Note - this Benefit Cost Analysis was submitted to the USDOT RAISE program in February 2023. The costs, planning horizon, etc. are consistent with that grant application. These benefits are applicable for the H-GAC Call for Projects.

Montrose Boulevard Safety and Multimodal Access Project

Benefit Cost Analysis Narrative

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Executive Summary

The 2023 USDOT Benefit-Cost Analysis (BCA) Guidance for Discretionary Grant Programs provides the foundation for the methodologies used to estimate the quantified and subsequent monetized benefits in this BCA.[1] The evaluation process examines the fundamental question of whether the expected societal benefits of the project justify the cost with the understanding that some benefits and costs are difficult to quantify. This analysis examines how the No-Build and Build Scenarios improve the societal benefits throughout the planning horizon.

The BCA quantifies the net difference between the No-Build and Build Scenarios for the project corridor. The Montrose Boulevard Safety and Multimodal Access Project ("Project") limits are described in Table 1.

Table 1. Project Limits

Street	Terminus A	Terminus B
Montrose Boulevard	U.S. Route 59 (US-59)	Halfway Between W Gray Street and W Clay Street

The **No-Build Scenario** assumes that the roadway will continue to deteriorate and be minimally maintained throughout the planning horizon. The planning horizon includes 25 years, from 2024 to 2049.

The **Build Scenario** assumes a replacement of infrastructure within public right-of-way (ROW) along the project limits, which will include the following major components:

- Reconstruct the roadway with new concrete panels and reduce travel lane widths.
- Expand existing sidewalks along both sides of the project corridor to 10 feet wherever possible and install ADA compliant ramps.
- Reduce speed limit in the north of Westheimer Road from 35 mile per hour (MPH) to 30 MPH and increase trees along the corridor which can also encourage slower vehicle speeds to increase safety.
- Extend turn lanes along Montrose Boulevard to 150' at select signalized intersections.
- Add a median south of Westheimer Road to create a divided roadway for the entirety of the project extents. The median enables enhanced crossing

1 United States Department of Transportation (2022). Benefit-Cost Analysis Guidance for Discretionary Grant Programs. Retrieved August 2022 from https://www.transportation.gov/office-policy/transportation-policy/benefit-cost-analysis-guidance-discretionary-grant-programs-0

treatments including Rectangular Rapid-Flashing Beacons (RRFB) and pedestrian refuges at unsignalized intersections. Left turn lanes will be added at certain intersections in conjunction with the new median.

- Install pavement markings and advance signage at unsignalized intersections.
- Upgrade traffic signals.
- Enhance bus stop platforms designed to BOOST standards that accommodate full-size shelters, unobstructed sidewalks, and bus stop amenities; improve bus travel time through signal priority and streamlined stops.
- Reconstruct the storm sewer system much deeper from the outfall working upstream and replace aging utilities along the Project corridor that have exceeded their useful life.
- Remove on-street parking on Montrose Boulevard to reduce points of conflicts on the corridor and accommodate a median and pedestrian realm.

Summarized Planning, Design, Environmental, and Capital Costs

The costs (excluding on-going maintenance) for the Project in year of expenditure, or nominal dollars, is $63,032,000. The annual inflation factor of 2.44% applied to the projected costs (nominal $), was discounted from the year of expenditure to reflect the real $ in year 2021. The 2.24% inflation factor is derived from the inflation adjustment values found in Table A-7 in the 2023 USDOT BCA Guide.[1] The total project cost in 2021 real dollars is $54,878,000. These costs are discounted 7% from the expenditure year to year 2021. The total year 2021 real discounted costs are $37,424,000. Project costs are described in Table 2.

Table 2. Project Costs

Cost	Nominal $ Year of Expenditure No Discount	Real $ $2021 No Discount	7% Discount $2021
Planning	$30,000	$30,000	$30,000
Design/Environmental	$4,908,000	$4,607,000	$3,878,000
Construction	$58,094,000	$50,241,000	$33,515,000
Project Costs	**$63,032,000**	**$54,878,000**	**$37,424,000**

Summarized Benefits

The proposed Project will provide a variety of societal benefits to the national, state, and local transportation system.

The No-Build Scenario will result in the following[2]:

[2] Gauge Engineering. (August 2022). Design Concept Report Montrose Boulevard Improvements Allen Parkway to US-59.

- The pavement condition along the project corridor will likely remain **poor**. The 2019 City of Houston's Pavement Condition Rating (PCR) for Montrose Boulevard shows that the pavement conditions vary from Fair to Satisfactory with PCR values ranging from 61 to 87. There are certain sections that were observed to be in poor condition. During the field visit conducted by the project team, it was observed that the pavement has deteriorated since then. Notable damage exists in the vicinity of Richmond Avenue, from Alabama Street to Hawthorne Street, and around Westheimer Road. From Richmond Avenue to Hawthorne Street there exists significant longitudinal and transverse cracking and a notable presence of potholes, in both the northbound and southbound directions. Failed patching is evident throughout, increasing in severity nearer the edges of the roadway. From Westheimer Road to the northern Project limits there is notable transverse cracking of the concrete throughout. This section also has prevalent pothole patching failure. Striping is poor throughout the length of the corridor. Curbs are in generally acceptable condition where present, although when broken or missing are overrun with vegetation or runoff sediment.
- The existing sidewalk will continue to be in **disrepair**. The existing narrow sidewalks on both sides of Montrose Boulevard, ranging from 4 to 6 feet, are mostly in poor condition. These sections have unpaved areas to accommodate trees and their root systems. There are a few areas where tree roots have damaged the sidewalk, causing cracks and vertical changes in level making a hazardous condition for pedestrians. Several intersections along the corridor lack ADA compliant ramps, and existing ramps are often overgrown with vegetation or in poor condition.
- The access management of the project corridor will continue to be **inadequate**. An access management assessment of the corridor intersections has determined that there are one or more non-compliant access management measures as described in the City of Houston Infrastructure Design Manual (COH IDM). Most of the intersections do not meet the minimum ROW corner cutbacks, driveway spacing, or median lengths required by the COH IDM.
- The existing storm sewer system along the corridor will remain **undersized**. Sections from Richmond Ave to Marshall Street and Lovett Boulevard to Hyde Park Boulevard lack a truckline. The pipes in service have unknown dates of installation and will likely be reaching the end of their useful service life.
- The transit service provided along the corridor will remain the same with **inadequate** transit stops. Many of the existing bus stops lack accessible boarding zones, shelters, and other transit stop elements and amenities, detracting from existing riders' transit experience and discouraging transit use. The current spacing and placing of bus stops, typically located on the near side

of intersections every eighth mile, contributes to bus delays and slow travel speeds on the 56 Airline/Montrose route.

- The Corridor will likely remain **unsafe** with poor sight-distances, aging sidewalks, limited pedestrian crossings and no bicycle facilities. The existing infrastructure limits opportunities for pedestrians and bicyclists to safely cross Montrose Boulevard at locations other than signalized intersections, reducing walking access to destinations and detracting from the safety of vulnerable road users. The lack of accessible median refuges force pedestrians to cross the four lanes of fast, heavy traffic on Montrose Boulevard in unsafe conditions, and the lack of marked crosswalks, advance signage, and visibility enhancements leads to low yielding rates by vehicles. Pedestrians must either wait for a sufficient gap in traffic at unsignalized intersections, deviate up to a third of a mile to cross via a signalized intersection, or cross in a risky fashion that jeopardizes their safety.

Moving forward with the **Build Scenario** will result in the following monetized societal benefits; however, there are some disbenefits also associated with the Project, as explained below:

Benefits Monetized – Transportation

- **Benefit 1: Remaining Useful Life of Asset**
  - The asset will be built with a useful life of 50 years, therefore there will be 60% remaining useful life at the end of the planning horizon.
- **Benefit 2: Maintenance (Disbenefit)**
  - The Project will build new or replace existing facilities that will lead to a change in on-going maintenance costs.
- **Benefit 3: State of Good Repair**
  - The Project will replace the pavement, which will significantly reduce vehicle wear and tear and ongoing maintenance costs.
- **Benefit 4: Motorist Safety Improvements**
  - The Project will provide significant safety improvements and as a result, a likely reduction of motor vehicle crashes (separate from pedestrian and bicycle related crashes).
- **Benefit 5: Pedestrian Safety Improvements**
  - The Project will experience significant pedestrian safety improvements and as a result, a likely reduction of pedestrian related injuries.
- **Benefit 6: Bicycle Safety Improvements**

    - The Project will experience significant bicycle safety improvements and as a result, a likely reduction of bicycle related injuries.
- **Benefit 7: Facility Improvements – Walking**
    - The Project will improve sidewalks and therefore improve the quality or comfort of journeys made by pedestrians.
- **Benefit 8: Facility Improvements – Cycling**
    - The Project will improve bicycle facilities and therefore improve the quality or comfort of journeys made by cyclists.
- **Benefit 9: Facility improvements – Transit**
    - The Project will improve transit service and amenities, therefore improve the quality or comfort of journeys made by transit users.
- **Benefit 10: Value of Travel Time**
    - The Project will improve the roadway infrastructure, therefore reduce travel delays.
- **Benefit 11: Operating Cost Savings – Walking**
    - The Project will include upgraded sidewalks and therefore encourage active transportation ultimately reducing automobile usage.
- **Benefit 12: Operating Cost Savings – Cycling**
    - The Project will include new bike facilities and therefore encourage active transportation ultimately reducing automobile usage.
- **Benefit 13: Operating Cost Savings – Transit**
    - The Project will include new transit amenities for users and therefore encourage transit usage, ultimately reducing automobile usage.
- **Benefit 14: Mortality Reduction Benefits — Walking**
    - The Project will encourage more walking which can lead to a reduction in mortality risks for pedestrians.
- **Benefit 15: Mortality Reduction Benefits — Cycling**
    - The Project will encourage more cycling which can lead to a reduction in mortality risks for bicyclists.
- **Benefit 16: Congestion Externalities Reduction**
    - The Project will include new active transportation facilities and therefore encourage active transportation, which reduces automobile usage and results in reduced congestion externalities.
- **Benefit 17: Emissions Reduction – Walking**
    - The Project will include upgraded sidewalks and therefore encourage active transportation, which reduces automobile usage and therefore a reduction of emissions from automobile usage.
- **Benefit 18: Emissions Reduction – Cycling**

    - The Project will include new bicycle facilities and therefore encourage active transportation, which reduces automobile usage and therefore a reduction of emissions from automobile usage.
- **Benefit 19: Emissions Reduction – Transit**
    - The Project will improve transit amenities and therefore encourage transit usage, which reduces automobile usage and therefore a reduction of emissions from automobile usage.
- **Benefit 20: Auto Idling Fuel Saving Benefits (Disbenefit)**
    - The Project will modernize existing traffic signals, however automobile idling time will be increased and does not lower fuel consumption.
- **Benefit 21: Auto Idling Environmental Benefits (Disbenefit)**
    - The Project will modernize existing traffic signals, however, automobile idling time will be increased.

The baseline (No-Build) and Build methodology and calculations for each benefit are contained within this technical memorandum, supported by the BCA Excel Workbook. The benefits are quantified and monetized for the BCA.

Benefits and costs in real dollars and discounted real dollars are showing in the following table. Real dollars, also known as inflation-free dollars or constant dollars, stands for dollars that are netted out the effect of inflation by using a common base year. Discounting is made to account for the time value of money. It means benefits and costs that occur sooner rather than later are valued more, and there is thus a cost associated with diverting the resources needed for an investment from other productive uses in the future.[3] Future streams of benefits and costs will be expressed in the same present value terms after discounting.

The benefit-cost ratio is 2.6 in 2021 real dollars and when discounted at a 7% discount rate, the benefit-cost ratio is 1.1. The 2021 real dollar NPV is $89,301,000 and when discounted at 7%, $3,587,000.

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3 Federal Highway Administration. Benefit-Cost Analysis Guidance for Discretionary Grant Programs https://www.transportation.gov/sites/dot.gov/files/2022-03/Benefit%20Cost%20Analysis%20Guidance%202022%20%28Revised%29.pdf

Table 3. BCA Summary

Scenario	$2021 Real Dollars	$2021 Real Dollars 7% Discount
Benefits	$144,179,000	$41,011,000
Costs	$54,878,000	$37,424,000
BCA	2.60	1.10
NPV	$89,301,000	$3,587,000

Table 4 summarizes the Project benefits.

Table 4. Project Benefits Summary

Benefit	Current Status/Baseline and Problem to be Addressed	Change to Baseline or Alternatives	Types of Impacts	$2021 Monetized Value	$2021 Real Dollars 7% Discount Rate
Benefit 1: Remaining Useful Life of Asset	The current asset has 0% remaining useful life	Replace infrastructure within public right-of-way	Extend useful life	$34,856,000	$5,242,000
Benefit 2: Maintenance	Ongoing maintenance for existing bus shelters	Ongoing maintenance for new BOOST bus shelters	Maintenance cost change	-$352,000	-$107,000
Benefit 3: State of Good Repair	Ongoing expensive maintenance of roadway pavement	Low maintenance required of new facility through the planning horizon	Maintenance cost savings	$11,716,000	$3,784,000
Benefits 4, 5 and 6: Safety Benefits	Outdated design, disproportionally higher crash rates	Safety improvement resulting in reduction in traffic crashes	Reduced crashes resulting in reduced fatalities and injuries	$46,286,000	$15,670,000
Benefits 7, 8, and 9: Facility Improvements	The current facilities are not conductive for active transportation or using transit	Improvements to the current facilities will improve the quality or comfort of journeys	Improved comfort for active transportation and public transportation users	$13,652,000	$4,283,000
Benefit 10: Value of Travel Time	The current facilities lead to significant delay of users.	Improvements to the current facilities will reduce delay	Travel time savings	$8,808,000	$2,795,000

Benefit	Current Status/Baseline and Problem to be Addressed	Change to Baseline or Alternatives	Types of Impacts	$2021 Monetized Value	$2021 Real Dollars 7% Discount Rate
Benefits 11, 12 and 13: Operating Cost Savings	The current facilities result in limited demand of walking, biking, and transit usage	New and improved walking, biking, and transit facilities will induce demand	Reduced operating costs derived from modal shift from driving personal vehicles to walking, biking, and taking transit	$387,000	$122,000
Benefit 14 and 15: Mortality Reduction Benefits	Roadway is not conducive for active transportation.	New and improved active transportation facilities will encourage more walking and cycling	Reduced mortality risks associated with increased walking and cycling	$26,480,000	$8,168,000
Benefits 16: Congestion Externalities Reduction	Roadway is not conducive for active transportation.	New and improved facilities will encourage more walking and cycling	Reduced congestion externalities	$1,048,000	$333,000
Benefits 17, 18, and 19: Emissions Reduction	The current facilities are not conductive for active transportation or using transit	Improvements to the existing facilities will induce demand for walking, cycling, and taking transit	Reduced emission derived from modal shift from driving personal vehicles to walking, biking, and taking transit	$1,476,000	$799,000
Benefit 20 and 21: Automobile Idling Emissions and Fuel Consumption	Vehicle idling results in exhaust and the consumption of fuel	Improvements slightly increase automobile emissions and fuel consumption	Increased exhaust and fuel consumption	-$179,000	-$80,000
			Totals	**$144,178,000**	**$41,009,000**

Foundations to Benefit / Cost Analysis

The following methodologies and/or general assumptions are used to quantify the benefits for the Project.

Real Dollars & Discount Rate

All monetized values in both benefit and cost equations within the analysis have been converted to a base year (real dollars) of 2021. Cost elements that were expended or derived from cost estimates in prior years were inflated using the inflation adjustment values found in Table A-7 in the 2023 USDOT BCA Guidance for Discretionary Grant Programs.[1] The inflation factors were removed for non-capital and operational cost elements (e.g., safety monetization factor) that occurred in 2021.

The OMB Circular A-94 provides guidance on discount rates. As a default position, OMB Circular A-94 states that a discount rate of 7% should be used as a base-case for regulatory analysis. The 7% rate is an estimate of the average before-tax rate of return to private capital in the U.S. economy. It is a broad measure that reflects the returns to real estate and small business capital as well as corporate capital. A 7% discount rate was applied to all 2021 real dollar monetized costs and benefits.

Planning, design, environmental and capital costs

The costs for the Project in year of expenditure, or nominal dollars, is $63,032,000. The annual inflation factor of 2.24% applied to the projected costs (nominal $), was discounted from the year of expenditure to reflect the real $ in year 2021. The 2.24% inflation factor is derived from the 2003 to 2021 inflation adjustment values found in Table A-7 in the 2023 USDOT BCA Guide. The total project cost in 2021 real dollars is $54,878,000. These costs are discounted 7% from the expenditure year to year 2021. The total year 2021 real discounted costs are $37,424,000.

Planning Horizon

The 25-year planning horizon is from 2024 to 2049 and discounted at 7% to 2021 dollars. The Project is assumed to open in 2029; thus, most benefits are generally quantified for a 20-year period, from 2029-2049 once the facility is open for users.

No-Build Scenario

The No-Build Scenario assumes that roadway improvements will only consist of minimal planned improvements to the project corridor within the No-Build Scenario.

Benefit 1: Remaining Useful Life of Asset

No-Build Scenario

The roadway in the Project corridor will need to be repaired throughout the planning horizon.

Build Scenario

The Project will be designed and constructed for a useful life of 50 years.[4]

Methodology/Summary

The residual life benefit assumes there will be 60% of the Project life remaining at the end of the planning horizon. The residual life benefit only captures 60% of the construction cost of the Project. Using Equation 1, the remaining useful life for the Project is calculated.

Equation 1. Useful Life Methodology

Useful Life = Construction Costs * 60%

Accumulated benefits for the 25-year horizon are quantified and discounted at a 7% rate, shown in Table 5.

Table 5. Useful Life Benefit

Scenario	Monetized Values
No-Build Benefit	$0
Build Benefit	$34,856,000
Net Benefit	**$34,856,000**
Net Benefit Discounted @ 7% to $2021	**$5,242,000**

Benefit 2: Maintenance

No-Build Scenario

The Metropolitan Transit Authority of Harris County (Houston METRO) or the Montrose Redevelopment Authority will continue to maintain the existing bus shelters on the project corridor throughout the planning horizon.

4 City of Houston (2022). Public Works Infrastructure Design Manual. Retrieved August 2022 from https://www.houstonpermittingcenter.org/news-events/2021-infrastructure-design-manual-announcement

Build Scenario

The Project will remove and replace existing bus shelters on the project corridor with standard BOOST bus shelters and add new shelters at stops that did not previously exist. All new shelters will require maintenance.

Methodology/Summary

The maintenance benefit is equal to the difference between the on-going maintenance cost for the existing bus shelters and the new maintenance cost for the BOOST bus shelters.

Equation 2. Maintenance Cost Methodology

Maintenance Cost = Existing Maintenance Cost – New Maintenance Cost

Accumulated benefits for the 25-year horizon are quantified and discounted at a 7% rate, shown in Table 5.

Table 6. Maintenance Benefit

Scenario	Monetized Values
No-Build Benefit	$150,000
Build Benefit	$480,000
Net Benefit	**-$352,000**
Net Benefit Discounted @ 7% to $2021	**-$107,000**

Benefit 3: State of Good Repair

Maintenance and user costs associated with the condition of a roadway's surface are significant factors in the decision to continue with the current pavement or to replace it. The capital expenditure required for a reconstruction project may make economic sense if it saves money over the planning horizon. Demonstrating a roadway's current surface condition, or state of good repair (SOGR), and projecting the costs and benefits for alternative maintenance strategies will provide the information needed to make this decision.

No-Build Scenario

Continue maintenance strategy through remaining life of facility. The roadway is currently composed of a concrete base and asphalt overlay from US-59 to Westheimer Road, and concrete pavement from Westheimer Road to the northern Project limits.

Build Scenario

The existing pavement along the project corridor will be replaced with new concrete pavement.

Methodology

This section summarizes the methodology and results of this analysis.

Life Cycle Cost Analysis Methodology

The evaluation for SOGR uses a Life Cycle Cost Analysis (LCCA) model adapted to the scope of this project to determine the more cost-effective of the No-Build and Build Scenarios.[5] The primary purpose of this method is to compare the costs of reconstruction to those of continued maintenance of the existing roadway surface. The focus of the analysis is pavement condition and does not include costs associated with drainage, traffic management, or other non-vehicular support facilities. The analyzed costs include agency costs due to reconstruction or repair, user costs due to construction zone time delays, and operation and upkeep of vehicles used on the roadway throughout its life cycle. The life cycles for asphalt and concrete pavement are assumed to be 25 years and 50 years. The phasing of the 25-year life cycle is shown in Figure 1.[6,7]

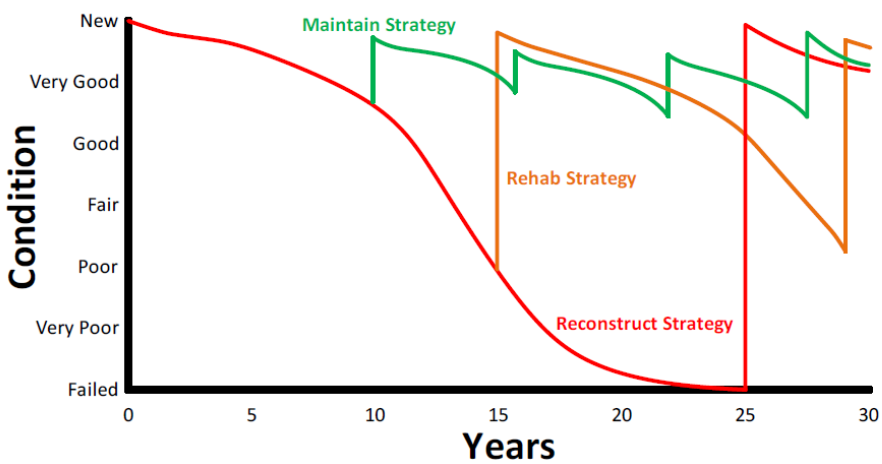

Figure 1. Pavement Life Cycle Curve

5 Federal Highway Administration. Life-Cycle Cost Analysis. Retrieved August 2022 at https://www.fhwa.dot.gov/infrastructure/asstmgmt/lcca.cfm.
6 Texas Department of Transportation. Transportation Asset Management Plan, p. 53. Retrieved August 2022 from https://www.nctcog.org/nctcg/media/Transportation/DocsMaps/Data/Performance/TxDOT-Initial-Transportation-Asset-Management-Plan.pdf
7 City of Houston (2018). Public Works Infrastructure Design Manual, p. 10-6. Retrieved June 2019 from https://edocs.publicworks.houstontx.gov/documents/design_manuals/idm.pdf

The key assumption is that if the proposed Project is not implemented (the No-Build Scenario), the City of Houston will follow a maintenance strategy that includes annual routine maintenance and periodic rehabilitation for the project corridor. Conversely, the Build Scenario, in which the roadway is rebuilt and thus brand new, would result in no maintenance or rehabilitation requirements within the planning horizon. The key roadway characteristics related to the analysis are summarized in **Table 7**.

Table 7. Montrose Boulevard Characteristics

Segment	Class	Pavement	Length (ft)	Lanes	Lane-miles	Average Daily Traffic (2021)	Truck %
US-59 to Westheimer Road	Minor Arterial	Asphalt Overlay	4,570	4	3.46	24,740	3.20%
Westheimer Road to Northern Limit	Minor Arterial	Concrete	3,524	4	2.67	23,087	3.20%

Maintenance - Concrete Pavement

An assessment of the pavement's current SOGR determines where the roadway is on its life cycle curve. The life cycle curve is composed of phases established by the Texas Department of Transportation (TxDOT) Transportation Asset Management Plan (TAMP) and assumes a 50-year life for concrete pavement. By modeling the deterioration of pavement over time due to environmental and traffic factors, the phases establish timings for maintenance requirements and effects on user vehicle operating costs for the No-Build Scenario.

The pavement's condition declines gradually in its first 10 years, but then quickly deteriorates to an unacceptable state. Any rehabilitation or maintenance strategy can reset the pavement's life cycle to a certain extent. Based on information from the City of Houston Public Works, and verified by site visits, the corridor is mostly in the final phase of its service life. Most of Montrose Boulevard between Westheimer Road and the Project's Northern Limit is in poor condition.

Table 8. Condition Assessment - Montrose Boulevard between Westheimer Road and Northern Limit

Street Name	Overall Condition (Weighted Average)
Montrose Boulevard between Westheimer Road and Northern Limit	Poor

A critical planning factor for maintenance operations is that the cost of repairs increases as the reliability of pavement decreases over the service life.[8] Essentially, newer pavement requires less maintenance than older, more deteriorated pavement to maintain acceptable levels of service. To approximate the increasing probabilities of portions of each roadway requiring repairs and the effects on maintenance costs, this analysis used approximate failure rate factors as a multiplier of the annual maintenance costs incurred by the City of Houston. The City of Houston FY2021 expenditures on street and bridge maintenance is over $100 million, which covers about 16,600 lane-miles of roadways, according to the Department of Public Works.[9] This analysis used the average expenditure from these totals ($6,135 per lane-mile), the lane-miles of each roadway, and the failure rate factor to develop estimates of annual maintenance costs by life cycle phase based on condition, shown in Table 9.

Table 9. Annual Pavement Maintenance Costs by Life Cycle Phase - Montrose Boulevard between Westheimer Road and Northern Limit

Phase	Percent of Life	Failure Rate Factor	Cost
New	24%	0.00	$0
Very Good	40%	0.00	$0
Good	52%	0.25	$4,094
Fair	64%	1.00	$16,377
Poor	80%	1.50	$24,566
Very Poor	100%	3.00	$49,132

Rehabilitation, which for this analysis consists of full-depth panel replacement for concrete conducted at select intervals in addition to routine annual repairs to maintain the structural integrity of the roadways. The expected result of this strategy is the extension of the service lives of the roadways by approximately 25 years for concrete.[10] Based on the concrete's life cycle, iterations of systematic repairs will be required over the next 20 years. Table 10 shows the schedule for rehabilitation under the No-Build Scenario.

Table 10. Rehabilitation Cycle - Montrose Boulevard between Westheimer Road and Northern Limit

Street Name	Pavement	2024	2045
Montrose Boulevard	Concrete	Panel Replacement	Panel Replacement

8 Federal Highway Administration (2013). Reformulated Pavement Remaining Service Life Framework, p. 43-49. Retrieved August 2022 from https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/13038/13038.pdf
9 City of Houston Fiscal Year Operating Budgets, Retrieved in August 2022 from https://www.houstontx.gov/budget/
10 City of Houston Report to TTI Committee. Retrieved August 2022 from https://www.houstontx.gov/council/committees/tti/20140513/Maintaining_Houston_Streets.pdf

For simplicity, this analysis assumes the rehabilitation of the entire length of the Project within the stated limits would be accomplished within time periods noted above. Similarly, it is assumed all failures of pavement within a certain life cycle phase occur all at once and the replacement costs may be captured as discrete projects. This analysis also assumes that unforeseen pavement failures that affect daily traffic are addressed as needed through annual maintenance and there would be residual life of the last major rehabilitation within the planning horizon.

This analysis assumes the rehabilitation of the Project takes the form of concrete panel replacement. According to City of Houston 2022 Capital Improvement Projects Panel Replacement Package, the cost for full-depth repair of joint concrete pavement is $171 per square yard (SY) in 2021. If the TxDOT standard panel dimensions of 12 feet (lane size) by 50 linear feet are used, the per panel replacement cost can be calculated using **Equation 3**.

Equation 3. Cost of Concrete Panel Replacement

Panel Replacement Cost = $171 · A · P
A = 67 SY (panel surface area)
P = number of panels required

The number of panels required to be replaced is based on the condition assessment presented above. The proportion of panels in the various phases of the life cycle for the length of the project under analysis and the associated life expectancies and replacement costs are summarized in Table 11.

Table 11. Concrete Pavement Costs - Montrose Boulevard between Westheimer Road and Northern Limit

Phase	Percent of Total	Number of Panels	Year(s) of Replacement	Replacement Cost	Remaining Life
Very Poor	0%	0	N/A	$0	$0
Poor	100%	281	2024, 2045	$5,723,000	$4,579,000
Fair	0%	0	N/A	$0	$0
Good	0%	0	N/A	$0	$0
Very Good	0%	0	N/A	$0	$0

The preferred alternative minimizes total maintenance costs over the planning horizon. As presented above, annual maintenance and scheduled rehabilitation for the existing pavements create a cost, or disbenefit, to the City of Houston for the No-Build Scenario. The Build Scenario presents an opportunity to avoid most of that financial burden. The proposed construction calls for concrete roadway and the new pavement would not require maintenance or rehabilitation for the remainder of the planning horizon; thus, the only rehabilitation costs are those incurred prior to project implementation. Table **12** summarizes the maintenance and rehabilitation costs for each scenario.

Table 12. Summary of Maintenance & Rehabilitation Costs - Montrose Boulevard between Westheimer Road **and** Northern Limit

Roadway	No-Build Scenario			Build Scenario		
	Annual Maintenance	Scheduled Rehab	Roadway Subtotal	Annual Maintenance	Scheduled Rehab	Roadway Subtotal
Montrose Boulevard	$259,000	$9,170,000	$9,429,000	$143,000	$0	$143,000

Maintenance – Asphalt Pavement

An assessment of the pavement's current SOGR determines where the roadway is on its life cycle curve. The life cycle curve is composed of phases established by the TxDOT TAMP and assumes a 25-year life for asphalt pavement. By modeling the deterioration of pavement over time due to environmental and traffic factors, the phases establish timings for maintenance requirements and effects on user vehicle operating costs for the No-Build Scenario.

The pavement's condition declines gradually in its first 4 years, but then quickly deteriorates to an unacceptable state. Any rehabilitation or maintenance strategy can reset the pavement's life cycle to a certain extent. Based on information from the City of Houston Public Works, and verified by site visits, the corridor is mostly in the final phase of its service life. Most of Montrose Boulevard between US-59 and Westheimer Road is in very poor condition.

Table 13. Condition Assessment - Montrose Boulevard between US-59 and Westheimer Road

Street Name	Overall Condition (Weighted Average)
Montrose Boulevard	Very Poor

A critical planning factor for maintenance operations is that the cost of repairs increases as the reliability of pavement decreases over the service life.[11] Essentially, newer pavement requires less maintenance than older, more deteriorated pavement to maintain acceptable levels of service. To approximate the increasing probabilities of portions of each roadway requiring repairs and the effects on maintenance costs, this analysis used approximate failure rate factors as a multiplier of the annual maintenance

11 Federal Highway Administration (2013). Reformulated Pavement Remaining Service Life Framework, p. 43-49. Retrieved August 2022 from https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/13038/13038.pdf

costs incurred by the City of Houston. The City of Houston FY2021 expenditures on street and bridge maintenance is over $100 million, which covers about 16,600 lane-miles of roadways, according to the Department of Public Works.[12] This analysis used the average expenditure from these totals ($6,135 per lane-mile), the lane-miles of each roadway, and the failure rate factor to develop estimates of annual maintenance costs by life cycle phase based on condition, shown in Table 14.

Table 14. Annual Pavement Maintenance Costs by Life Cycle Phase - Montrose Boulevard between US-59 and Westheimer Road

Phase	Percent of Life	Failure Rate Factor	Cost
New	24%	0.00	$0
Very Good	40%	0.00	$0
Good	52%	0.25	$5,310
Fair	64%	1.00	$21,239
Poor	80%	1.50	$31,858
Very Poor	100%	3.00	$63,716

Rehabilitation, for this analysis, consists of asphalt mill and overlay conducted at select intervals in addition to routine annual repairs to maintain the structural integrity of the roadway. The expected result of this strategy is the extension of the service life of the roadway by approximately 10 years for asphalt.[13] Based on each pavement's life cycle, iterations of systematic repairs will be required over the next 20 years.

Table **15** shows the schedule for rehabilitation under the No-Build Scenario.

Table 15. Rehabilitation Cycle - Montrose Boulevard between US-59 and Westheimer Road

Roadway	Pavement	2024	2032	2040	2048
Montrose Boulevard	Mill & Overlay	Mill & Overlay	Mill & Overlay	Mill & Overlay	Mill & Overlay

For simplicity, this analysis assumes the rehabilitation of the entire length of the Project within the stated limits would be accomplished within time periods noted above. Similarly, it is assumed all failures of pavement within a certain life cycle phase occur all at once and the replacement costs may be captured as discrete projects. This analysis also assumes that unforeseen pavement failures that affect daily traffic are addressed

12 City of Houston Fiscal Year Operating Budgets, Retrieved in August 2022 from https://www.houstontx.gov/budget/

13 City of Houston Report to TTI Committee. Retrieved August 2022 from https://www.houstontx.gov/council/committees/tti/20140513/Maintaining_Houston_Streets.pdf

as needed through annual maintenance and there would be residual life of the last major rehabilitation within the planning horizon.

The rehabilitation projects for the asphalt surfaces of the Project are projected in this analysis to occur in 10-year increments. According to TxDOT's Average Low Bid Unit Prices, the cost for mill and overlay is $11,400 per lane-mile in 2021. The total cost of mill and overlay can be calculated using Equation 4.

Equation 4. Cost of Asphalt Pavement with Mill & Overlay

Mill & Overlay Cost = $11,400 * L * M
L = number of lanes M = roadway (project limits) length in miles

Given the roadway characteristics and rehabilitation schedule, the total rehabilitation costs of the asphalt pavement under the No-Build Scenario are listed in in Table 16.

Table 16. Asphalt Pavement Mill and Overlay Costs - Montrose Boulevard between US-59 and Westheimer Road

Roadway	Lane-miles	1st Mill & Overlay	2nd Mill & Overlay	3rd Mill & Overlay	4th Mill & Overlay	Residual Life Remaining	Total Cost
Montrose Boulevard	3.46	$430,000	$520,000	$63,000	$765,000	$587,000	$1,755,000

The preferred alternative minimizes total maintenance costs over the planning horizon. As presented above, annual maintenance and scheduled rehabilitation for the existing pavements create a cost, or disbenefit, to the City of Houston for the No-Build Scenario. The Build Scenario presents an opportunity to avoid most of that financial burden. The proposed construction calls for new pavement would not require maintenance or rehabilitation for the remainder of the planning horizon; thus, the only rehabilitation costs are those incurred prior to project implementation.

Table **17** summarizes the maintenance and rehabilitation costs for each scenario.

Table 17. Summary of Maintenance & Rehabilitation Costs - Montrose Boulevard between US-59 and Westheimer Road

Roadway	No-Build Scenario			Build Scenario		
	Annual Maintenance	Scheduled Rehab	Roadway Subtotal	Annual Maintenance	Scheduled Rehab	Roadway Subtotal
Montrose Boulevard	$413,000	$2,343,000	$2,756,000	$230,000	$0	$230,000

User Costs

As pavement conditions worsen over the life of the roadway, the cost to the community to maintain vehicles operated on the roads also increases.[14] For planning purposes, this analysis assumes that qualitative assessments of pavement condition are correlated with established roughness indices and thus may be used to estimate its impact on vehicle operating costs. The study referenced by this analysis established baseline costs in terms of cents per mile for passenger and commercial vehicles on new pavement, as well as cost factors for each of five roughness index values, listed in Table 18.

Table 18. Vehicle Operating Costs in ¢/mile (inflated to $2021)

Vehicle Class	Road Class	Pavement Roughness Index / TxDOT Phase					
		Baseline	Adjustment Factors (multiplied by baseline for cost per mile)				
		Cents Per Mile ($2021)	2 Very Good	3 Good	4 Fair	5 Poor	6 Very Poor
Very Poor Poor Fair	Collector	19.8	1.02	1.03	1.07	1.15	1.25
	Arterial	24.7	1.02	1.03	1.07	1.15	1.24
	Highway	32.4	1.01	1.02	1.06	1.14	1.22
Good Very Good	Collector	52.1	1.02	1.03	1.07	1.13	1.21
	Arterial	80.3	1.01	1.02	1.05	1.11	1.18
	Highway	114.0	1.01	1.02	1.04	1.09	1.15

When correlated with the five TxDOT pavement condition phases, these factors can be applied to forecast vehicle operating costs that the public bears to the planning horizon. Several variables are required to complete this analysis, including current condition assessments of the roadways, H-GAC traffic model data for volume on each road type over time, and TxDOT traffic count data for commercial vehicle (truck) percentage; all of which were provided earlier in this section.

The difference between the costs due to the condition of the pavement during any year within the planning horizon and the baseline costs for new pavement is the disbenefit to the community from the state of good (or bad) repair. This analysis accumulated the year-over-year car and truck cost differentials to compare the total disbenefit due to vehicle operating costs for No-Build and Build Scenarios.

14 National Academy of Sciences, Engineering, and Medicine (2012). Estimating the Effects of Pavement Condition on Vehicle Operating Costs, p. 40-50. Retrieved August 2022 from https://www.nap.edu/catalog/22808/estimating-the-effects-of-pavement-condition-on-vehicle-operating-costs.

Table 19 shows the total operating costs for each scenario.

Table 19. Summary of Vehicle Operating Costs (inflated to $2021)

Roadway	No-Build Scenario			Build Scenario		
	Car	Truck	Total Vehicle	Car	Truck	Total Vehicle
Montrose Boulevard between US-59 and Westheimer Road	$2,343,000	$178,000	$2,521,000	$1,692,000	$124,000	$1,815,000
Montrose Boulevard between Westheimer Road and Northern Limit	$1,302,000	$99,000	$1,401,000	$1,056,000	$77,000	$1,133,000

During reconstruction (Build Scenario) or maintenance treatment cycles (No-Build Scenario), users incur costs due to delays. They may need to reduce speed or wait in a queue. For the purposes of this analysis, overall speed through work zones is assumed to drop by 35%. Repairs are assumed to take approximately 240 days per mile for reconstruction and 120 days per mile for the maintenance treatment cycles. Per USDOT guidance, the value of travel time is $19.24 per hour per person and vehicle occupancy is 1.65 persons per vehicle. Since repair projects occur in multiple years, this analysis adjusted traffic volume used to calculate cost based on growth rate to the year of repair. Equation 5 shows the total user cost due to delays during the construction period is equivalent to time lost to slower overall speeds through the work zones.

Equation 5. User (Delay) Cost

User (Delay) Cost = AADT · 1.65 * $19.24 * D * 0.65(T)
AADT = Average Annual Daily Traffic (number vehicles per day)
D = construction work zone duration (workdays)
T = Normal travel time (hours) through zone = Lane-miles / Speed Limit (mph)

The analysis tabulated AADT for each year in the planning horizon by factoring the growth rate inferred from results of forecast year traffic volumes from the TxDOT. Assuming linear growth, annual traffic volume can be calculated using Equation 6.

Equation 6. Traffic Volume

Traffic Volume = AADTc * (1+ X) * N
$AADT_c$ = Current year's volume
X = Annual growth rate
N = Number of years to which volume is being forecasted

The results of the user delay costs are shown in **Table 20**.

Table 20. Summary Value of Travel Time Costs

Scenario	Costs
No-Build Cost	$9,274,000
Build Cost	$5,177,000

SOGR Benefit Summary

The preferred scenario from the perspective of SOGR minimizes costs due to maintenance and user costs. Overall, the Build Scenario is preferable to No-Build on the merits of savings in each of the three categories covered in this section: life cycle costs, maintenance, and user costs. Accumulated benefits for the analysis period are quantified and discounted at a 7% rate, shown in Table 21.

Table 21. State of Good Repair Benefit

Scenario	Monetized Value
No-Build Cost	$20,213,000
Build Cost	$8,498,000
Net Benefit	$11,715,000
Net Benefit Discounted @ 7% to $2021	**$3,784,000**

Benefit 4, 5 and 6: Safety Benefits

The Project will improve safety along the Project corridor by reducing the number of crashes. Benefits can be derived from the projected reduction in the number of crashes and property damage incurred.

No-Build Scenario

The corridor would incur no safety improvements and would continue to be an unsafe urban corridor in Houston, Texas.

Build Scenario

The Project would experience significant safety improvements, resulting in fewer traffic accidents.

Methodology/Summary

The analysis uses the average number of crashes by type over the last 5 years (2018-2022) from TxDOT Crash Record Information System (CRIS) database. The appropriate reduction factor was given by TxDOT based on the 2022 TxDOT Highway Safety

Improvement Program (HSIP) work codes, and the damages avoided are quantified.[15] Accumulated benefits are totaled and discounted at a 7% rate.

To evaluate the existing conditions on the Project corridor, crash records were obtained from TxDOT CRIS database for years 2018-2022. TxDOT uses the KABCO Scale in the CRIS database, which uses law enforcement data and rates traffic crash injuries. The monetary value of potential safety improvements used in the BCA that are provided by the 2023 USDOT BCA Guide are listed in.

Table 22. The methodology uses the reduction in crashes associated with each roadway improvement, as identified in HSIP.

For all Project types, when the number of crashes decrease with safety improvements, benefits also accrue from reduced property damages. This methodology is documented in the 2023 USDOT BCA Guide. The guide values each crash with only property damage at $8,600 in damages ($2021).

Table 22. Monetary Value of Fatalities and Injuries from Traffic Accidents

KABCO Level	Monetized Value ($2021)
O – No Injury	$4,000
C – Possible Injury	$78,500
B – Non-incapacitating	$153,700
A – Incapacitating	$564,300
K – Killed	$11,800,000
U – Injured (Severity Unknown)	$213,900
# Accidents Reported (Unknown if Injured)	$162,600

HSIP Work Codes correspond to different enhancements (e.g., improve traffic signals, install raised medians, install pavement markings). TxDOT has a work code table that provides associated definitions, reduction factors, and preventable crash codes. Preventable crashes are those with defined characteristics that may be affected by the proposed improvement as described by the work code. The codes correspond to numeric codes assigned in CRIS to the indicated variable. Information is collected from law enforcement crash reports and converted into a coded format that corresponds to the work code table.

15 Texas Department of Transportation (2022). Highway Safety Improvement Manual. Retrieved August 2022 from https://www.txdot.gov/inside-txdot/forms-publications/publications/highway-safety.html

A crash can only be assigned to one work code. If multiple work codes are applicable to one crash, the work code with the highest crash reduction rate will be assigned to that crash. For the Project, the previous 5-year crashes were assigned to codes listed in Figure **2**.

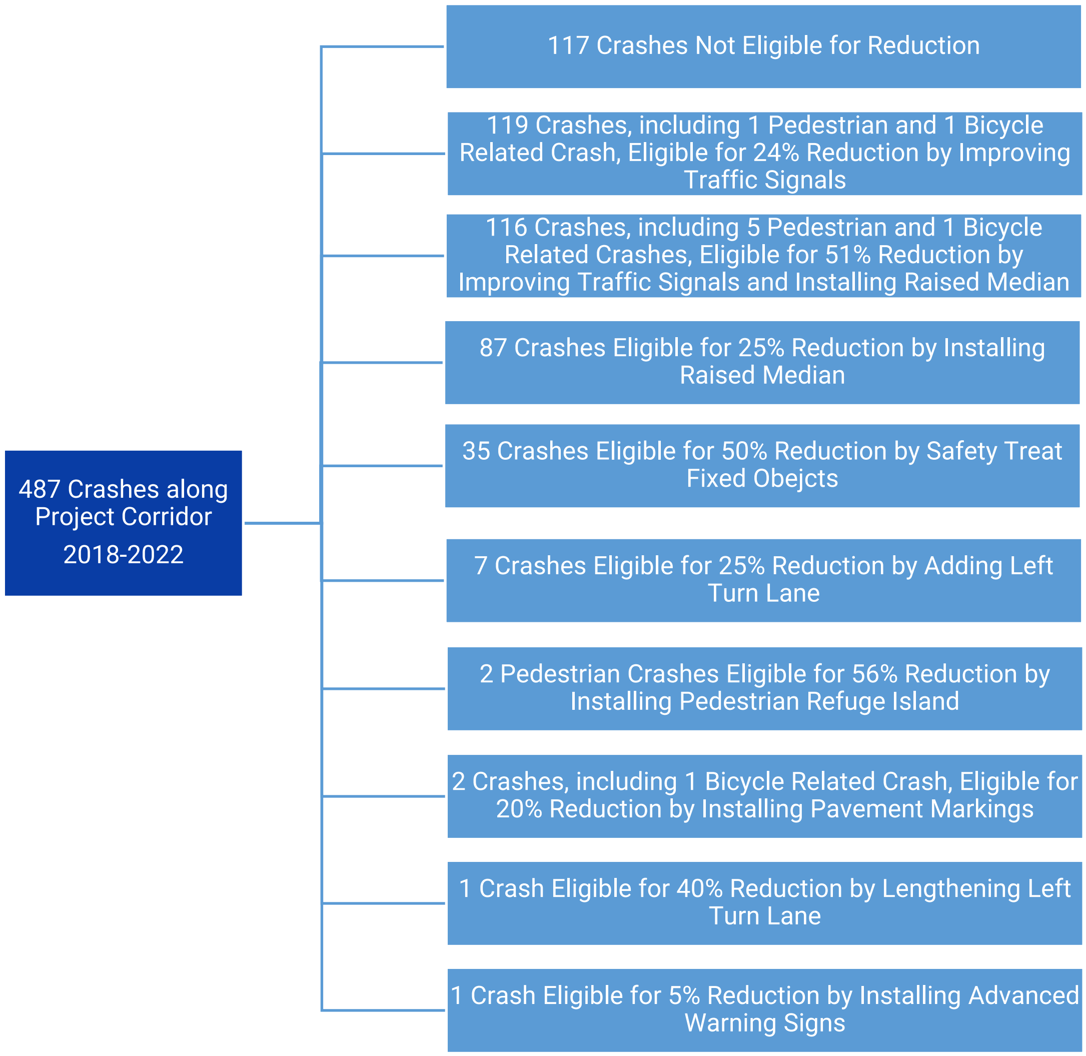

Figure 2. Traffic Crashes and HSIP Work Codes

Work codes based on crashes that can be avoided are described in the following tables.

Table 23. Crash Reduction Factor – Improve Traffic Signals

Work Code 108: Improve Traffic Signals	
Definition	Improve existing intersection signals to current design standards.
Reduction Factor	24%
Service Life (Years)	10
Maintenance Cost	N/A

Preventable Crashes	(Intersection Related = 1 or 2) AND [(Vehicle Movements/Manner of Collision =10-39) OR (First Harmful Event = 1 or 5)]

Table 24. Crash Reduction Factor – Improve Traffic Signals and Install Raised Median

Work Code 108 and 203: Improve Traffic Signals and Install Raised Median	
Definition	Improve existing intersection signals to current design standards; Install a roadway divider using barrier curb.
Reduction Factor	51%
Service Life (Years)	20
Preventable Crashes	(Intersection Related = 1 or 2) AND [(Vehicle Movements/Manner of Collision =10-39) OR (First Harmful Event = 1 or 5)] OR [(Part of Roadway No. 1 Involved = 1) AND (Vehicle Movements/Manner of Collision = 10, 14, 20-22, 24, 26, 28-30, 34, 36, or 38)]

Table 25. Crash Reduction Factor – Install Raised Median

Work Code 203: Install Raised Median	
Definition	Install a roadway divider using barrier curb.
Reduction Factor	25%
Service Life (Years)	20
Maintenance Cost	N/A
Preventable Crashes	(Part of Roadway No. 1 Involved = 1) AND (Vehicle Movements/Manner of Collision = 10, 14, 20-22, 24, 26, 28-30, 34, 36, or 38)

Table 26. Crash Reduction Factor – Safety Treat Fixed Objects

Work Code 209: Safety Treat Fixed Objects	
Definition	Remove, relocate, or safety treat all fixed objects including the installation of guardrail for safety treatment of a fixed object or drainage structures within the project limits, to include both point and continuous objects.
Reduction Factor	50%
Service Life (Years)	20
Maintenance Cost	N/A
Preventable Crashes	(Roadway Related = 2, 3 or 4) OR (Object Struck = 20-26, 29-36, 40-42, 56-58, 60, 62, or 63)

Table 27. Crash Reduction Factor – Add Left Turn Lane

Work Code 519: Add Left Turn Lane	
Definition	Provide an exclusive left turn lane where none existed previously. The affected intersection approaches must be specified.
Reduction Factor	25%
Service Life (Years)	10

Maintenance Cost	N/A
Preventable Crashes	Vehicle Movements/Manner of Collision = 20-22, 24, 26, 28-30, 34 or 38 AND Intersection Related != 4

Table 28. Crash Reduction Factor – Pedestrian Refuge Island

Pedestrian Refuge Island[16]	
Definition	A pedestrian refuge island is a median with a refuge area that is intended to help protect pedestrians who are crossing a road.
Reduction Factor	56%
Service Life (Years)	20
Maintenance Cost	N/A
Preventable Crashes	First Harmful Event = 1

Table 29. Crash Reduction Factor – Install Pavement Markings

Work Code 401: Install Pavement Markings	
Definition	Place complete pavement markings, excluding crosswalks, in accordance with the TMUTCD where either no markings or nonstandard markings exist. This work code includes items such as turn arrows, stop bars, lane markings, etc.
Reduction Factor	20%
Service Life (Years)	4 (Product used must meet 4-year service life.)
Maintenance Cost	N/A
Preventable Crashes	(Roadway Related = 1) OR (Vehicle Movements/Manner of Collision = 21 or 30)

Table 30. Crash Reduction Factor – Lengthen Left Turn Lane

Work Code 520: Lengthen Left Turn Lane	
Definition	Provide additional length to an existing exclusive left turn lane. Affected intersection approaches must be specified.
Reduction Factor	40%
Service Life (Years)	10
Maintenance Cost	N/A
Preventable Crashes	Vehicle Movements/Manner of Collision = 20-22 AND Intersection Related != 4

Table 31. Crash Reduction Factor – Install Advanced Warning Signs (Intersection)

Work Code 128: Install Advanced Warning Signs (Intersection)	
Definition	Provide signs in advance of an intersection where none previously existed.
Reduction Factor	5%

[16] U.S. Department of Transportation Federal Highway Administration. (n.a.). Medians and Pedestrian Refuge Islands in Urban and Suburban Areas. Retrieved February 2023 from https://highways.dot.gov/safety/proven-safety-countermeasures/medians-and-pedestrian-refuge-islands-urban-and-suburban-areas

Service Life (Years)	6
Maintenance Cost	N/A
Preventable Crashes	Intersection Related = 1 or 2

Using the average crash data from 2018-2022 available in the CRIS dataset, eligible crashes are reduced by the reduction factor above and monetized based on the USDOT recommended values in **.**

Table 22. Accumulated benefits for the specified service life are quantified up and discounted at a 7% rate, shown in the following tables.

Table 32. Motorist Safety Benefits

Scenario	Monetized Value
No-Build Cost	$116,143,000
Build Cost	$76,318,000
Net Benefit	**$39,825,000**
Net Benefit Discounted @ 7% to $2021	**$13,557,000**

Table 33. Pedestrian Safety Benefits

Scenario	Monetized Value
No-Build Cost	$11,455,000
Build Cost	$5,566,000
Net Benefit	**$5,889,000**
Net Benefit Discounted @ 7% to $2021	**$1,905,000**

Table 34. Bicycle Safety Benefits

Scenario	Monetized Value
No-Build Cost	$1,241,000
Build Cost	$669,000
Net Benefit	**$572,000**
Net Benefit Discounted @ 7% to $2021	**$208,000**

Benefits 7, 8, and 9: Facility Improvement Benefits

Improvements to pedestrian, cycling, transit facilities, and transit vehicles often provide amenities that can improve the quality or comfort of journeys made by active transportation (e.g., cyclists and pedestrians) and public transportation users. The improvements will not only benefit the existing users, but also encourage more people walking, biking, and using the public transit. Method for estimating new active or public transportation demand is explained in the Modal Diversion and Reduced VMT section at the end of this document. The 2023 USDOT BCA Guidance provides recommended monetized values for facility improvement benefits based on the research of revealed preferences of system users. For additional users attracted to the improved facilities, the value of the benefits they receive is at one-half the product of the value and the difference in volumes between the build and no-build cases.

No-Build Scenario

The current condition of the existing facilities is not conductive for walking, cycling, or using transit.

Build Scenario

The Project will improve the active transportation and transit facilities.

Methodology/Summary

This section summarizes the methodology and results of the analysis for facility improvement benefits.

Pedestrian Facility Improvements

The 2023 USDOT BCA Guidance points out that traffic speeds and volumes along key pedestrian corridors, as well as elevation gains and width of sidewalks, can directly affects the comfort, convenience, and safety of the facility for pedestrian use.

Using revealed preference studies, the recommended value per person-mile walked on an expanded sidewalk is $0.11 for each foot of added width, and it is $0.09 per MPH of traffic speed reduction for the roadway segment at where the current speed limit is equal to or lower than 45 MPH. For the mile-based benefits, the estimated value per pedestrian is capped at 0.86 miles, which is the average length of a walking trip in the 2017 National Household Travel Survey. And the monetized benefits for expansions are appliable for sidewalks up to approximately 31 feet. For additional users attracted to the improved facilities, the value of the benefits they receive is at one-half the product of the value and the difference in volumes between the build and no-build cases. The benefits of improved pedestrian facility are calculated using Equation 7 and Equation 8.

Equation 7. Pedestrian Facility Improvement Benefits – Sidewalk Expansion

Sidewalk Expansion Benefit = $0.11 * Added Width (foot) * (Number of Existing Walking Trips + ½ New Walking Trips) * Trip Length
Trip Length = Proposed Length of Expanded Sidewalk or 0.86 Miles (whichever is smaller)

Equation 8. Pedestrian Facility Improvement Benefits – Traffic Speed Reduction

Traffic Speed Reduction Benefit = $0.09 * Reduced MPH of Traffic Speed * (Number of Existing Walking Trips + ½ New Walking Trips) * Trip Length
Trip Length = Proposed Length of Roadway Segment for Traffic Speed Reduction or 0.86 Miles (whichever is smaller)

Accumulated benefits for the 25-year horizon are quantified and discounted at a 7% rate, presented in Table 35.

Table 35. Pedestrian Facility Improvement Benefit

Scenario	Monetized Value
No-Build Cost	$0
Build Cost	$5,626,000
Net Benefit	**$5,626,000**
Net Benefit Discounted @ 7% to $2021	**$1,735,000**

Bicycle Facility Improvements

The 2023 USDOT BCA Guidance suggests that cycling facilities can improve journey quality and comfort for cyclists, in addition to any travel time savings they provide. The recommended monetized value per cycling mile for various cycling facility improvements are listed in Table 36. The Project expands existing sidewalk to 10-ft that could be used by cyclists as well. The value of Cycling Path with At-Grade Crossings is used for calculating the improvement benefit.

Table 36. Cycling Facility Improvement Revealed Preference Values

Facility Type	Recommended Value per Cycling Mile (2021 $)
Cycling Path with At-Grade Crossings	**$1.42**
Cycling path with no At-Grade Crossings	$1.78
Dedicated Cycling Lane	$1.69
Cycling Boulevard/"Sharrow"	$0.26
Separated Cycle Track	$1.69

The benefit of cycling facility improvement is calculated using the Equation 9. The average length of a cycling trip in the 2017 National Household Travel Survey is 2.38 miles. According to 2023 USDOT BCA Guidance, if the cycling facility length is less than 2.38 mile, then the trip length per cyclist would be the facility length; however, if the cycling facility is longer than 2.38 miles, the assumption of all cyclists travel the full distance of a proposed facility cannot be made. For additional users attracted to the improved facilities, the value of the benefits they receive is at one-half the product of the value and the difference in volumes between the build and no-build cases. The benefit of improved cycling facility is calculated using Equation 9.

Equation 9. Cycling Facility Improvement Benefit

Cycling Facility Improvement Benefit = Value per Cycling Mile * (Number of Existing Cycling Trips + ½ New Cycling Trips) * Trip Length
Trip Length = Proposed Cycling Facility Length or 2.38 Miles (whichever is smaller)

Accumulated benefits for the 25-year horizon are quantified and discounted at a 7% rate, presented in the following table.

Table 37. Cycling Facility Improvement Benefit

Scenario	Monetized Value
No-Build Benefit	$0
Build Benefit	$694,000
Net Benefit	**$694,000**
Net Benefit Discounted @ 7% to $2021	**$214,000**

Transit Facility Improvements

The 2023 USDOT BCA Guidance suggests that transit facility and vehicle improvements can improve the accessibility, quality, convenience, and comfort of users of transit systems. The recommended transit facility amenity revealed and states preference value per user trip for bus stops are listed in
Table **38**. The project team documented the existing amenities at the current bus stations to determine which facilities riders already have at each stop. For the new BOOST bus stations of the Project, the proposed amenities would include electronic real-time information displays, platform/stop seating availability, platform/stop weather protection, step-free access to station/stop, and step-free access to vehicle in
Table **38**.

Table 38. Transit Facility Amenity Revealed and Stated Preference Values

Attribute Type	Recommended Value per User Trip (2021 $, Bus Stop)
Clocks	$0.03
Electronic Real-Time Information Displays	**$0.31**
Information/Emergency Button	$0.24
PA System	$0.31
Platform/Stop Seating Availability	**$0.19**
Platform/Stop Weather Protection	**$0.25**
Restroom Availability	$0.14

Retail/Food Outlet Availability	$0.11
Staff Availability	$0.08
Step-Free Access to Station/Stop	**$0.32**
Step-Free Access to Vehicle	**$0.42**
Surveillance Cameras	$0.31
Temperature Controlled Environment	$0.62
Ticket Machines	$0.10
Timetables	$0.23
Clocks	$0.03
Electronic Real-Time Information Displays	**$0.31**
Information/Emergency Button	$0.24
PA System	$0.31

The benefit of transit improvement is calculated using

Equation 10. Benefits to existing users for any given year in the analysis period is calculated based on the number of users projected in that year under the No-Build baseline. For additional users attracted to the improved facilities, the value of the benefits they receive is at one-half the product of the value and the difference in volumes between the build and no-build cases.

Equation 10. Transit Facility Improvement Benefit per Bus Stop

Transit Facility Improvement Benefit per Bus Stop= Total of Transit Facility Amenity Revealed and Stated Preference Values per User Trip * (Number of Existing Transit Riders + ½ New Transit Riders)

Accumulated benefits for the 25-year horizon are quantified and discounted at a 7% rate, presented in Table 39.

Table 39. Transit Facility Improvement Benefit

Scenario	Monetized Value
No-Build Benefit	$0
Build Benefit	$7,332,000
Net Benefit	**$7,332,000**
Net Benefit Discounted @ 7% to $2021	**$2,334,000**

Benefit 10: Value of Travel Time

No-Build Scenario

The roadway would increase in traffic volumes and congestion delays throughout the planning horizon. Active transportation users would face delays in crossing the corridor, and transit users would be encumbered by waiting at traffic lights.

Build Scenario

The Project will improve traffic flow and reduce travel times for all roadway users of this corridor, including active and public transportation users.

Methodology/Summary

The impact of a project on congestion can be measured through the value of travel time (VoTT) on the network. Travel time has a direct relationship with overall network congestion. The more congested a roadway or network is, the longer the travel time is, thereby increasing person hours traveled. The methodology for determining congestion benefits uses Synchro software to analyze delay reduction at intersections with a micro-level model during the AM and PM peak hour for driving and walking separately. This method requires collecting the current traffic counts, including pedestrian counts, along the affected roadways and project the future volume under the Build and No-build scenarios. The Synchro analysis shows the operational impacts of the proposed Project, which includes intersection delay. The modeling results suggest that the Project will decrease average vehicle delays at the signalized intersections but increase average pedestrian delays at non-signalized crossings. Therefore, the Project will benefit travel time savings of motor vehicles but will increase the average non-signalized intersection crossing time of pedestrians.

While the traffic model is not able to include Traffic Signal Priority/Preemption (TSP), the Project includes applying TSP to all signals on Montrose Boulevard to support faster and more reliable service on METRO's 56 Airline/Montrose route. Transit signal priority extends the green signal phase on the transit corridor or calls the cross street's green phase early to minimize bus delay. Transit preemption overrides the normal operation of a traffic signal to provide buses with a green signal to proceed directly through the intersection. Research suggests a 10% to 15% decrease in bus running times in a bus priority area was identified as a desirable objective for bus priority treatments[17]. The calculation of VoTT assumes a 15% reduction in bus travel time after the project is completed. Thus, the Project will decrease travel time of transit users.

[17] Danaher, A. R. (2010). *Bus and rail transit preferential treatments in mixed traffic* (Vol. 83). Transportation Research Board.

The Synchro traffic impact analysis provides the average delay caused by the Project, while the 2023 USDOT BCA Guidance provides recommended hourly values ($2021) of travel time savings for occupants of passenger vehicles ($18.80/person-hour and 1.67 persons per vehicle) and for commercial vehicle operators ($32.40/person-hour). A separate value is provided for reductions in other components or aspects of travel time, including walking, cycling, waiting time, transfer time, and time spent standing in a crowded transit vehicle ($34.00/person-hour). Using

Equation 11, the users' value of time, including driving, walking, and taking public transit, for the Project is calculated.

Equation 11. Value of Travel Time

Travel Time Savings = Annual Person-Hour Saved * VoTT
Annual Person-Hour Saved for Year N = VHT for Project build year*$(1.7\%+x\%)^{n}$ x% is assumed to be the annual growth rate

Accumulated benefits for the 25-year horizon are quantified and discounted at a 7% rate, presented in Table 40.

Table 40. Summary Value of Travel Time Costs

Scenario	Monetized Value
No-Build Cost	$214,247,000
Build Cost	$205,439,000
Net Benefit	**$8,808,000**
Net Benefit Discounted @ 7% to $2021	**$2,795,000**

Benefits 11, 12, and 13: Operating Cost Savings

Operating a vehicle is one of the most expensive budget items in American households. The reduction in VMT from automobile trips converted to walking, cycling, and transit trips results in a benefit for automobile owners. The methodology for modal diversion and VMT reduced is explained in the last section of this document (Modal Diversion and Reduced VMT).

No-Build Scenario

The current condition of the active transportation and transit facilities are not conducive for pedestrians, cyclists, or transit users.

Build Scenario

The Project will improve pedestrian, bicycle, and transit facilities along the project corridor. These amenities will induce new pedestrian, cyclists, and transit users.

Methodology

The 2023 USDOT BCA Guide estimates the cost of light duty vehicle operation as $0.46 ($2021) per mile. The value per mile includes operating costs such as gasoline, maintenance, tires, and depreciation. The benefit omits fixed costs of owning a vehicle such as insurance and registration.

Equation 12 is used to estimate the total automobile operating costs saved by reducing VMT.

Equation 12. Automobile Operating Cost Saving

Automobile Operating Savings = VMT * MC * 260
VMT = Annual Reduced Vehicle Miles Traveled Due to Modal Diversion MC = Automobile Operating Costs per mile 260 = Average Number of Working Days in a Year

For operating cost savings resulted from modal diversion from driving to using public transit, the savings calculated in

Equation **12** also account for the average cost of bus tickets as Equation 13 shows.

Equation 13. Bus Ticket Cost

Bus Ticket Cost = Average Transit Ticket Price * Number of Annual Transit Trips

The accumulated benefits of increased walking, biking, and transit trips on automobile maintenance savings for the analysis period are quantified and discounted at a 7% rate, presented in the tables below.

Table 41. Operating Cost Savings - Walking

Scenario	Monetized Value
No-Build Cost	$3,000
Build Cost	$69,000
Net Benefit	**$65,000**
Net Benefit Discounted @ 7% to $2021	**$20,000**

Table 42. Operating Cost Savings - Cycling

Scenario	Monetized Value
No-Build Cost	$2,000
Build Cost	$27,000
Net Benefit	**$24,000**
Net Benefit Discounted @ 7% to $2021	**$7,000**

Table 43. Operating Cost Savings - Transit

Scenario	Monetized Value
No-Build Cost	$5,832,000
Build Cost	$6,130,000
Net Benefit	**$298,000**
Net Benefit Discounted @ 7% to $2021	**$95,000**

Benefits 14 and 15: Mortality Reduction Benefits

Active transportation modes such as walking and cycling can help improve cardiovascular health and lead to other positive outcomes for users. Adding or upgrading cycling or pedestrian facilities can convert users from inactive transportation modes to active transportation modes. A key health outcome from increased physical activity is a reduction in mortality risks for those users that are converted to active transportation modes from inactive modes. The methodology for modal diversion is explained in the last section of this document (Modal Diversion and Reduced VMT).

No-Build Scenario

The existing sidewalks are in disrepair and there is a lack of bicycle facilities.

Build Scenario

The Project will install new 10 feet sidewalks. The paths will be wide enough to accommodate bicyclists.

Methodology

Mortality Reduction - Walking

The 2023 USDOT BCA Guide recommends $7.20 ($2021) per induced walking trip for monetizing reduced mortality risks associated with increased walking. It is based on an assumed average walking speed of 3.2 miles per hour, an assumed average age of the relevant age range (20-74 years) of 45, a corresponding baseline mortality risk of 267.1 per 100,000, an annual risk reduction of 8.6 percent per daily mile walked, and an average walking trip distance of 0.86 miles. This monetization value can only be applied to trips induced from non-active transportation modes within the relevant age ranges. A general assumption of 68% of overall induced trips falling into the walking age range (20-74 years), assuming a distribution matching the national average, is applied in the absence of more localized data on the proportion of the expected users falling into the age range. Equation 14 is used to estimate the mortality reduction benefits of induced walking trips.

Equation 14. Mortality Reduction Benefits - Walking

Mortality Reduction Benefits = Number of New Walking Trips Induced from Non-Active Transportation Modes * 68% * $7.20

The accumulated benefits of mortality reduction benefits for the analysis period are quantified and discounted at a 7% rate, presented in Table 44.

Table 44. Mortality Reduction Benefit - Walking

Scenario	Monetized Value
No-Build Cost	$0
Build Cost	$24,990,000
Net Benefit	**$24,990,000**
Net Benefit Discounted @ 7% to $2021	**$7,708,000**

Mortality Reduction - Cycling

The 2023 USDOT BCA Guide recommends $6.42 ($2021) per induced cycling trip for monetizing reduced mortality risks associated with increased cycling. It is based on an assumed average cycling speed of 9.8 miles per hour, an assumed average age of the relevant age range (20-64 years) of 42, a corresponding baseline mortality risk of 217.9 per 100,000, an annual risk reduction of 4.3 percent per daily mile cycled, and an average cycling trip distance of 2.38 miles. This monetization value can only be applied to trips induced from non-active transportation modes within the relevant age ranges. A general assumption of 59% of overall induced trips falling into the cycling age range (20-64 years), assuming a distribution matching the national average, is applied in the absence of more localized data on the proportion of the expected users falling into the age range.

Equation **15** is used to estimate the mortality reduction benefits of induced cycling trips.

Equation 15. Mortality Reduction Benefits – Cycling

Mortality Reduction Benefits = Number of New Cycling Trips Induced from Non-Active Transportation Modes * 59% * $6.42

The accumulated benefits of mortality reduction benefits for the analysis period are quantified and discounted at a 7% rate, presented in Table 45.

Table 45. Mortality Reduction Benefit - Cycling

Scenario	Monetized Value
No-Build Cost	$0
Build Cost	$1,490,000
Net Benefit	**$1,490,000**
Net Benefit Discounted @ 7% to $2021	**$460,000**

Benefits 16: Congestion Externalities Reduction

Reductions in external costs from modal diversion may represent a source of potential benefits beyond those experienced directly by users of an improved facility or service. The operation of automobiles can cause negative impacts such as delays to other vehicles during congested travel conditions, increased external crash costs, emissions of air pollutants, noise pollution, and damage to pavements or other road infrastructure. These impacts impose costs on occupants of other vehicles and on the society at large. The methodology for modal diversion and VMT reduced is explained in the last section of this document (Modal Diversion and Reduced VMT).

No-Build Scenario

The current condition of the existing facilities is not conducive for pedestrians, cyclists, or transit riders.

Build Scenario

The Project will install new sidewalks and rehabilitate existing sidewalks to meet the COH's current design standards, as well as install new bicycle facilities and improve the existing transit facilities along the project corridor. These amenities will result in modal shift with a reduction in overall VMT.

Methodology/Summary

The 2023 USDOT BCA Guide provides recommended monetarized values for external highway use costs. The recommended costs per vehicle mile traveled including all kinds of vehicles in urban locations are $0.144 for congestion and $0.0048 for noise. Equation 16 can be used to determine the benefit of reducing congestion externalities.

Equation 16. Congestion Externalities Reduction

Congestion Externalities Reduction = VMT * ($0.144+$0.0048)
VMT = Vehicle Miles Traveled Reduced because of Modal Diversion

The accumulated benefits of increased walking and transit trips on reducing external highway use costs for the analysis period are quantified and discounted at a 7% rate, presented in **Table 46**.

Table 46. Congestion Externalities Reduction

Scenario	Monetized Value
No-Build Benefit	$9,682,000
Build Benefit	$10,730,000
Net Benefit	**$1,048,000**
Net Benefit Discounted @ 7% to $2021	**$333,000**

Benefits 17, 18, and 19: Emission Reduction Benefits

The EPA has classified the Houston-Galveston-Brazoria area in marginal nonattainment of the eight-hour ozone standard; air quality does not meet federal standards.[18] The investment in mobility infrastructure could produce environmental benefits due to decreased automobile use or vehicle delay which reduces air pollutants and is important to the region's future growth. The methodology for modal diversion and VMT reduced is explained in the last section of this document (Modal Diversion and Reduced VMT).

No-Build Scenario

The current condition of the existing facilities is not conducive for pedestrians, cyclists, or transit riders.

Build Scenario

The Project will install new sidewalks that can accommodate both pedestrians and bicyclists, as well as improve the existing transit facilities along the project corridor. These amenities will result in modal shift with a reduction in overall VMT.

Methodology/Summary

H-GAC models NOx using the following emissions factor:

18 United States Environmental Protection Agency (2022). 8-Hour Ozone (2015) Nonattainment Area State/Area/County Report. Green Book. Retrieved September 2022 from https://www3.epa.gov/airquality/greenbook/jncs.html#TX

- Nitrogen Oxides (NO_X): 0.19 grams (g) per VMT

United Environmental Protection Agency (EPA) using the following emissions factor for CO_2:[19]

- Carbon Dioxide (CO_2): 0.0089 metric tons per gallon of gasoline used

NOx and CO_2 have measurable societal economic impacts on the economy. The 2023 USDOT BCA Guide provides recommended monetized values of damage costs for NOx and CO_2 emissions per metric ton by year between 2022 and 2050. These values are used to calculate the Project's benefit derived from the reduction of harmful air pollutants.

For active transportation and transit improvements that improve the walkability and bikeability of an area and increase transit utilization, there is a presumed environmental benefit from automobile trips being converted into walking, biking, and transit trips. The VMT benefit is derived and converted into the amount of NOx and CO_2 grams reduced, which is then monetized based on the H-GAC emissions factor. VMT is assumed to grow annually at the same rate as the internal trips. Accumulated benefits for pedestrian and transit users are quantified over the 25-year analysis period and discounted at a 7% rate, shown in tables below.

Table 47. Emission Reduction Benefits - Walking

Scenario	Monetized Value
No-Build Benefit	$0
Build Benefit	$7,000
Net Benefit	**$7,000**
Net Benefit Discounted @ 7% to $2021	**$4,000**

Table 48. Emission Reduction Benefits - Cycling

Scenario	Monetized Value
No-Build Benefit	$0
Build Benefit	$3,000
Net Benefit	**$2,000**
Net Benefit Discounted @ 7% to $2021	**$1,000**

19 Environmental Protection Agency. (n.d.). EPA. Retrieved August 23, 2022, from https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references

Table 49. Emission Reduction Benefits - Transit

Scenario	Monetized Value
No-Build Benefit	$14,799,000
Build Benefit	$16,267,000
Net Benefit	**$1,468,000**
Net Benefit Discounted @ 7% to $2021	**$794,000**

Benefits 20 and 21: Automobile Idling

EPA defines auto idling (not including truck) as waiting at traffic lights or sitting in congestion on highways or during emergencies. Reducing vehicle idling time saves fuel and money and decreases pollution and greenhouse gas emissions.

No-Build Scenario

Congestion on the roadway would increase throughout the planning horizon, which causes increased idling, fuel consumption, and harmful air emissions.

Build Scenario

The proposed improvements of the Project will increase fuel consumption, and harmful air emissions based on the modeling results.

Methodology/Summary

Fuel consumption and emissions are modeled for the AM and PM peak hours in the No-Build and Build scenarios. The 2021 U.S. Energy Information Administration shows that the fuel cost per gallon in Texas is $2.73. The Texas Comptroller shows the fuel taxes as $0.38. The total cost of fuel can be estimated with Equation 17.

Equation 17. Total Cost of Fuel

Total Cost of Fuel = (Fuel Cost per Gallon in Texas – Fuel Taxes) *Daily Gallons of Fuel Consumed * 365

The total cost of harmful emissions can be estimated with Equation 18.

Equation 18. Total Cost of Harmful Emissions

Total Cost of Harmful Emissions = Metric Ton of Harmful Emissions * Value of Harmful Emissions

Accumulated benefits for auto idling are quantified and discounted at a 7% rate, presented in the following tables.

Table 50. Environmental Benefit of Auto Idling

Scenario	Monetized Value
No-Build	$4,517,000
Build	$4,526,000
Net Benefit	**-$9,000**
Net Benefit Discounted @ 7% to $2021	**-$15,000**

Table 51. Fuel Consumption due to Auto Idling

Scenario	Monetized Value
No-Build	$9,709,000
Build	$9,880,000
Net Benefit	**-$170,000**
Net Benefit Discounted @ 7% to $2021	**-$65,000**

Modal Diversion and Reduced VMT

The benefits of active transportation improvements of the Project are mostly derived from the new projected walking and cycling trips divert from automobile usage. The additional transit users are derived from the addition of better amenities for access. The additional users of these alternative modes result in less passenger vehicle usage. This in turn leads to reduced VMT, which has a variety of benefits.

Sidewalk Improvements

Sidewalk Expansion

According to the USDOT's BCA Guidance, sidewalk width has a direct and significant impact on the comfort, convenience, and safety of the facility for pedestrian use, principally by increasing the allowance for distances between pedestrians and moving vehicles and among pedestrians themselves, leading to improved safety, decreased noise exposure, and increased comfort. Meanwhile, the research conducted by Aziz, etc. (2018) indicates that increasing sidewalk width will increase the likelihood of more people taking active transportation modes. The empirical results show that when the average width of sidewalks increased by 30 percent, 50 percent, or 65 percent, the probability to walk increases in the origin and destination tracts by 12.07 percent, 17.65 percent, and 21.67 percent correspondingly. The trips shift from driving to walking are mostly likely for commuting purposes.

For this Project, the sidewalk improvement would add 786 new daily pedestrian trips in the project open year (Equation 19). In other words, 786 daily pedestrian trips will be converted from internal trips within half mile from the Project. The annual internal auto vehicle trips within half mile from the Project is obtained from the StreetLight Data.

Equation 19. New Daily Pedestrian Trips - Sidewalk Expansion

New Daily Pedestrian Trips = W * IAT
W = Increased Probability of Walking IAT = Internal Automobile Trips within Half-mile from the Project

Decreased Automobile Usage from New Walking Trips

The 2017 NHTS reports an average walking trip length of 0.86 mile.[20] Equation 20 can be used to estimate the reduction in VMT from newly converted auto to pedestrian trips. The annual reduction of VMT is used to calculate the benefit from reduced emissions and reduced automobile maintenance required.

Equation 20. VMT Reduction from New Walking Trips

Annual VMT reduced = New Daily Walking Trips * 260 * Trip Length
260 = Weekdays in the year (Annual trips) Trip Length = 0.86 Mile or Proposed Pedestrian Facility Length in Mile (whichever is smaller)

Reduced Auto VMT from Pedestrian Diversion (Opening Year)
Build Scenario Annual Reduction in VMT: 11,664

Bicycle Facility Improvements

New Cycling Trips

Measuring and forecasting the demand for bicycling in a project area is vital to calculate the benefits of a given facility. Based on research by the Texas A&M Transportation Institute, new bike trips within the 1- mile buffer of the Project corridors equal 1.36% of the internal trips within the same area.[21] The annual internal auto vehicle trips within half mile from the Project is obtained from the StreetLight Data.

Equation 21. New Bike Trips

New Cycling Trips = 1.36%* Internal Trips

20 Federal Highway Administration (2017). National Household Travel Survey. Retrieved in August 2022 from https://nhts.ornl.gov/

21 Lasley, P, M. Metzger-Galarza, S. Guo. (2017). Estimating Congestion Benefits of Transportation Projects with FIXiT 2.0: Updating and Improving the Sketch Planning Tool. Texas A&M Transportation Institute. Retrieved February 2022, from https://tti.tamu.edu/tti-publication/estimating-congestion-benefits-of-transportation- projects-with-fixit-2-0-updating-and-improving-the-sketch-planning-tool/

Total Bike Users Demand (Opening Year) Build Scenario Daily Bike Trips: 61

Decreased Automobile Usage from New Cycling Trips

There is a presumed benefit from automobile trips being converted into both commuter and recreation bicycle trips for improvements that enhance bicycle access and mobility in an area. This benefit is based on the additional commuter and recreational travelers now using a bicycle as their mode of transportation.

To estimate this, the Build Scenario total bike demand trips were used. It is assumed that the reduction in automobile trips will increase in proportion to the increase in internal trips within the area. Additionally, the 2017 NHTS reports an average biking trip length of 2.38 miles; however, the proposed cycling facility, which is 1.54 miles, is less than the average bike trip length, thus the trip length of 1.54 miles is used to estimate the annual reduction in VMT as a result of new bicycle trips. The VMT saved is used tocalculate the benefit from reduced emissions and reduced automobile maintenance required.

Equation 22. VMT Reduction from New Cycling Trips

Annual VMT Reduction = New Cycling Trips * Trip Length *260
Trip Length = 2.38 Mile or Proposed Cycling Facility Length in Mile (whichever is smaller) 260 = Weekdays in the year (Annual trips)

Bike Diversion from Auto VMT Reduced (Opening Year) Build Scenario Annual VMT Reduced: 4,421

Transit Improvements

New Transit Trips

Better access to transit amenities (e.g., shelters, sidewalks, ramps, signage) improve the transit level of service of an area, thus there is a presumed increase in transit usage. TCRP Report 163 *Strategy Guide to Enable and Promote the Use of Fixed Route Transit by People with Disabilities* reports that of the transit systems studied, updated or newly installed transit amenities increase the stop ridership by 12.9%.[22] In addition, a study

22 Thatcher, Russell, C. Ferris, et al. (2013). TCRP Report 163: Strategy Guide to Enable and Promote the Use of Fixed-Route Transit by People with Disabilities. Transit Cooperative Research Program. Retrieved June 2019 from https://nacto.org/wp-content/uploads/2016/05/2-9_Thatcher-et-al-Strategy-Guide-to-Enable-and-Promote-the-Use-of-Fixed-Route-Transit-by-People-with-Disabilities-TCRP-Report-163_2013.pdf

was conducted along the 56 Airline/Montrose route (north of the Project corridor) where BOOST shelters and improvements have already been installed. The ridership between BOOST and non-BOOST bus stations along the route showed an increase of 13% in ridership for the BOOST stops between 2019 and 2022.

According to METRO, in 2019 annual boarding and alighting counts (henceforth transit trips) at stops along the Project corridor totaled 412,334 annual transit trips (337,610 on the weekdays, 40,716 on Saturdays and 34,008 on Sundays) in the No-Build Scenario. The Build Scenario would result in an increase of transit trips by 13% in the project open year, and 0.39% annual growth in transit ridership, yielding 482,480 annual transit trips in 2029.

Transit Trips Demand (Opening Year)
No-Build Scenario Annual Transit Trips: 428,718
Build Scenario Annual Transit Trips: 482,480

Decreased Automobile Usage from New Transit Users

An average one-way transit trip length in the METRO service area is 5.67 miles.[23] The following formula is used to estimate reduced VMT due to new transit users. The annual reduction in VMT is used to calculate the benefit from reduced emissions and reduced automobile maintenance required.

Equation 23. New Transit Users to VMT Reduction

Annual VMT reduced = TrT * 5.67
VMT = Vehicle Miles Traveled
TrT = Annual Transit Trips
5.67 = Average Transit Trip Length (Miles)

Transit Trips Diversion to Auto VMT Reduced (Opening Year)
No-Build Scenario Annual VMT: 2,429,041
Build Scenario Annual VMT: 2,733,647

23 National Transit Database. (2021). Houston METRO Annual Agency Report. Retrieved in February 2023 from https://www.transit.dot.gov/ntd/transit-agency-profiles/metropolitan-transit-authority-harris-county-texas