table 11 to calculate the expected change in safety performance with the equations in Figure 5 and Figure 7. The proposed design is expected to reduce 4.3 FI crashes per year and add 6.3 PDO crashes per year. Table 12 summarizes the expected annual change in safety performance for the proposed design.

Table 12: Expected Annual Crash Reduction.

Crash Types	Existing Crash Frequency in Design Year	Surrogate CMF	Expected Crash Frequency in Design Year, Build	Expected Annual Crash Reduction
FI Crashes	25.3	0.83	21.0	4.3
PDO Crashes	100.3	1.06	106.3	(6.0)

The Benefit Cost Analysis (BCA) process of the RAISE grant application requires the distribution of the change in safety performance to be summarized by crash severity category. VHB elected to use the Statewide distribution of crashes by KABCO severity level for the years 2015 through 2019.

Table 13: Percent Distribution of FI Crashes by KABCO Severity in Rhode Island, 2015-2019.

KABCO Category	Percent of FI Crashes
K Severity	0.7%
A Severity	3.9%
B Severity	10.6%
C Severity	84.8%

Using the distribution in Table 13, VHB calculated the expected annual reduction of crashes for each KABCO severity level. Table 14 summarizes these results, showing the expected crashes in the design year in a no build condition, the crash reduction factor (1 minutes the CMF), and the predicted annual crash reduction. Note Table 14 uses crash reduction factor, which is calculated as 1-CMF.

Table 14: Annual Crash Reduction by KABCO Severity level.

KABCO Category	Expected Crashes in the Design Year, No Build	Crash Reduction Factor	Predicted Annual Crash Reduction
K Severity	0.18	0.17	0.03
A Severity	0.99	0.17	0.17
B Severity	2.68	0.17	0.46
C Severity	21.45	0.17	3.65
O Severity	100.3	(0.06)	(6.0)

A-2

Travel Time

Memorandum

To: Ken White, Ph.D.
Assistant Director for Administrative Services
Division of Planning
Rhode Island Department of Transportation
Two Capitol Hill, Room 318
Providence, Rhode Island

Date: February 23, 2023

Project #: 73337.04

From: Kristin Caouette, PE
Peter Pavao, PE
Amphone Soupharath
Zachary Tiang

Re: Right-Sizing Route 37 Travel Time Savings

The Rhode Island Department of Transportation (RIDOT) is responding to a Notice of Funding Opportunity (NOFO) for grant funding through the Rebuilding American Infrastructure with Sustainability and Equity (RAISE) discretionary grant program to request a construction grant for **Right-sizing Route 37 Improve Community Connections**. RIDOT requested support from VHB for preparation of the NOFO application, including estimation of the traffic, safety, noise, environmental, and other impacts, as well as costs, of the proposed design.

RIDOT has requested that VHB evaluate and determine the travel time savings associated with the proposed improvements at the Route 37 at Post Road interchange in Warwick, RI by removing the Route 37 overpass (Post Road Bridge 0638) and loop ramps and installing an at-grade signalized intersection. The purpose of this memorandum is to document the methodologies and assumptions used in the development of the VISSIM microsimulation model and provide documentation of the model results.

Prior reviews identified the structural deficiency on Post Road Bridge 0638 and removing the bridge would be step in the right direction to achieve a state of good repair. This review found that there would be positive travel time benefit by removing the bridge and installing an at-grade intersection. The results presented in the BCA are the net results for the entire modeled study area, described in the following section. This memorandum concludes with a summary of change in travel time by roadway facility in the modeled study area.

Study Area

Figure 1 illustrates the project location and the area of influence. No other aspects of the **Right-Sizing Route 37** projects proposes changes to traffic operations, therefore, this analysis focuses on a limited study area. The study area, as defined by RIDOT, includes Route 37 from I-95 Ramps to Route 1 (Post Road) and Post Road from Maple Street to Lincoln Avenue in Warwick, RI. Route 37 is a limited access highway that provides regional connection between I-295 and I-95 with three lanes in each direction plus auxiliary lanes between major interchanges. Route 37 ends at Post Road and formed a partial cloverleaf interchange configuration type. Post Road is a principle arterial with two lanes in each direction with turn lanes at major intersections and provides direct access to the T.F. Green Airport.

The Route 37 eastbound off-ramp to Post Road southbound is controlled by a YIELD sign and vehicle queues extend to the Route 37 mainline during the PM peak hour condition and occasionally extend to the I-95 northbound off-ramp. The Route 37 eastbound to Post Road northbound movement carries two lanes over Post Road (Post Road Bridge 0638) and begins to taper down to one lane before picking up a short acceleration lane and then merges with the northbound traffic. The Post Road northbound to Route 37 westbound movement also carries two lanes over Post Road (Post Road Bridge 0638). This movement is controlled by the traffic signal at the Post Road at Lincoln Avenue intersection just 200 ft south of the on-ramp. Vehicle queues often extend to about 500 ft on all approaches to the

intersection during the peak hour periods. The Post Road southbound to Route 37 westbound movements are controlled by the traffic signal at the Post Road at Balise Car Dealership/westbound on-ramp. Similarly, vehicle queues extend about 500 ft on the Post Road southbound approach.

Figure 1 Post Road at Route 37 between Maple Street and Lincoln Avenue in Warwick, Rhode Island

Study Area modeled - VISSIM 21

Model Development

The 2023 existing VISSIM model was developed using PTV VISSIM 2021. The model includes Route 37 from the I-95 ramps to Post Road, the trumpet interchange, and the two signalized intersections along Post Road between Maple Street and Lincoln Avenue.

Data Collection

To identify current traffic flow characteristics, traffic counts were collected in March 2022 on the four on/off ramps at the interchange from Tuesday to Saturday including vehicle classification. Additional turning movement counts during the weekday peak hour periods were also collected at the Post Road at Lincoln Avenue and the Post Road at Balise Car Dealership/westbound on-ramp signalized intersections. A review of the historical traffic counts in 2003 and 2018 (Pre-COVID) revealed that the March 2022 counts were slightly higher than the 2018 but lower than the 2003. It was determined that the March 2022 counts were not affected by COVID. Therefore, the March 2022 volumes were used to develop the 2023 existing condition without growth or seasonal adjustment. The 2023 existing daily and peak hour volumes are shown below in Table 1.

Table 1 Existing Condition Study Area Traffic Volumes

	Daily	Weekday Morning Peak Hour			Weekday Evening Peak Hour		
Location	Weekday[1]	Volume[2]	K-Factor[3]	Dir. Dist.[4]	Volume[2]	K-Factor[3]	Dir. Dist.[4]
Post Road, north of Dealership driveway	34,595	2,270	7%	61% SB	3,135	9%	56% NB
Route 37, east of Jefferson Boulevard	46,490	3,430	7%	61% WB	3,865	8%	55% EB

Source: PDI. Based on automatic traffic recorder (ATR) counts conducted in March 2022.
1 average daily traffic (ADT) volume expressed in vehicles per day
2 peak hour traffic volumes expressed in vehicles per hour
3 percent of daily traffic that occurs during the peak period
4 directional distribution of peak period traffic
Note: Peak hours do not necessarily coincide with the peak hours of the individual intersection turning movement counts

Google Maps average traffic conditions and travel times were used to provide travel time and speed measurements and to help identify hotspot and bottleneck locations. StreetLight OD analysis was used to determine the travel behavior of vehicles in the study area and to help determine vehicle routes in VISSIM.

Model Geometrics and Traffic Controls

The existing roadway, interchange, and intersection geometries were initially modeled using aerial mapping provided within VISSIM and verified with a combination of field observations, Google Maps/StreetView, and Nearmap. Traffic controls and signal timings were modeled and verified by field observations. Vehicle speed data was modeled and verified using the Posted Speed Limit, in miles-per-hour (mph) in the field.

Model Verification and Error Checking

Before beginning the calibration process, the model was checked for errors. Roadway geometry, traffic volumes and routes, speeds, signal timing data, and other inputs were reviewed along with a visual check of the simulation. The VISSIM error file was also reviewed and critical errors were corrected. The simulation was reviewed to verify traffic signals were operating correctly, to visually inspect queue lengths, and to check general traffic operations throughout

the model. Coding errors were corrected and adjustments were made to various model parameters to accurately reflect field conditions.

Model Calibration and Results

The North America default network parameters were used and adjusted as part of the calibration process including conflict areas, lane-change distances, and driver behaviors.

Based on the required benefit-cost analysis inputs, the 2023 existing VISSIM model was developed and modeled for 15-hours from 6:00 AM to 8:00 PM in order to capture both the AM and PM peak hour periods as well the shoulder hours building up the congestion and the recovering periods after the peak hour periods. This 15-hour period accounted for approximately 92% of the daily traffic demand.

Ten model runs with random seed numbers were simulated to provide varying nature of vehicles entering the network. The simulated traffic volumes (average of the ten model runs) were within 10% of the 2022 counted volumes and the simulated travel times and speeds were with 15% of the observed data. A visual inspection of the calibrated model simulation during the AM and PM peak hour periods indicated that the model simulates the traffic operations reasonably and correctly. The heat/speed maps shown in Figures 2 and 3 during the AM and PM peak hour, respectively, are consistent with field observations. The 2023 existing VISSIM model has been calibrated and serves as the base model for the future No-Build and Build alternatives.

Figure 2 2023 Existing AM Peak Condition

Figure 3 2023 Existing PM Peak Condition

Alternatives Analysis

The proposed improvements are expected to be constructed and opened to traffic in 5 years. This alternatives analysis will be evaluating the following future year conditions:

- No-Build - Opening Day (2028),
- Build - Opening Day (2028),
- No-Build – 30 Year Design (2058),
- Build – 30 Year Design (2058)

Traffic volumes in and around the project area are expected to change in the future based on the ambient background traffic growth. A review of the RIDOT historical count data indicated that traffic volumes in the area remained steady with minimal growth. In order to provide some growth in the area, a background traffic growth rate of 0.25% annually was chosen and applied to the 2023 existing condition to get the 2028 and 2058 No-Build conditions.

Table 2 summarizes the 2058 daily traffic volumes.

Table 2 2058 No-Build/Build Condition Study Area Traffic Volumes

	Daily	Weekday Morning Peak Hour			Weekday Evening Peak Hour		
Location	Weekday[1]	Volume[2]	K-Factor[3]	Dir. Dist.[4]	Volume[2]	K-Factor[3]	Dir. Dist.[4]
Post Road, north of Dealership driveway	37,752	2,477	7%	61% SB	3,421	9%	56% NB
Route 37, east of Jefferson Boulevard	50,733	3,743	7%	61% WB	4,218	8%	55% EB

Source: PDI. Based on automatic traffic recorder (ATR) counts conducted in March 2022 grown annually by 0.25%.
1 average daily traffic (ADT) volume expressed in vehicles per day
2 peak hour traffic volumes expressed in vehicles per hour
3 percent of daily traffic that occurs during the peak period
4 directional distribution of peak period traffic
Note: Peak hours do not necessarily coincide with the peak hours of the individual intersection turning movement counts

The proposed improvements will replace the overpass with an at-grade signalized intersection and provide improved connectivity from Route 37 eastbound to Post Road northbound.

Tables 3 and 4 summarize the Route 37 and Post Road corridor, respectively, for the hourly volumes, vehicle miles traveled (VMT), vehicle hours traveled (VHT), average speed, and total delay comparison between the 2058 No-Build and Build conditions. As noted earlier, the 15-hour modeling period accounted for 92% of the total daily demand. As highlighted in Table 3 and 4, the proposed improvements "Build" alternative is expected to process more vehicles in the network and lower VMT and VHT along both the Route 37 corridor and Post Road corridor. Even though the average speeds along the corridors are comparable between the No-Build and Build alternatives, the delays are significantly less.

Table 3 Route 37 Corridor Measures of Effectiveness (MOE) Comparison

Time	Total Vehicles in Network		VMT: Total Path Distance (mi)		VHT: Total Time in Network (hr)		Average Speed (mph)		Total Delay (hr)		Average Delay (hr/veh)	
	2058 No-Build	2058 Build	2058 No-Build	2058 Build	2058 No-Build	2058 Build	2058 No-Build	2058 Build	2058 No-Build	2058 Build	2058 No-Build	2058 Build
6:00 AM	590	594	464	420	13	14	37	30	1	4	0.001	0.003
7:00 AM	2,198	1,392	1,764	980	69	36	27	29	23	11	0.004	0.003
8:00 AM	1,431	2,242	1,130	1,586	35	63	34	26	6	22	0.002	0.004
9:00 AM	2,102	2,162	1,694	1,520	58	60	31	27	14	21	0.003	0.004
10:00 AM	1,579	1,600	1,285	1,132	40	42	34	29	6	13	0.002	0.003
11:00 AM	1,572	1,592	1,276	1,128	39	41	34	29	6	12	0.002	0.003
12:00 PM	1,628	1,653	1,334	1,171	42	43	34	29	7	13	0.002	0.003
1:00 PM	1,733	1,750	1,375	1,226	44	48	33	27	7	17	0.002	0.004
2:00 PM	1,913	1,939	1,486	1,337	49	54	32	26	9	19	0.002	0.004
3:00 PM	2,195	2,242	1,712	1,556	74	66	26	25	28	25	0.006	0.005
4:00 PM	2,355	2,489	1,806	1,737	110	75	19	24	62	30	0.011	0.005
5:00 PM	2,372	2,545	1,786	1,771	141	77	14	24	94	31	0.017	0.005
6:00 PM	2,291	2,389	1,728	1,659	146	71	13	25	100	28	0.019	0.005
7:00 PM	1,953	1,813	1,544	1,254	117	51	15	26	75	18	0.017	0.004
8:00 PM	1,348	1,312	1,052	905	54	35	28	27	26	11	0.008	0.004
Total	**27,260**	**27,714**	**21,435**	**19,381**	**1,029**	**777**	**27**	**27**	**465**	**275**	**0.096**	**0.061**

Table 4 Post Road Corridor Measures of Effectiveness (MOE) Comparison

Time	Total Vehicles in Network		VMT: Total Path Distance (mi)		VHT: Total Time in Network (hr)		Average Speed (mph)		Total Delay (hr)		Average Delay (hr/veh)	
	2058 No-Build	2058 Build	2058 No-Build	2058 Build	2058 No-Build	2058 Build	2058 No-Build	2058 Build	2058 No-Build	2058 Build	2058 No-Build	2058 Build
6:00 AM	781	787	615	557	17	19	34	28	2	5	0.001	0.004
7:00 AM	2,914	1,846	2,339	1,299	91	48	25	26	30	14	0.006	0.004
8:00 AM	1,898	2,972	1,498	2,102	47	84	31	24	8	30	0.002	0.006
9:00 AM	2,787	2,866	2,245	2,014	77	79	28	24	18	28	0.004	0.005
10:00 AM	2,094	2,120	1,704	1,500	53	55	31	26	8	17	0.002	0.004
11:00 AM	2,084	2,110	1,691	1,495	52	55	31	26	8	16	0.002	0.004
12:00 PM	2,157	2,192	1,768	1,553	55	57	30	26	9	17	0.002	0.004
1:00 PM	2,297	2,320	1,822	1,625	58	64	30	24	10	22	0.002	0.005
2:00 PM	2,536	2,570	1,969	1,772	64	71	29	24	12	25	0.003	0.006
3:00 PM	2,909	2,972	2,269	2,063	98	87	24	22	37	34	0.007	0.006
4:00 PM	3,121	3,300	2,394	2,303	146	100	17	22	82	40	0.015	0.007
5:00 PM	3,145	3,374	2,368	2,347	187	102	12	22	125	41	0.023	0.007
6:00 PM	3,037	3,166	2,291	2,199	193	94	11	22	132	37	0.025	0.007
7:00 PM	2,590	2,403	2,047	1,662	154	67	13	24	100	24	0.022	0.006
8:00 PM	1,786	1,739	1,394	1,200	71	46	26	25	34	15	0.011	0.005
Total	**36,136**	**36,737**	**28,414**	**25,691**	**1,364**	**1,029**	**25**	**24**	**616**	**364**	**0.128**	**0.081**

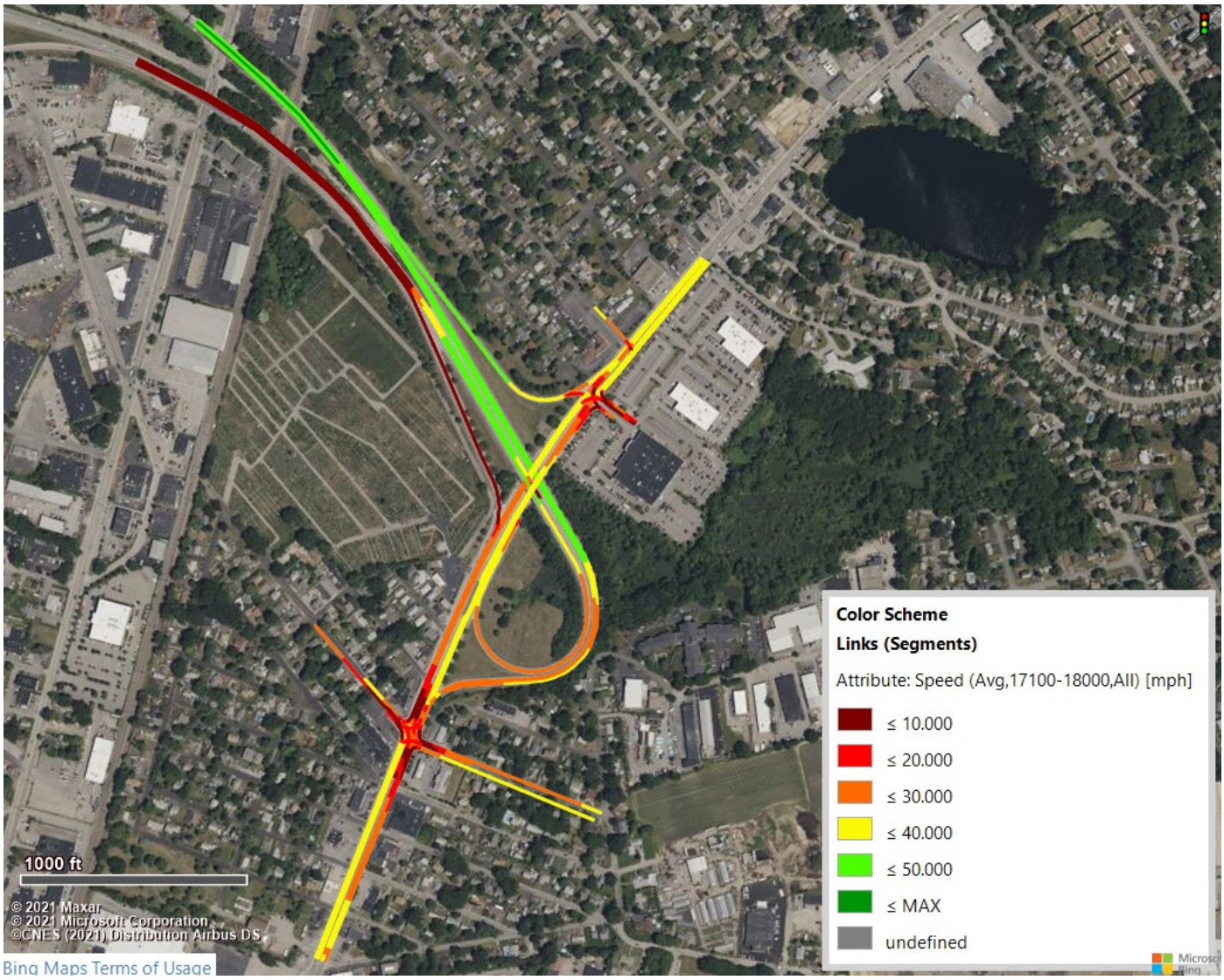
Figures 4 to 7 illustrate the 2028 and 2058 No-Build Condition AM and PM peak hour heat/speed maps. There are few changes in speed under the 2028 No-Build AM peak hour. Due to the existing deficiencies of the Route 37 eastbound to Post Road southbound movement, deficiencies are expected to escalate in the future, causing speeds on the Route 37 eastbound off-ramp to reduce with vehicle queues spilling back to the mainline. With the increase in traffic volumes in 2058, the speed on the Route 37 eastbound off-ramp would be further reduced to 10 mph or less.

Figure 4 2028 No-Build AM Peak Condition

Figure 5 2028 No-Build PM Peak Condition

Figure 6 2058 No-Build AM Peak Condition

Figure 7 2058 No-Build PM Peak Condition



Figures 8 to 11 illustrate the 2028 and 2058 Build Condition AM and PM peak hour speeds. Although the speeds along the Route 37 and Post Road corridor seem to reduce with the introduction of traffic signals, the proposed traffic signal provides simplified phasing and processes more traffic through the network compared to the No-Build alternative.

Figure 8 2028 Build AM Peak Condition

Figure 9 2028 Build PM Peak Condition

Figure 10 2058 Build AM Peak Condition

Figure 11 2058 Build PM Peak Condition

Table 5 summarizes the study area travel time segment comparison between the 2058 No-Build and Build conditions. While some segments show minor increases to travel time, the Route 37 eastbound movements to Post Road showw significant decreases in travel time, primarily in the weekday PM peak hour which was identified to be the worst-case condition.

Table 5 Travel Time Segment Comparison

	2058 No-Build				2058 Build			
	AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
Travel Time Segments	sec	min	sec	min	sec	min	sec	min
Post Rd NB	92.2	1.5	119.2	2.0	98.3	1.6	107.4	1.8
Post Rd SB	72.6	1.2	122.9	2.0	94.7	1.6	116.2	1.9
Post Rd NB to Rte 37 WB	108.1	1.8	130.2	2.2	126.3	2.1	132.1	2.2
Rte 37 EB to Post Rd SB	159.3	2.7	675.8	11.3	92.7	1.5	102.1	1.7
Rte 37 EB to Post Rd NB	111.4	1.9	485.9	8.1	96.9	1.6	106.2	1.8
Post Rd SB to Rte 37 WB	41.5	0.7	41.6	0.7	52.1	0.9	58.0	1.0

A-3
Emissions

Memorandum

To: Ken White, Ph.D.
Assistant Director for Administrative Services
Division of Planning
Rhode Island Department of Transportation
Two Capitol Hill, Room 318
Providence, Rhode Island

Date: February 24, 2023

Project #: 73337.04

From: Mark Arnoldy, PE
Kristin Caouette, PE
Peter Pavao, PE
Heidi Richards, PE

Re: Right-Sizing Route 37 Emissions Analysis

The proposed Project addresses asset management and state of good repair needs along Route 37 between I-295 (Cranston) and Post Road (Warwick) for 8 bridges. The treatments needed range from full replacement to decommissioning. Where Route 37 intersects with Route 2 New London Avenue and Route 1 Post Road, considerations are being made to improve multimodal use of those intersecting roadways within the project footprint. Multiple intersections are being proposed to replace the current interchange of Route 37 with Route 1 Post Road.

An air quality study of the Project was conducted using traffic data developed for the transportation analysis. Emission factors for the study area were developed using the Motor Vehicle Emission Simulator (MOVES3)[1]. Emissions were analyzed for the first five years of operation (2028-2032) and the design year (2058). Analyses were conducted for the No Build and Build alternatives to determine the emissions reduction associated with the Project. The emission factors represent the corresponding year of the traffic modeling. The factors were derived by calculating a seasonal average during the evening peak hour with a representative vehicle mix. Oxides of Nitrogen (NO_X), Sulfur Dioxide (SO_2), Particulate Matter 2.5 ($PM_{2.5}$), and Carbon Dioxide (CO_2) were studied based on the latest grant application guidance. Volatile Organic Compounds (VOC) and Particulate Matter 10 (PM_{10}) were estimated for informational purposes and do not have associated damage costs.

Emissions Results

The detailed emissions analyses are presented in the summary table below and on the following pages. Damages costs are calculated using the latest benefit-cost analysis guidance from the US Department of Transportation.[2] Since the guidance only includes damage costs to 2050, damages in the design year of 2058 were calculated using the 2050 values. For the purposes of quantifying benefits for the grant application, it is reasonable to apply a linear approximation for the years between 2032 and 2058 using the values estimated in this document.

[1] MOVES3 (Motor Vehicle Emission Simulator), US EPA, Office of Mobile Sources, Ann Arbor, MI.
[2] "Benefit-Cost Analysis Guidance for Discretionary Grant Programs" US DOT. January 2023.

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Table 1. Route 37 Emissions Analysis Summary

		NO_X	SO_2	$PM_{2.5}$	CO_2	VOC	PM_{10}	Total
2028	Savings (Metric Tons/yr)	0.16	0.0025	-0.006	202.9	0.11	-0.10	
	Savings ($)	$2,894	$126	-$5,504	$12,578	-	-	**$10,094**
2029	Savings (Metric Tons/yr)	0.15	0.0030	-0.004	230.2	0.12	-0.08	
	Savings ($)	$2,808	$150	-$3,863	$14,503	-	-	**$13,598**
2030	Savings (Metric Tons/yr)	0.14	0.0031	-0.004	237.2	0.12	-0.07	
	Savings ($)	$2,667	$158	-$3,666	$15,420	-	-	**$14,580**
2031	Savings (Metric Tons/yr)	0.13	0.0032	-0.004	244.1	0.12	-0.07	
	Savings ($)	$2,480	$164	-$3,355	$16,113	-	-	**$15,403**
2032	Savings (Metric Tons/yr)	0.12	0.0033	-0.003	251.0	0.13	-0.06	
	Savings ($)	$2,322	$169	-$3,020	$16,814	-	-	**$16,286**
2058	Savings (Metric Tons/yr)	0.15	0.0064	0.012	449.0	0.16	0.06	
	Savings ($)	$2,862	$329	$10,486	$39,516	-	-	**$53,193**

In the five opening years (2028-2032), the Build scenario operates with a lower average speed than the No Build scenario, but greatly reduces the distance traveled by the vehicles in the network by eliminating the loop ramps. VMT is expected to decrease from the No Build to Build scenario by approximately 11% in each of the five years. Under the Build Scenario in these five years, average speeds are estimated to have a modest 4 mph decrease relative to the No Build Scenario. As such, emission factors in each year are expected to increase from the No Build to Build scenario by a range of 7% to 20%, depending on the pollutant and year. The larger increases in emission factors are seen for Particulate Matter because a major component of this pollutant is brakewear which is largely dependent on variations in speed. For all pollutants except Particulate Matter, the anticipated decrease in VMT is larger than the corresponding increase in emission factor, resulting in a decrease in emissions. In the case of Particulate Matter, the decrease in

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speed from No Build to Build increases the brakewear emissions such that the decrease in VMT is not enough to provide a benefit. Overall, the estimated pollutant savings results in a damage benefit for the opening five years.

By 2058, the No Build scenario is expected to deteriorate from opening year levels such that the change in speed between the No Build and Build scenarios is minor (approximately 1 mph). However, the VMT in the network is expected to decrease by approximately 10 percent from No Build to Build. This decrease in VMT, as a direct result of the project eliminating the loop ramps, results in emission benefits for all pollutants. resulting in a benefit of $53,193. Further detail on the emissions analysis is presented on the following pages.

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Route 37

Emissions Reduction Benefits

		NO_X	SO_2	$PM_{2.5}$	CO_2	VOC	PM_{10}	Total
2028	Savings (Short Tons/yr)	0.18	0.0028	-0.007	223.5	0.12	-0.11	
	Savings ($)	$2,894	$126	-$5,504	$12,578	-	-	**$10,094**
2029	Savings (Short Tons/yr)	0.17	0.0033	-0.005	253.6	0.13	-0.09	
	Savings ($)	$2,808	$150	-$3,863	$14,503	-	-	**$13,598**
2030	Savings (Short Tons/yr)	0.16	0.0034	-0.004	261.3	0.13	-0.08	
	Savings ($)	$2,667	$158	-$3,666	$15,420	-	-	**$14,580**
2031	Savings (Short Tons/yr)	0.14	0.0035	-0.004	268.9	0.14	-0.08	
	Savings ($)	$2,480	$164	-$3,355	$16,113	-	-	**$15,403**
2032	Savings (Short Tons/yr)	0.14	0.0036	-0.004	276.4	0.14	-0.07	
	Savings ($)	$2,322	$169	-$3,020	$16,814	-	-	**$16,286**
2053	Savings (Short Tons/yr)	0.17	0.0071	0.013	494.6	0.17	0.07	
	Savings ($)	$2,862	$329	$10,486	$39,516	-	-	**$53,193**

*Note pollutants costs have been updated to match the updated 2023 BCA Guidance

		NO_X	SO_2	$PM_{2.5}$	CO_2	VOC	PM_{10}	Total
2028	Savings (Metric Tons/yr)	0.16	0.0025	-0.006	202.9	0.11	-0.10	
	Savings ($)	$2,894	$126	-$5,504	$12,578	-	-	**$10,094**
2029	Savings (Metric Tons/yr)	0.15	0.0030	-0.004	230.2	0.12	-0.08	
	Savings ($)	$2,808	$150	-$3,863	$14,503	-	-	**$13,598**
2030	Savings (Metric Tons/yr)	0.14	0.0031	-0.004	237.2	0.12	-0.07	
	Savings ($)	$2,667	$158	-$3,666	$15,420	-	-	**$14,580**
2031	Savings (Metric Tons/yr)	0.13	0.0032	-0.004	244.1	0.12	-0.07	
	Savings ($)	$2,480	$164	-$3,355	$16,113	-	-	**$15,403**
2032	Savings (Metric Tons/yr)	0.12	0.0033	-0.003	251.0	0.13	-0.06	
	Savings ($)	$2,322	$169	-$3,020	$16,814	-	-	**$16,286**
2053	Savings (Metric Tons/yr)	0.15	0.0064	0.012	449.0	0.16	0.06	
	Savings ($)	$2,862	$329	$10,486	$39,516	-	-	**$53,193**

Route 37 Mesoscale Air Quality Analysis

2028 Opening Year

Daily Traffic Parameters

Alt ID	Condition	Vehicle Hours Travelled (hrs/day)	Average Speed (mph)	Vehicle Miles Travelled (mi/day)	
NB	No Build	1,812	30.6	51,270	**VMT Change**
BD	Build Alternative	1,790	26.1	45,497	-11.3%

Air Pollutants

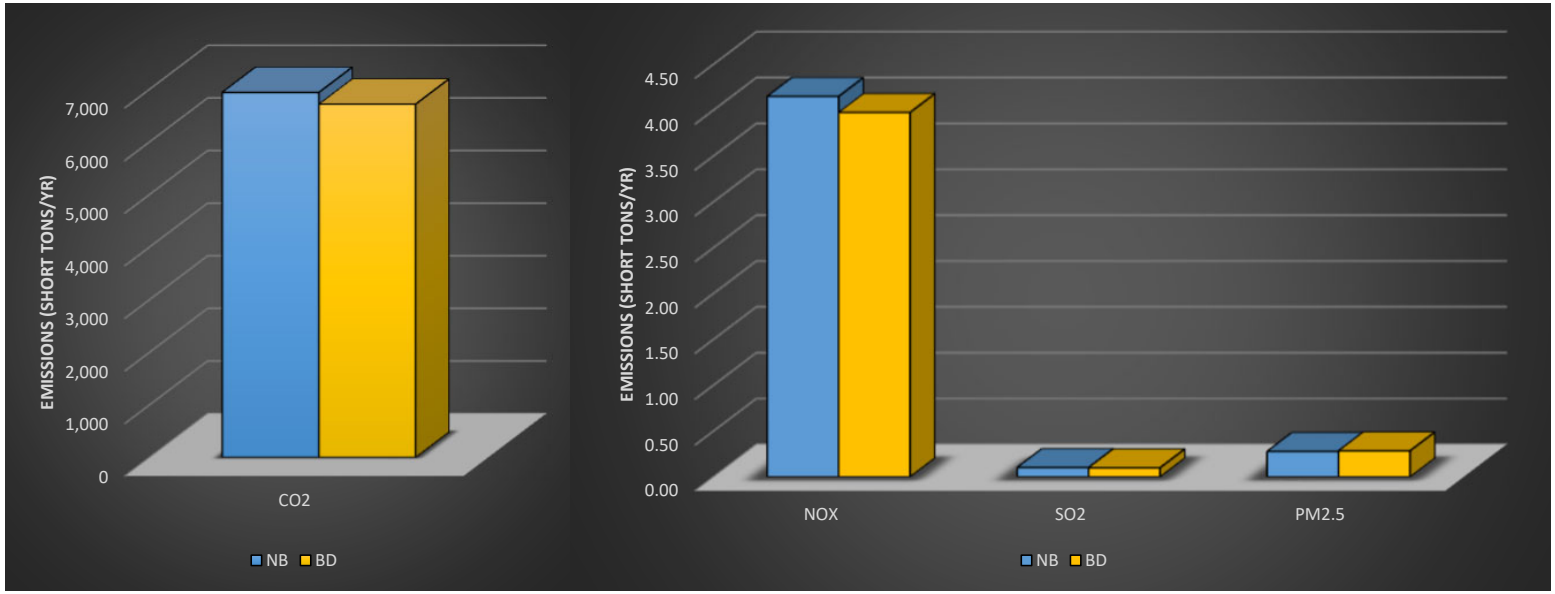
		NO_X	SO_2	$PM_{2.5}$	CO_2	VOC	PM_{10}	
		3	31	110+116+117	90	87	100+106+107	
Annual Daily	NB Emission Factor (g/mi)	0.201	0.00490	0.013	336.4	0.141	0.062	
	BD Emission Factor (g/mi)	0.217	0.00537	0.016	366.8	0.152	0.075	
	Emission Factor Change (%)	7.9%	9.6%	15.5%	9.1%	8.0%	22.1%	
	NB (kg/d)	10.31	0.251	0.69	17,245	7.21	3.16	
	BD (kg/d)	9.88	0.244	0.71	16,690	6.91	3.42	
	NB (tons/yr)	4.15	0.101	0.28	6,939	2.90	1.27	
	BD (tons/yr)	3.97	0.098	0.28	6,715	2.78	1.38	
	BD Emissions Savings (tons/yr)	**0.18**	**0.003**	**-0.01**	**223**	**0.12**	**-0.11**	
	Damage Cost ($/short ton)	$16,523	$44,939	$798,366	$56	-	-	**Total**
	BD Cost Savings ($/yr)	**$2,894**	**$126**	**-$5,504**	**$12,578**	**-**	**-**	**$10,094**

Notes:

-1 short ton equals 907.185 kilograms

Route 37 Mesoscale Air Quality Analysis

2028 Opening Year



Route 37 Mesoscale Air Quality Analysis

2029 Year

Daily Traffic Parameters

Alt ID	Condition	Vehicle Hours Travelled (hrs/day)	Average Speed (mph)	Vehicle Miles Travelled (mi/day)	
NB	No Build	1,865	29.9	51,464	**VMT Change**
BD	Build Alternative	1,801	25.9	45,730	-11.1%

Annual Daily

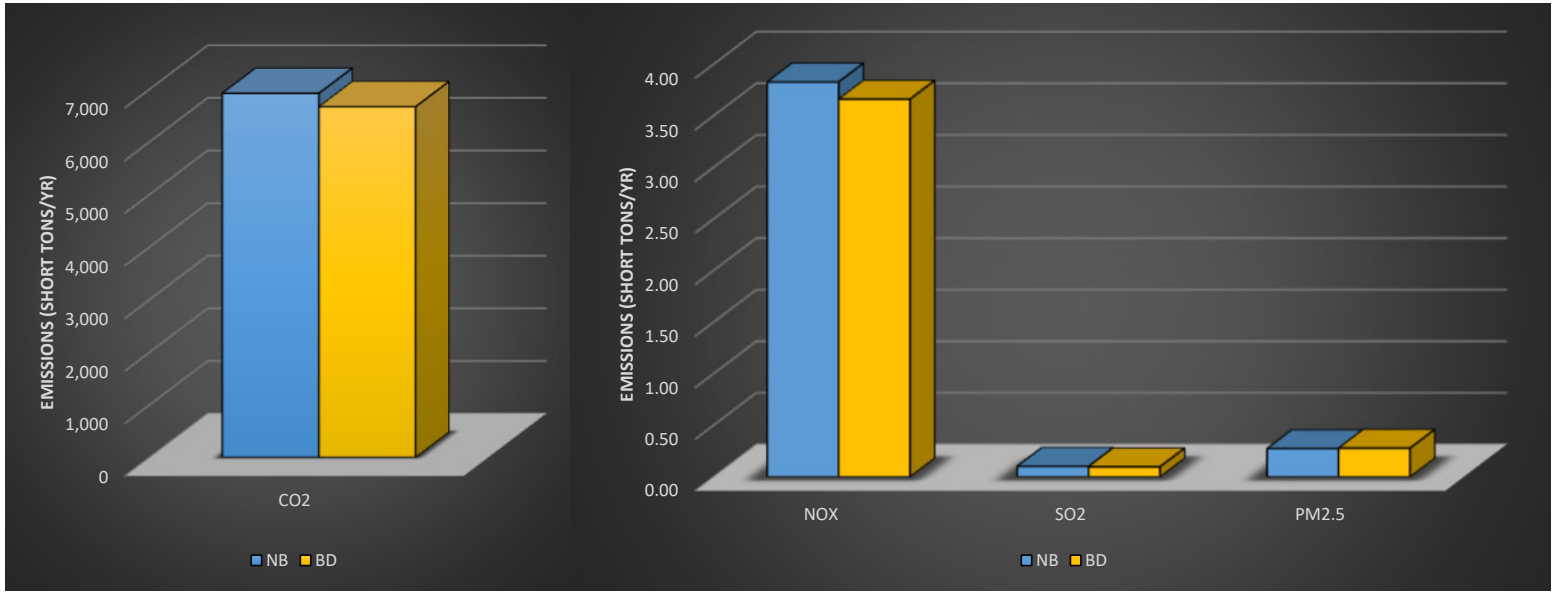
	Air Pollutants						
	NO_X	**SO_2**	**$PM_{2.5}$**	**CO_2**	**VOC**	**PM_{10}**	
	3	31	110+116+117	90	87	100+106+107	
NB Emission Factor (g/mi)	0.185	0.00487	0.013	334.2	0.138	0.063	
BD Emission Factor (g/mi)	0.199	0.00530	0.015	362.3	0.148	0.076	
Emission Factor Change (%)	7.7%	8.9%	14.5%	8.4%	7.4%	20.2%	
NB (kg/d)	9.51	0.251	0.68	17,199	7.10	3.24	
BD (kg/d)	9.10	0.243	0.69	16,569	6.77	3.46	
NB (tons/yr)	3.83	0.101	0.27	6,920	2.85	1.30	
BD (tons/yr)	3.66	0.098	0.28	6,666	2.72	1.39	
BD Emissions Savings (tons/yr)	**0.17**	**0.003**	**0.00**	**254**	**0.13**	**-0.09**	
Damage Cost ($/short ton)	$16,886	$45,756	$811,076	$57	-	-	**Total**
BD Cost Savings ($/yr)	**$2,808**	**$150**	**-$3,863**	**$14,503**	**-**	**-**	**$13,598**

Notes:

-1 short ton equals 907.185 kilograms

Route 37 Mesoscale Air Quality Analysis

2029 Year



Route 37 Mesoscale Air Quality Analysis

2030 Year

Daily Traffic Parameters

Alt ID	Condition	Vehicle Hours Travelled (hrs/day)	Average Speed (mph)	Vehicle Miles Travelled (mi/day)	
NB	No Build	1,891	29.8	51,562	**VMT Change**
BD	Build Alternative	1,807	25.8	45,846	-11.1%

Annual Daily

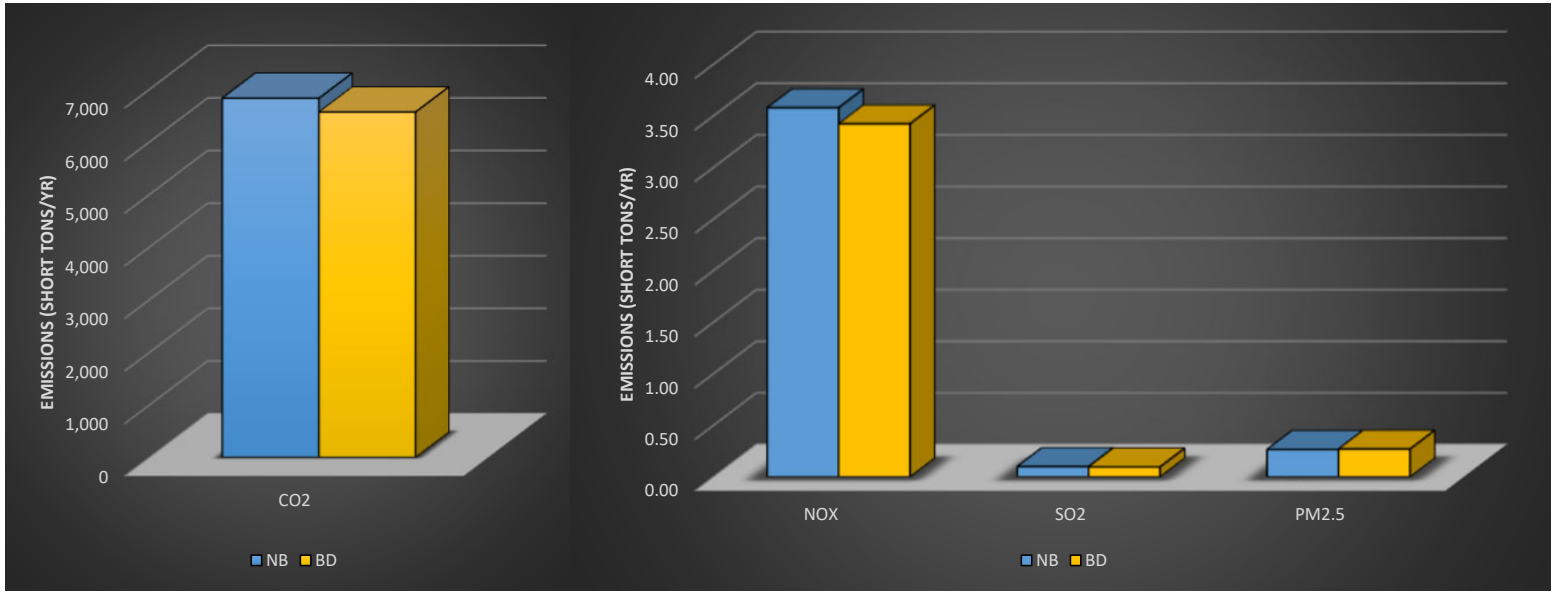
	Air Pollutants						
	NO_X	**SO_2**	**$PM_{2.5}$**	**CO_2**	**VOC**	**PM_{10}**	
	3	31	110+116+117	90	87	100+106+107	
NB Emission Factor (g/mi)	0.172	0.00479	0.013	329.1	0.134	0.063	
BD Emission Factor (g/mi)	0.186	0.00520	0.015	356.0	0.144	0.075	
Emission Factor Change (%)	7.6%	8.6%	14.4%	8.2%	7.1%	19.6%	
NB (kg/d)	8.89	0.247	0.66	16,969	6.93	3.24	
BD (kg/d)	8.51	0.239	0.67	16,320	6.60	3.45	
NB (tons/yr)	3.58	0.099	0.27	6,827	2.79	1.31	
BD (tons/yr)	3.42	0.096	0.27	6,566	2.66	1.39	
BD Emissions Savings (tons/yr)	**0.16**	**0.003**	**0.00**	**261**	**0.13**	**-0.08**	
Damage Cost ($/short ton)	$17,158	$46,573	$823,967	$59	-	-	**Total**
BD Cost Savings ($/yr)	**$2,667**	**$158**	**-$3,666**	**$15,420**	**-**	**-**	**$14,580**

Notes:

-1 short ton equals 907.185 kilograms

Route 37 Mesoscale Air Quality Analysis

2030 Year



Route 37 Mesoscale Air Quality Analysis

2031 Year

Daily Traffic Parameters

Alt ID	Condition	Vehicle Hours Travelled (hrs/day)	Average Speed (mph)	Vehicle Miles Travelled (mi/day)	
NB	No Build	1,918	29.6	51,659	**VMT Change**
BD	Build Alternative	1,813	25.8	45,963	-11.0%

Air Pollutants

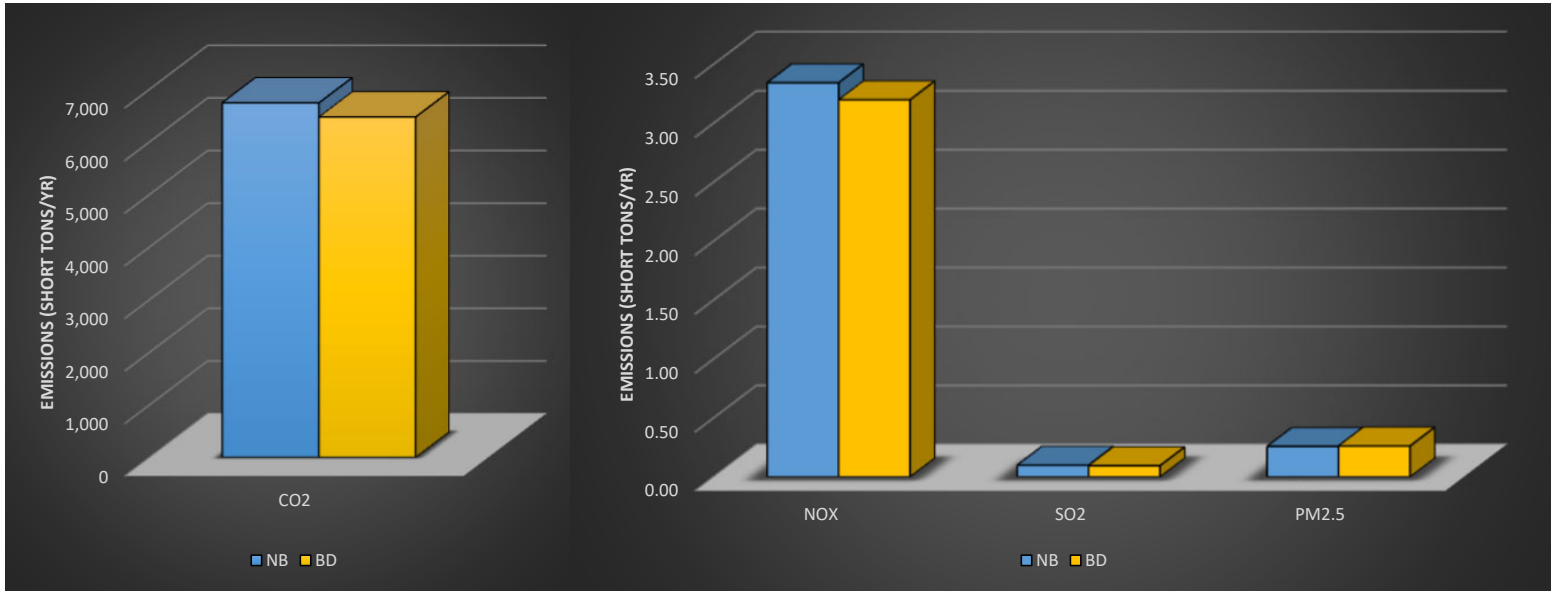
		NO_X	SO_2	$PM_{2.5}$	CO_2	VOC	PM_{10}	
		3	31	110+116+117	90	87	100+106+107	
Annual Daily	NB Emission Factor (g/mi)	0.161	0.00471	0.012	324.2	0.131	0.063	
	BD Emission Factor (g/mi)	0.173	0.00511	0.014	349.9	0.140	0.075	
	Emission Factor Change (%)	7.5%	8.4%	14.2%	7.9%	6.8%	19.0%	
	NB (kg/d)	8.31	0.244	0.64	16,750	6.78	3.25	
	BD (kg/d)	7.95	0.235	0.65	16,081	6.45	3.44	
	NB (tons/yr)	3.34	0.098	0.26	6,739	2.73	1.31	
	BD (tons/yr)	3.20	0.094	0.26	6,470	2.59	1.38	
	BD Emissions Savings (tons/yr)	**0.14**	**0.004**	**0.00**	**269**	**0.14**	**-0.08**	
	Damage Cost ($/short ton)	$17,158	$46,573	$823,967	$60	-	-	**Total**
	BD Cost Savings ($/yr)	**$2,480**	**$164**	**-$3,355**	**$16,113**	**-**	**-**	**$15,403**

Notes:

-1 short ton equals 907.185 kilograms

Route 37 Mesoscale Air Quality Analysis

2031 Year



Route 37 Mesoscale Air Quality Analysis

2032 Year

Daily Traffic Parameters

Alt ID	Condition	Vehicle Hours Travelled (hrs/day)	Average Speed (mph)	Vehicle Miles Travelled (mi/day)	
NB	No Build	1,944	29.5	51,756	**VMT Change**
BD	Build Alternative	1,819	25.8	46,079	-11.0%

Annual Daily

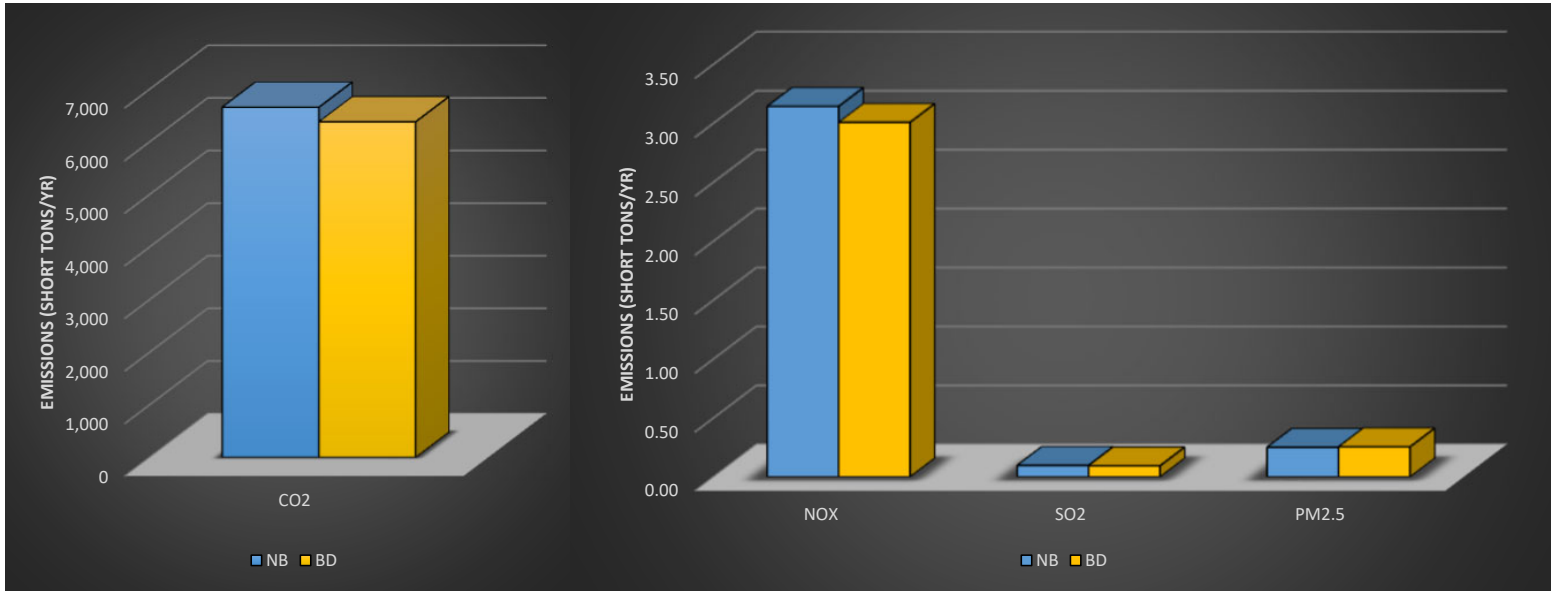
	Air Pollutants						
	NO_X	**SO_2**	**$PM_{2.5}$**	**CO_2**	**VOC**	**PM_{10}**	
	3	31	110+116+117	90	87	100+106+107	
NB Emission Factor (g/mi)	0.151	0.00464	0.012	319.6	0.129	0.063	
BD Emission Factor (g/mi)	0.162	0.00502	0.014	344.1	0.137	0.074	
Emission Factor Change (%)	7.5%	8.1%	14.0%	7.7%	6.5%	18.3%	
NB (kg/d)	7.81	0.240	0.62	16,543	6.67	3.25	
BD (kg/d)	7.47	0.231	0.63	15,856	6.33	3.42	
NB (tons/yr)	3.14	0.097	0.25	6,656	2.69	1.31	
BD (tons/yr)	3.01	0.093	0.25	6,379	2.55	1.38	
BD Emissions Savings (tons/yr)	**0.14**	**0.004**	**0.00**	**276**	**0.14**	**-0.07**	
Damage Cost ($/short ton)	$17,158	$46,573	$823,967	$61	-	-	**Total**
BD Cost Savings ($/yr)	**$2,322**	**$169**	**-$3,020**	**$16,814**	**-**	**-**	**$16,286**

Notes:

-1 short ton equals 907.185 kilograms

Route 37 Mesoscale Air Quality Analysis

2032 Year



Route 37 Mesoscale Air Quality Analysis

2058 Design Year

Daily Traffic Parameters

Alt ID	Condition	Vehicle Hours Travelled (hrs/day)	Average Speed (mph)	Vehicle Miles Travelled (mi/day)	
NB	No Build	2,602	26.7	54,183	**VMT Change**
BD	Build Alternative	1,963	25.8	48,992	-9.6%

Air Pollutants

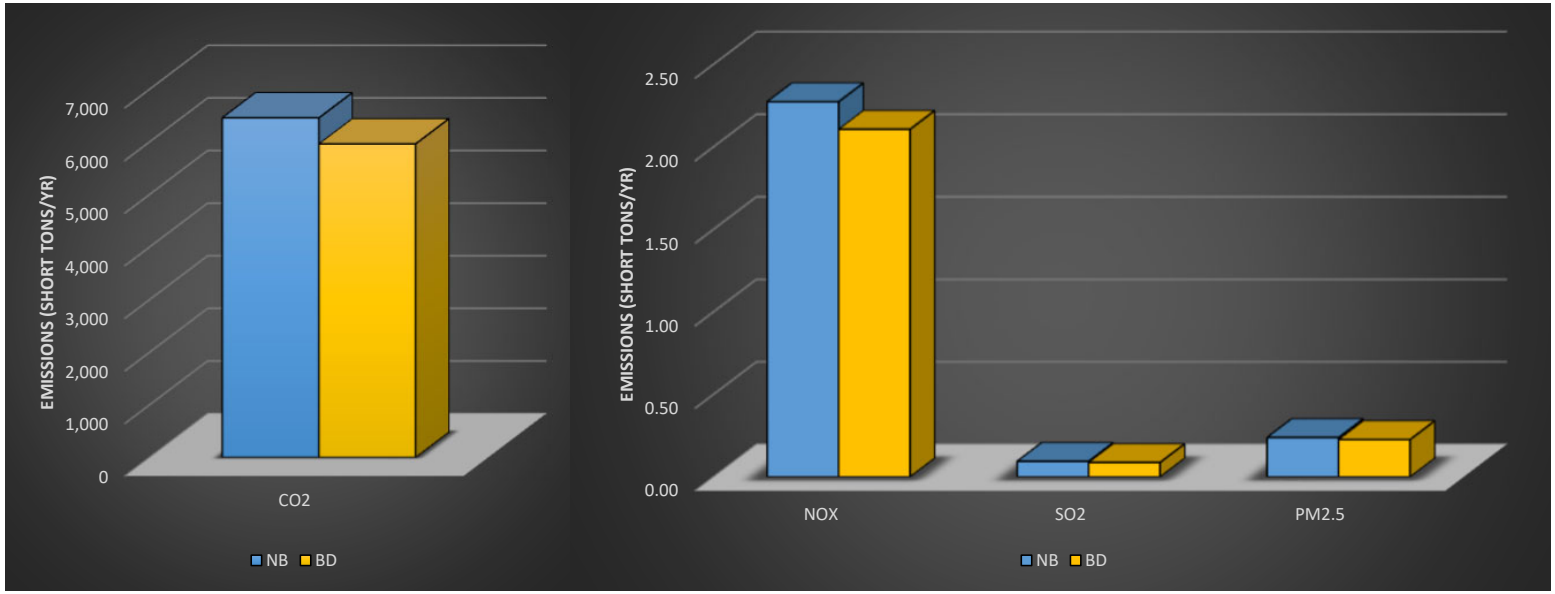
		NO_X	SO_2	$PM_{2.5}$	CO_2	VOC	PM_{10}	
		3	31	110+116+117	90	87	100+106+107	
Annual Daily	NB Emission Factor (g/mi)	0.104	0.00429	0.011	296.0	0.100	0.068	
	BD Emission Factor (g/mi)	0.107	0.00439	0.011	302.3	0.102	0.072	
	Emission Factor Change (%)	2.5%	2.2%	4.7%	2.1%	1.8%	5.4%	
	NB (kg/d)	5.65	0.233	0.59	16,040	5.42	3.71	
	BD (kg/d)	5.23	0.215	0.56	14,811	4.98	3.53	
	NB (tons/yr)	2.27	0.094	0.24	6,454	2.18	1.49	
	BD (tons/yr)	2.11	0.086	0.23	5,959	2.01	1.42	
	BD Emissions Savings (tons/yr)	**0.17**	**0.007**	**0.01**	**495**	**0.17**	**0.07**	
	Damage Cost ($/short ton)	$17,158	$46,573	$823,967	$80	-	-	**Total**
	BD Cost Savings ($/yr)	**$2,862**	**$329**	**$10,486**	**$39,516**	**-**	**-**	**$53,193**

Notes:

-1 short ton equals 907.185 kilograms

Route 37 Mesoscale Air Quality Analysis

2058 Design Year



A-4

Infrastructure Maintenance Plans

Memorandum

To: Ken White, Ph.D.
Assistant Director for Administrative Services
Division of Planning
Rhode Island Department of Transportation
Two Capitol Hill, Room 318
Providence, Rhode Island

Date: February 22, 2023

Project #: 73337.04

From: Kristin Caouette, PE

Re: RIDOT Bridge Maintenance Plan – Lifecycle Management Costs

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Based on historic construction project bids for RIDOT of comparable size, the estimated price for high-friction surface treatment is assumed to be $30 per square yard, conservatively. Table 1 below summarizes recent estimates.

It is assumed that high-friction surface treatment will be applied every 10 years.

Table 1 Historic Price Estimates

PRICE JUSTIFICATION			
Reference Contract	**Quantity (SY)**	**Award**	**WAUP All**
2022-CS-044	24,500	$ 25.90	$ 28.73
2021-CT-016	15,400	$ 25.00	$ 28.88

Memorandum

To: Ken White, Ph.D.
Assistant Director for Administrative Services
Division of Planning
Rhode Island Department of Transportation
Two Capitol Hill, Room 318
Providence, Rhode Island

Date: February 22, 2023

Project #: 73337.04

From: Kristin Caouette, PE

Re: RIDOT Bridge Maintenance Plan – Lifecycle Management Costs

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Working on behalf of RIDOT, the following future bridge maintenance activities have been identified by RIDOT (February 17, 2023) for the following bridges:

- 816 Meshanticut Brook Culvert #6
- 623 Oaklawn Avenue
- 616 Glen Hills
- 624 New London Avenue
- 636 Hillgrove Railroad carrying Route 37 EB
- 637 Hillsgrove Railroad carrying Route 37 WB

This proposed maintenance plan assumes that RAISE funds have been awarded to complete the Right-Sizing Route 37 project in its entirety. The attached maintenance plans document future lifecycle costs for the six bridges in the study area. This plan assumes that Bridge 625: Howard Bridge/Power Road and Bridge 638: Post Road have been demolished.

Per RIDOT, this bridge maintenance plan assumes:

- Maintenance program based on a 30-year projection.
- All costs are in current year dollars and raw construction costs only to perform the actual work (no factors for design or construction related services).
- Planned work strategies were developed based on a combination of the deterioration modeling component of AASHTOWare BrM and past experience.

MESHANICUT BROOK CULVERT BRIDGE NO. 081601

2/17/2023

BRIDGE MAINTENANCE & PRESERVATION SUMMARY			
#	YEAR	WORK DESCRIPTION/ACTION(S)	TODAY $
0	2025	Minor Rehab	$ -
5	2030	Remove Channel Debris, Clearing/Vegetation Removal	$ 10,000
10	2035	Remove Channel Debris, Clearing/Vegetation Removal	$ 10,000
15	2040	Remove Channel Debris, Clearing/Vegetation Removal	$ 10,000
20	2045	RC Repairs (Culvert), Remove Channel Debris, Clearing/Vegetation Removal	$ 60,000
25	2050	Remove Channel Debris, Clearing/Vegetation Removal	$ 10,000
30	2055	Remove Channel Debris, Clearing/Vegetation Removal	$ 10,000
		Agency Cost	**$ 110,000**

OAKLAWN AVENUE BRIDGE NO. 062301

2/17/2023

BRIDGE MAINTENANCE & PRESERVATION SUMMARY			
#	YEAR	WORK DESCRIPTION/ACTION(S)	TODAY $
0	2025	Bridge Replacement	$ -
2	2027	Bridge Washing	$ 17,500
4	2029	Bridge Washing	$ 17,500
6	2031	Bridge Washing	$ 17,500
8	2033	Bridge Washing	$ 17,500
10	2035	Bridge Washing, Replace Joints, RC Protective Coating	$ 93,300
12	2037	Bridge Washing	$ 17,500
14	2039	Bridge Washing	$ 17,500
16	2041	Bridge Washing	$ 17,500
18	2043	Bridge Washing	$ 17,500
20	2045	Bridge Washing, Replace Joints, RC Protective Coating, Full Painting, RC Patching (Subs)	$ 900,600
22	2047	Bridge Washing	$ 17,500
24	2049	Bridge Washing	$ 17,500
25	2050	Repl. Membrane & Overlay, Minor Deck Repairs	$ 403,700
26	2051	Bridge Washing	$ 17,500
28	2053	Bridge Washing	$ 17,500
30	2055	Bridge Washing, Replace Joints, RC Protective Coating	$ 93,300
		Agency Cost	**$ 1,700,900**

BRIDGE MAINTENANCE & PRESERVATION SUMMARY			
#	YEAR	WORK DESCRIPTION/ACTION(S)	TODAY $
0	2025	Minor Rehab	$ -
2	2027	Bridge Washing	$ 11,200
4	2029	Bridge Washing	$ 11,200
6	2031	Bridge Washing	$ 11,200
8	2033	Bridge Washing	$ 11,200
10	2035	Bridge Washing, Replace Joints, RC Protective Coating	$ 58,500
12	2037	Bridge Washing	$ 11,200
14	2039	Bridge Washing	$ 11,200
16	2041	Bridge Washing	$ 11,200
18	2043	Bridge Washing	$ 11,200
20	2045	Bridge Washing, Replace Joints, RC Protective Coating, RC Beam End Repair, RC Patching (Subs)	$ 241,300
22	2047	Bridge Washing	$ 11,200
24	2049	Bridge Washing	$ 11,200
25	2050	Repl. Membrane & Overlay, Minor Deck Repairs	$ 274,800
26	2051	Bridge Washing	$ 11,200
28	2053	Bridge Washing	$ 11,200
30	2055	Bridge Washing, Replace Joints, RC Protective Coating	$ 58,500
		Agency Cost	**$ 767,500**

NEW LONDON AVENUE BRIDGE NO. 062401

2/17/2023

BRIDGE MAINTENANCE & PRESERVATION SUMMARY			
#	YEAR	WORK DESCRIPTION/ACTION(S)	TODAY $
0	2025	Bridge Replacement	$ -
2	2027	Bridge Washing	$ 20,800
4	2029	Bridge Washing	$ 20,800
6	2031	Bridge Washing	$ 20,800
8	2033	Bridge Washing	$ 20,800
10	2035	Bridge Washing, Replace Joints, RC Protective Coating	$ 112,100
12	2037	Bridge Washing	$ 20,800
14	2039	Bridge Washing	$ 20,800
16	2041	Bridge Washing	$ 20,800
18	2043	Bridge Washing	$ 20,800
20	2045	Bridge Washing, Replace Joints, RC Protective Coating, Full Painting, RC Patching (Subs)	$ 1,120,100
22	2047	Bridge Washing	$ 20,800
24	2049	Bridge Washing	$ 20,800
25	2050	Repl. Membrane & Overlay, Minor Deck Repairs	$ 504,000
26	2051	Bridge Washing	$ 20,800
28	2053	Bridge Washing	$ 20,800
30	2055	Bridge Washing, Replace Joints, RC Protective Coating	$ 112,100
		Agency Cost	**$ 2,097,900**

BRIDGE MAINTENANCE & PRESERVATION SUMMARY			
#	YEAR	WORK DESCRIPTION/ACTION(S)	TODAY $
0	2025	Replace Joints, RC Protective Coating, Full Painting, Repl. Membrane & Overlay, Minor Deck Repairs (<10%), RC Patching (Subs), Steel Repairs (Moderate), Replace Bearings (Partial)	$ 1,658,000
2	2027	Bridge Washing	$ 17,700
4	2029	Bridge Washing	$ 17,700
6	2031	Bridge Washing	$ 17,700
8	2033	Bridge Washing	$ 17,700
10	2035	Bridge Washing, Replace Joints, RC Protective Coating, RC Patching (Subs)	$ 155,300
12	2037	Bridge Washing	$ 17,700
14	2039	Bridge Washing	$ 17,700
16	2041	Bridge Washing	$ 17,700
18	2043	Bridge Washing	$ 17,700
20	2045	Bridge Washing, Replace Joints, RC Protective Coating, RC Patching (Subs), Spot Painting, Steel Repairs (Minor)	$ 319,500
22	2047	Bridge Washing	$ 17,700
24	2049	Bridge Washing	$ 17,700
26	2051	Bridge Washing	$ 17,700
28	2053	Bridge Washing	$ 17,700
30	2055	Bridge Replacement	$ 8,755,200
		Agency Cost	**$ 11,100,400**