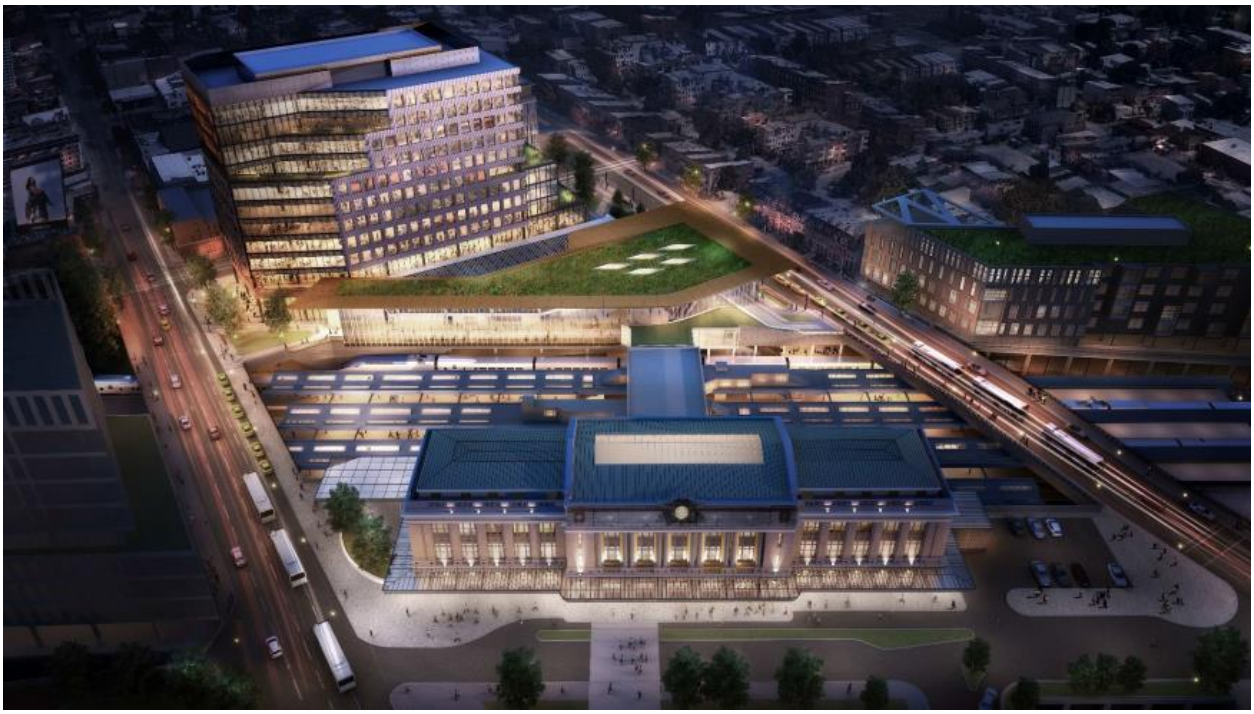
BUILDING BALTIMORE PENN STATION CONECTIONS

BENEFIT-COST ANALYSIS SUPPLEMENTARY DOCUMENTATION



FY2022 RAISE DISCRETIONARY GRANT PROGRAM

PREPARED FOR: MARYLAND DEPARTMENT OF TRANSPORTATION MARYLAND TRANSIT ADMINISTRATION (MDOT MTA)
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Executive Summary

A benefit-cost analysis (BCA) was conducted for the Building Baltimore Penn Station Connections by the Maryland Department of Transportation Maryland Transit Administration (MDOT MTA) for submission to the U.S. Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the 2022 Rebuilding American Infrastructure with Sustainability and Equity (RAISE) program. The analysis was conducted in accordance with the benefit-cost methodology as outlined by U.S. DOT in the Benefit-Cost Analysis Guidance for Discretionary Grant Programs, released in March 2022. The period of analysis corresponds to 33 years and includes 3 years of construction and 30 years of benefits after operations begin in 2026.

The project includes dedicated bus lanes and curb extensions on Charles Street and St. Paul Street, improved curbside management for more efficient intermodal connections, and new bus stop amenities. Improved bicycle and pedestrian connectivity are expected to improve travel time for users of the Baltimore Penn Station. Reduced delays are also expected to reduce operating costs for the MDOT MTA. In addition, there are several benefits such as improved safety, signage, and convenience features that are not quantified in this BCA but discussed qualitatively in the main narrative.

COSTS

The capital cost for this Project is expected to be $12 million in undiscounted 2020 dollars through 2026. At a seven percent real discount rate, these costs are $8.6 million. Table ES-1 shows how these costs are allocated across time and major expense category.

Table ES-1: Project Costs by Category and Year, in Undiscounted Millions of 2020 Dollars

Cost Category	2023	2024	2025	2026	Total
Planning and Design	$1.21	$2.02	$0.00	$0.00	$3.23
Construction	$0.00	$0.73	$4.37	$3.64	$8.73
Total	$1.21	$2.75	$4.37	$3.64	$11.97
Total, Discounted 7%	$0.99	$2.10	$3.11	$2.43	$8.62

In addition to the upfront capital cost, the project will result in average net operations and maintenance (O&M) savings of $0.15 million per year in the long term. These are a result of improved travel times caused by the dedicated bus lanes and curb extensions. Over the entire 30-year operations period these costs accumulate to $4.5 million in undiscounted 2020 dollars, or $1.3 million when discounted at seven percent. Note that these O&M costs are included as the numerator of the benefit-cost ratio calculation.

BENEFITS

In 2020 dollars, the Project is expected to generate $10.0 million in discounted benefits using a seven percent discount rate. Benefits are composed of travel time savings for transit passengers from the dedicated bus lanes and curb extensions, auto travel time savings from more efficient pick-up/drop-offs, the net O&M savings described above, and transit facility amenity improvements from two new bus stops. This leads to an overall project Net Present Value of $1.3 million and a Benefit Cost Ratio (BCR) of 1.16[1]. The overall project benefit matrix can be seen in Table ES-2.

[1] Per USDOT guidance, operations and maintenance costs are included in the numerator along with other project benefits when calculating the benefit-cost ratio.

Table ES-2: Project Impacts and Benefits Summary, Monetary Values in Millions of 2020 Dollars

Current Status/Baseline & Problem to be Addressed	Change to Baseline/ Alternatives	Type of Impact	Population Affected by Impact	Economic Benefit	Summary of Results (at 7% discount rate)
Economic Competitiveness	Dedicated bus lanes; improved curbside management	Cost & Time Savings	Station users; MDOT MTA	Reduced travel time; Reduced operating costs	$8.6
Quality of Life	Bus Stop Amenities	Passenger Value	Bus passengers	Improved user experience	$1.0
Safety	Crossing improvements, security cameras, and lighting	# of Accidents	Station users	Avoided injuries and accidents	Qualitative
Residual Value		Residual Value of Assets	MDOT MTA	Residual Value of Assets	$0.4

The overall Project impacts can be seen in Table ES-3, which shows the magnitude of change and direction of the various impact categories.

Table ES-3: Project Impacts for Project, Cumulative 2026-2055

Category	Unit	Quantity	Change
Passenger-Hours Traveled	PHT	1.5M	▼
Transit O&M Cost	$PV (7%)	$1.3M	▼
Transit Amenity User Value	$PV (7%)	$1.0M	▲

In addition to the monetized benefits presented in Table ES-2, the project scope includes several pedestrian and bike safety improvements such as crossing improvements and safety cameras. Even though these benefits are not quantified directly, they contribute to the overall importance of this project in improving the quality of life and safety in the project area. The Project Narrative further details these qualitative benefits for those who travel to, from, and through the Station and surrounding project area.

While these benefits are not easily quantifiable, they do provide real advantages and improvements that will be experienced by individuals and businesses in the region.

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1 INTRODUCTION

A benefit-cost analysis (BCA) was conducted for the Building Baltimore Penn Station Connections Project for submission to the U.S. Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the RAISE 2022 program. The following section describes the BCA framework, evaluation metrics, and report contents.

1.1 BCA FRAMEWORK

A BCA is an evaluation framework to assess the economic advantages (benefits) and disadvantages (costs) of an investment alternative. Benefits and costs are broadly defined and are quantified in monetary terms to the extent possible. The overall goal of a BCA is to assess whether the expected benefits of a project justify the costs from a national perspective. A BCA framework attempts to capture the net welfare change created by a project, including cost savings and increases in welfare (benefits), as well as disbenefits where costs can be identified (e.g., project capital costs), and welfare reductions where some groups are expected to be made worse off as a result of the proposed project.

The BCA framework involves defining a Base Case or "No Build" Case, which is compared to the "Build" Case, where the grant request is awarded and the project is built as proposed. The BCA assesses the incremental difference between the Base Case and the Build Case, which represents the net change in welfare. BCAs are forward-looking exercises which seek to assess the incremental change in welfare over a project life-cycle. The importance of future welfare changes are determined through discounting, which is meant to reflect both the opportunity cost of capital as well as the societal preference for the present.

The analysis was conducted in accordance with the benefit-cost methodology as recommended by the U.S. DOT in the 2022 Benefit-Cost Analysis Guidance for Discretionary Grant Programs.[2] This methodology includes the following analytical assumptions:

- Defining existing and future conditions under a No Build base case as well as under the Build Case;
- Estimating benefits and costs during project construction and operation, including 30 years of operations beyond the Project completion when benefits accrue;
- Using U.S. DOT recommended monetized values for reduced fatalities, injuries, property damage, travel time savings, and emissions, while relying on best practices for monetization of other benefits;
- Presenting dollar values in real 2020 dollars. In instances where cost estimates and benefits valuations are expressed in historical or future dollar years, using an appropriate inflation factor to adjust the values;
- Discounting future benefits and costs with a real discount rate of seven percent consistent with U.S. DOT guidance.

1.2 REPORT CONTENTS

Section 2 of this report contains a description of the project, information on the general assumptions made in the analysis, and a description of the base case compared to the build case. Section 3 provides a summary

[2] U.S. Department of Transportation, Benefit-Cost Analysis Guidance for Discretionary Grant Applications, March 2022. https://www.transportation.gov/sites/dot.gov/files/2022-03/Benefit%20Cost%20Analysis%20Guidance%202022%20%28Revised%29.pdf Access March 18, 2022.

of the anticipated project costs. Section 4 reviews the expected economic benefits the project would generate, including a review of the assumptions and methodology used to calculate the benefits. Finally, Section 5 reports the high-level results of the benefit-cost analysis.

2 PROJECT OVERVIEW

2.1 DESCRIPTION

The **Building Baltimore Penn Station Connections Project** (the Project) adds dedicated bus lanes and curb extensions on Charles Street and St. Paul Street, improved curbside management for more efficient intermodal connections, and new bus stop amenities. Improved bicycle and pedestrian connectivity are also expected to improve travel time for users of the Baltimore Penn Station. Reduced delays will also reduce operating costs for MDOT MTA's bus operations. In addition, there are several benefits such as reduced emissions and improved safety, signage, and convenience features that are not quantified in this BCA but discussed qualitatively in the main narrative.

2.2 GENERAL ASSUMPTIONS

The evaluation period for this project includes a 4-year design and construction period, from 2023-2026, during which capital expenditures are undertaken, plus 30 years of operations beyond Project completion within which to accrue benefits, through 2056.[3]

Dollar figures in this analysis are expressed in constant 2020 dollars (2020$). The real discount rate used for this analysis was 7.0 percent, consistent with USDOT guidance for 2022 RAISE grants and OMB Circular A-94.[4]

2.3 BASE CASE AND BUILD CASE

The analysis of the project segment considered how the balance of costs and benefits resulting from the construction of the project improvements would result in long-term benefits to its users and general society. The "Build" Case assumes that the project is built with the proposed scope of work. The "No-Build" case assumes the status quo.

[3] Operations are scheduled to commence in 2026, and there is a partial year adjustment capturing 22% of annual benefits in 2026 and 78% of annual benefits in 2056 to arrive at a 30-year operations period of analysis.

[4] White House Office of Management and Budget, Circular A-94, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs. October 29, 1992. https://obamawhitehouse.archives.gov/sites/default/files/omb/assets/a94/a094.pdf. Accessed March 18, 2022.

3 PROJECT COSTS

3.1 CAPITAL COSTS

Total capital costs of $12.0 Million (2020$) were included in the project budget as shown in Table 1.

Table 1: Project Costs by Category and Year, in Undiscounted Millions of 2020 Dollars

Cost Category	2023	2024	2025	2026	Total
Planning and Design	$1.21	$2.02	$0.00	$0.00	$3.23
Construction	$0.00	$0.73	$4.37	$3.64	$8.73
Total	$1.21	$2.75	$4.37	$3.64	$11.97
Total, Discounted 7%	$0.99	$2.10	$3.11	$2.43	$8.62

Source: MDOT MTA, 2022

4 PROJECT BENEFITS

The primary benefits of this project are reduced travel time and operating costs. Per USDOT BCA guideline, total benefits also include the residual value of the project. Table 2 shows how the benefit categories align with the merit criteria of the BUILD Grants program. The total benefits amount to $44.6 Million in undiscounted 2020 dollars, or $11.6 Million when discounted at 7%.

Table 2: Project Benefits

Benefit (Disbenefit) Category	Description	Monetized	Qualitative
Travel Time Savings	Dedicated bus lane and curbside management lead to lower travel times	√	
Reduced Transit Operating Costs	Reduced delays save transit operating costs	√	
Transit Amenities	Bus stop enhancements add value to passengers	√	
Safety	Critical safety improvements for transit riders, drivers, pedestrians, and cyclist		√
Reduced Emissions	Dedicated bus lanes and curb extensions reduce bus-related emissions		√

4.1 DEMAND PROJECTIONS

A forecast of MDOT MTA transit ridership and travel time was provided by MDOT MTA, while the forecast of other users of the station such as Amtrak and curbside pick-up and drop-off using ride share and taxis was developed by WSP. While the Project Narrative presents projected growth in ridership across the modes (e.g., Amtrak, regional rail, etc.), for the purposes of the BCA a conservative approach has been taken to growth. Therefore, the travel time savings presented in this analysis and report are presumed to be on the low end of what will ultimately be realized through the Project's full implementation.

4.1.1 *BUS PASSENGER TRAVEL TIME SAVINGS FROM DEDICATED BUS LANES*

For the transit forecast, the selected bus lane improvement included 0.85 miles on Charles Street from Madison to North Ave., which has an average daily ridership of 11,187 including service by MDOT MTA, Johns Hopkins Shuttle, and Charm City Circulator buses. Based on observed delays, it was assumed that delays amount to about 1 minute per mile of bus operations, which when combined with the total daily ridership, leads to a total daily delay of 4,719 minutes of avoided delays. This is converted to annual passenger hours of delays of 20,450 by dividing by 60 to convert to hours, and then multiplying by a conservative annualization factor of 260. This calculation is summarized below in Table 4.

Table 3: Summary of Travel Time Savings Forecast

	Madison to Oliver	Oliver to North	Total
Length (mi.)	0.55	0.30	0.85
Total Ridership	5,528	5,659	11,187
Daily Delays (mins)	3,015	1,704	4,719
Daily Delays (hrs)	50.25	28.40	78.65
Annual Delays (hrs)	13,066	7,384	20,450

Source: MDOT MTA, WSP

4.1.2 *BUS PASSENGER TRAVEL TIME SAVINGS FROM CURB EXTENSIONS*

Additional travel time savings are expected due to curb extensions at bus stops along Charles Street and St. Paul Street. While the Project Narrative includes 10 curb extensions, for the purposes of the BCA a conservative approach has been taken to only consider five bus stops along Charles Street from Madison to North and St. Paul from Mt. Royal to Madison. Peak weekday ridership at these stops is estimated at 29,977. It is assumed that curb extensions can reduce travel times by about 4 seconds per stop. The total annual passenger hours reduced from the curb extensions are calculated as (29,835 * 4)/3600 * 260 to give 8,619 passenger hours.

Combining the bus lane extension and curb extension, the total reduction in annual passenger hours traveled is calculated at 29,069 passenger hours. Calculations for the travel time savings from the dedicated bus lanes and curb extensions are included in the attached spreadsheet model in the "Transit Savings" tab for USDOT review.

4.1.3 *VEHICLE TRAVEL TIME SAVINGS FROM CURBSIDE PICK-UP/DROP-OFF*

Next, WSP developed a forecast of passenger hours traveled for curbside pick-up and drop-offs including taxis and rideshare services. The methodology for this forecast is discussed below.

1. The first step is to estimate the growth in ridership by 2025 using the existing ridership at BPS for MARC and Amtrak. The estimated growth is based on projections provided by Amtrak, population increase, and planned service and infrastructure improvements at BPS.
2. The projected mode share in 2025 is applied to the passenger volumes. The result is total number of passengers using taxis, TNCs, or private vehicle pick-up/drop-off to access the station.
3. The bulk of the delay is associated with vehicle congestion, expected to happen during peak hours and peak shoulder hours. No congestion during off-peak hours is assumed.
4. Existing dwell and clearing times are projected to the 2025 growth, with the additional 1-2 minutes of delay per vehicle during peak hours and peak shoulder hours. This provides the delay in the 2025 No-Build scenario. Subtracting the 2025 Build scenario dwell and clearing time provides total delay savings per vehicle in minutes.
5. To calculate daily time savings in person-minutes and person-hours, volumes by mode are multiplied with respective mode's savings per vehicle. For annual delay savings, a Daily to Annual Factor of 303 was used in this analysis.
6. To calculate the delay savings, it was assumed that:
    a. Taxi passengers are essentially unaffected.

b. Drop-offs are less affected than pick-ups, since some TNC and car drop-offs can occur without having to circulate through the curb roadways. Therefore, average time savings for drop-offs are reduced by 50%.

c. Only some of the passengers in the peak periods experience delays (since demand is peaked, and there are times in the peaks when the curbside functions relatively smoothly). Therefore, it is assumed that 75% of peak hour passengers and 33% of peak shoulder hour passengers experience the delays.

Based on this methodology, the total reduction in passenger hours traveled (PHT) for pick-up/drop-offs was estimated at 19,654 PHT per year. These calculations are included in the attached spreadsheet model in the "Additional Ridership" tab for USDOT review. The resulting demand projections are presented in the following table.

Table 4: Summary of Travel Time Savings Forecast

	2026	2026-2055
Reduction in PHT from bus ridership	29,110	873,300
Reduction in PHT from curb-side pick-up/drop-off	19,654	589,634

4.2 SAFETY

The project scope includes several pedestrian and bike safety improvements such as crossing improvements and safety cameras. Even though these benefits are not quantified directly, they contribute to the overall importance of this project in improving the quality of life and safety in the project area. The Project Narrative further details these qualitative benefits for those who travel to, from, and through the Station and surrounding project area.

4.3 ENVIRONMENTAL SUSTAINABILITY

No environmental benefits have been quantified, although it is likely that the Project's transit priority, pedestrian and bicycle improvements will inspire mode shift from single-occupancy vehicles to low- and no-emissions modes. While the transportation investments can support non-automobile travel within the Baltimore Metropolitan area, the Project's increased access to Penn Station may impact mode choice at the regional level, including the highly-traveled Baltimore-Washington corridor. While mode shift away from automobile travel reduces emissions, the faster bus speeds and shorter bus dwell times resulting from the Transportation Demand Management strategies like dedicated bus lanes and curb extensions at bus stops will reduce bus-related emissions for existing service.

4.4 QUALITY OF LIFE

Two bus stop replacements at the station on St. Paul Street and Charles Street will add quantifiable benefits to bus passengers based on revealed and stated preference values of these transit facility amenities. These include electronic real-time information displays, weather protection, ticket machines, and bike facilities. Although there is already a real-time information sign and weather protection at the St. Paul Street bus stop,

there are opportunities to add these amenities at the Charles Street stop along with ticket vending machines and validation at both stops and adjacent bike and micromobility parking facilities.

Table 5: Transit Amenity Assumptions and Sources

Variable	Unit	Value per User Trip (2020$)	St. Paul Stop	Charles Stop	Source
Electronic Real-Time Information Displays	2020$ per user trip	$0.29	-	1	US DOT Guidance, 2022
Weather Protection	2020$ per user trip	$0.24	-	1	US DOT Guidance, 2022
Ticket Machines	2020$ per user trip	$0.10	1	1	US DOT Guidance, 2022
Bike Facilities	2020$ per user trip	$0.09	1	1	US DOT Guidance, 2022

These improvements result in an increase in value of $0.19 per user trip for the St. Paul Street stop and $0.72 per user trip at the Charles Street stop. These values were combined with the latest available data on average daily boardings and alightings at each stop from MDOT MTA (414 at St. Paul Street and 524 at Charles Street), along with an annualization factor of 260 to calculate the annual monetized benefit of these improvements:

- St. Paul Street Bus Stop: 414 * $0.19 * 260 = $20,430
- Charles Street Bus Stop: 524 * $0.72 * 260 = $98,093

Table 6: Transit Amenity Value Benefit, Millions of 2020 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Bus Stop Improvements	$0.12	$0.07	$3.56	$1.00

4.5 MOBILITY AND COMMUNITY CONNECTIVITY

No mobility and community connectivity benefits are quantified. However, the project would increase mobility and expand connectivity for all users, particularly non-motorized travelers (those walking, cycling, rolling, or using transit).

4.6 ECONOMIC COMPETITIVENESS AND OPPORTUNITY

The Project would contribute to increasing economic competitiveness through improvements in the mobility of transit riders at the Baltimore Penn Station and reduced travel time. Based on the traffic projections discussed above, the total PHT saved by this project over 30 years is estimated at about 1.5 million PHT, of which 0.9 million PHT is due to bus ridership, while 0.6 million is due to curbside pick-up/drop-offs. The travel time savings is calculated to be $7.3 million in discounted 2020 dollars. Travel Time Savings and assumptions are summarized below.

Table 7: Travel Time Savings Assumptions and Sources

Variable	Unit	Value	Source
Value of Travel Time Savings – Auto	2020$ per person hour	$17.80	US DOT Guidance, 2022
Value of Travel Time Savings – Transit (in-vehicle)	2020$ per person hour	$17.80	US DOT Guidance, 2022
Value of Time – Real Growth Rate	Annual Rate	0%	US DOT Guidance, 2022

Table 8: Travel Time Savings, Millions of 2020 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Travel Time Savings – Bus Ridership	$0.5	$0.3	$15.5	$4.3
Travel Time Savings – Curbside Users	$0.3	$0.2	$10.5	$2.9

4.7 STATE OF GOOD REPAIR

This section includes the residual value of the Project and the Project's operating cost savings to MDOT MTA due to improved travel times caused by the dedicated bus lanes and curb extensions. These costs are expressed as bus operating cost per revenue hour, which were $186.67 per hour for MDOT MTA in 2020.

Table 9: Operating Cost Assumptions and Sources

Variable	Unit	Value	Source
MDOT MTA Operating Cost	2020$ per Revenue Hour	$186.67	FTA National Transit Database

The dedicated bus lanes are assumed to save one minute per mile. To calculate bus operating time savings, this per-mile time savings was applied to peak period MDOT MTA buses per day to arrive at 587 bus operating hours per year saved. The curb extensions are assumed to save four seconds per stop. Applying this savings rate to peak period buses at each of the five curb extensions results in an additional 222 bus operating hours saved per year. Multiplying the total 809 hours by MDOT MTA's $186.67 operating cost per revenue hour results in $151,093 per year in 2020 dollars. The present value of these cost savings amounts to $1.3 million when discounted at seven percent.

These operating costs are limited to MDOT MTA's bus operations, and do not include potential savings that other bus operators are likely to garner, including routes operated by the Charm City Circulator and Johns Hopkins University.

Table 10: Operating Cost Reduction Benefits, Millions of 2020 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Operating Cost Savings	$0.15	$0.1	$4.5	$1.3

The residual value is calculated by determining the percentage of useful life remaining beyond the analysis period and multiplying that percentage by the construction cost for that component. The project improvements are assumed to have a useful life of 50 years and are depreciated on a straight line.

Table 11: Residual Value Estimation of Benefits, Millions of 2020 Dollars

Benefit	Final Analysis Year (2055)	
	Undiscounted	Discounted (7%)
Total Residual Value	$4.8	$0.4

5 SUMMARY OF RESULTS

5.1 EVALUATION MEASURES

The benefit-cost analysis converts potential gains (benefits) and losses (costs) from the Project into monetary units and compares them. The following common benefit-cost evaluation measures are included in this BCA:

- Net Present Value (NPV): NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.
- Benefit Cost Ratio (BCR): The evaluation also estimates the benefit-cost ratio; the present value of incremental benefits is divided by the present value of incremental costs to yield the benefit-cost ratio. The BCR expresses the relation of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of the costs.
- Internal Rate of Return (IRR): The IRR is the discount rate which makes the NPV from the Project equal to zero. In other words, it is the discount rate at which the Project breaks even. Generally, the greater the IRR, the more desirable the Project.

5.2 BCA RESULTS

The table below presents the evaluation results for the Project. Results are presented undiscounted and discounted at seven percent as prescribed by the U.S. DOT. All benefits and costs were estimated in constant 2020 dollars over an evaluation period extending 30 years beyond system completion in 2026.

- Benefits from all categories total $44.6 million undiscounted and $10.0 discounted at 7 percent.
- Travel time savings represent 73 percent of total benefits, followed by reduced O&M costs (13%), facility amenities (10%,) and residual value (4%).
- Total benefits less total costs, discounted at 7 percent, generate an NPV of $1.3 million.
- Compared to the undiscounted capital cost of $12 million and discounted capital cost of $8.6 million, the resulting BCR is 3.3 and 1.2 respectively.

Notably, the BCA does not quantify and monetize several likely benefits from the project, including those resulting from improved safety and reduced emissions. Even without including these benefits, the Project has a positive BCR and NPV, clearly making it a worthwhile investment.

Table 12: Benefit Cost Analysis Results, Millions of 2020 Dollars

BCA Metric	Undiscounted	Discounted (7%)
Total Benefits	$38.89	$9.97
Travel Time Savings	$26.02	$7.29
Facility Amenities	$3.56	$1.00
Residual Value	$4.79	$0.42
Change in O&M Costs	$4.53	$1.27
Total Costs	$11.97	$8.62
Net Present Value (NPV)	$26.93	$1.34
Benefit Cost Ratio (BCR)	3.3	1.2
Internal Rate of Return (IRR)	8%	