08 September 2022

Benefit-Cost Analysis

to Support

North Carolina Department of Transportation's Application for the USDOT's 2022 BIP Program

For the

BLUE RIDGE Project

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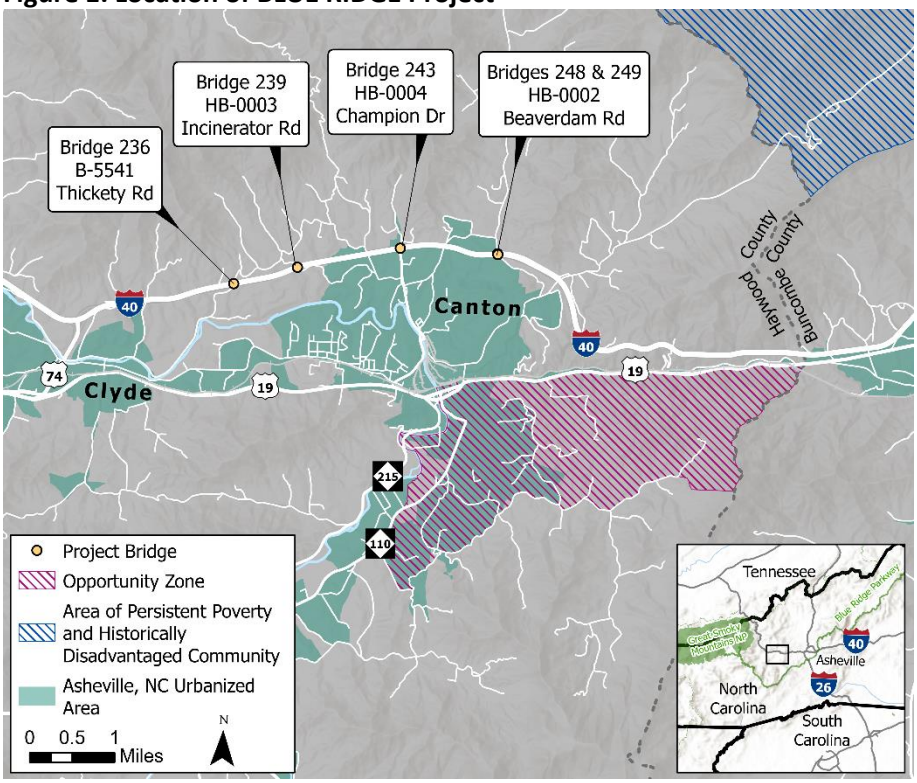
Introduction

This memorandum presents a Benefit-Cost Analysis (BCA) in support of the North Carolina Department of Transportation's (NCDOT's) application for a Bridge Investment Program (BIP) grant. NCDOT is seeking this grant to support its "BuiLding rUral Equity by Replacing Infrastructure and Driving Good Economies" (BLUE RIDGE) Project, known hereafter as "the Project." The Project consists of the replacement of five outdated bridges[1] in rural Hayward Country, NC, along an important east-west corridor that connects North Carolina with Tennessee. Four of these bridges would be replaced by culverts.

Figure 1 shows the location of the five bridges encompassed by the Project, and their proximity to the Asheville Urbanized Area and areas of Persistent Poverty / Opportunity Zones. Without the Project, emergency repairs of these five bridges will continue to be needed intermittently, requiring significant additional maintenance expenses and detours that cost users extra mileage and travel time. The Project will result in benefits from the each bridge's renewed "state of good repair," including improved safety and reduced travel times for travelers in the Asheville, NC region.

Figure 1. Location of BLUE RIDGE Project



Source: NCDOT

[1] Bridge ID# (STIP#) are as follows: Bridge ID#430236 (B-5541), Bridge ID#430248 (HB-0002), Bridge ID#430249 (HB-0002), Bridge ID#430239 (HB-0003), Bridge ID#430243 (HB-0004)

The methodology used for this BCA follows the guidelines of the "Notice of Funding Opportunity for the Department of Transportation's Bridge Investment Program, 2022[2]" (NOFO) and the *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*, March 2022 (USDOT BCA Guidance)[3]. Estimates of the expected benefits for each of the applicable project outcome criteria specified in the NOFO are presented for both the full completion of the Project (the "build" scenario) against a "no build" baseline scenario.

In this document, net benefits are estimated as the difference between the total benefits and total costs of the "build" and the "no build" scenarios. Costs and benefits were discounted using a 7% discount rate as required by USDOT BCA Guidance.[4] Costs and benefits were calculated independently for each bridge and then summed to understand the overall impact. Benefits of the whole Project are compared to the costs of the whole Project, including previously incurred costs, to compute the final benefit-cost ratio (BCR).

Table 1 presents the BCA for the Project in total. The Impact Matrix in Table 2 describes the Project and likely local impacts from its construction. The individual BCAs of each bridge are found in Table 11. The BCA was estimated using the present value of benefits and costs over an analysis period of 20 years for each bridge. Because each bridge has a different construction schedule, Table 1 is an overall summary, considering 20 full years of benefits from 2025 through 2046. The total Project BCR is 1.65, indicating that the Project is cost-effective. Table 1 and Table 2 present the BCA Summary and Impact Matrix, respectively.

[2] USDOT, Notice of Funding Opportunity 2022 Bridge Investment Program Grants, https://www.grants.gov/web/grants/view-opportunity.html?oppId=341050.
[3] USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs, March 18, 2022 https://www.transportation.gov/office-policy/transportation-policy/benefit-cost-analysis-guidance-discretionary-grant-programs-0 .
[4] With the exception of CO_2 emissions, which were discounted at 3% as per USDOT Guidance.

Table 1. Benefit-Cost Analysis Summary for the Total BLUE RIDGE Project

	7% Discount Rate
	Total, $2020 M
Project Benefits	**$74.2**
State of Good Repair	
Residual Value	$5.9
O&M Savings	$0.6
Road Maintenance Savings due to Closures Avoided	$0.004
Bridge Repair Cost Savings	$42.4
Safety	
Reduced Highway Fatalities and Crashes	$2.1
Detour Safety Savings due to Closures Avoided	$0.6
Mobility and Economic Competitiveness	
Travel Time Savings due to Closures Avoided	$28.3
Truck Operating Savings due to Closures Avoided	$0.3
Vehicle Operating Savings due to Closures Avoided	$0.8
Transit Operating Savings due to Closures Avoided	$0.0
Construction Delays	-$6.9
Climate Change, Resiliency, and the Environment	
Emissions Savings from Closures Avoided	$0.1
Emissions from Construction of Bridges and Culverts (ISI)	-$0.01
Emergency Response	Qualitative
Quality of Life	
Greyhound Time Savings from Closures Avoided	$0.05
Innovation	Qualitative
Project Costs	**$45.1**
Capital Costs	$45.1
Net Benefits	$29.1
Benefit-Cost Ratio	**1.65**

Table 2. Impact Matrix for the Total BLUE RIDGE Project

Current Status/Baseline & Problem to be Addressed	Change to Baseline or Alternatives	Types of Impacts	Affected Population	Economic Benefit (Net Present Values, $2020 M) Discounted at 7%	Page Reference in BCA
The project will replace 5 bridges along I-40 between mile markers 29 and 33 in rural Haywood County, NC. These 5 bridges, all of which are on the National Bridge Inventory, have reached or exceeded the end of their useful life, and are characterized by substandard shoulder widths, substandard lane widths, and inadequate clearances on secondary routes. Moreover, one of the bridges (236) is structurally deficient, while three of the bridges (243, 248, and 249) are functionally obsolete. These facilities are in immediate need of replacement to bring the bridges into a state of good repair, thereby removing barriers for individuals and communities to access transportation, jobs, business opportunities and medical care; improving safety for freight vehicles and motorists; supporting the local and national economy; and ensuring that vital connections to points east and west are maintained.	The Project will improve safety and state of good repair by replacing these structures with bridges that meet current design standards, while also promoting mobility, economic competitiveness, and resilience. The replaced bridges will have improved safety and reduced maintenance costs, and allow corridor drivers to avoid the delays or diversions that result from needed repairs.	**State of Good Repair**			
		Residual Value	NCDOT and North Carolina taxpayers	$5.9	10
		O&M Savings	NCDOT	$0.6	10
		Road Maintenance Savings due to Closures Avoided	NCDOT and corridor drivers	$0.0	10
		Bridge Repair Cost Savings	NCDOT	$42.4	10
		Safety			
		Reduced Highway Fatalities and Crashes	Corridor drivers	$2.1	11
		Detour Safety Savings due to Closures Avoided	NCDOT and corridor drivers	$0.6	12
		Mobility and Economic Competitiveness			
		Travel Time Savings due to Closures Avoided	Corridor drivers	$28.3	13
		Truck Operating Savings due to Closures Avoided	Corridor drivers	$0.3	13
		Vehicle Operating Savings due to Closures Avoided	Corridor drivers	$0.8	13
		Transit Operating Savings due to Closures Avoided	Corridor transit users	$0.0	13
		Construction Delays	Corridor drivers	-$6.9	14
		Climate Change, Resiliency, and the Environment			
		Emissions Savings from Closures Avoided	All regional users and non-users	$0.1	14
		Emissions from Construction of Bridges and Culverts (ISI)	All regional users and non-users	$0.0	14
		Emergency Response	Haywood County residents and visitors	Qualitative	15
		Quality of Life			
		Greyhound Time Savings from Closures Avoided	Corridor transit users	$0.1	15
		Innovation	NCDOT and North Carolina Taxpayers	Qualitative	15

Methodology

The NOFO lists six project outcome criteria against which the Project should be evaluated: State of Good Repair; Safety; Mobility and Economic Competitiveness; Climate Change, Resiliency, and the Environment; Quality of Life; and Innovation. Benefits were assessed for each of these categories quantitatively or qualitatively.

State of Good Repair: The Project has a useful life that extends beyond the 20-year analysis period and therefore has residual value at the end of the analysis period. The facility will result in reduced operations and maintenance (O&M) costs, savings from bridge repair costs avoided, and road maintenance savings due to closures avoided.

Safety: Drivers will experience safety benefits from a reduction in the number and severity of crashes at the bridges, as determined by the Crash Modification Factors (CMF) for the individual Project components. Avoiding detours during bridge repair activities will result in fewer vehicle miles traveled (VMT) on I-40, resulting in additional safety benefits.

Mobility and Economic Competitiveness: Drivers on I-40 will experience travel time savings as users of the reconstructed bridges will avoid detours and closures for periodic repairs, in addition to reducing operating savings for passenger vehicles, trucks, and intercity buses that operate in the corridor. Construction activities will result in a temporary increase in congestion.

Climate Change, Resiliency, and the Environment: The closures avoided and travel time savings result in emissions avoided, while construction of the bridges will result in negligible increases to emissions during the construction period. Emergency response times would also be improved when detours are avoided.

Quality of Life: Transit users will benefit from travel time savings associated with closures avoided.

Innovation: The Project will leverage innovative project development techniques and approaches, including Bridge Bundling, contracting and construction of bridges, use of vehicular culverts, and the Construction Manager/General Contractor (CM/GC) method for construction management.

Net benefits are discounted to 2020 using a 7% discount rate, as recommended in the USDOT BCA guidance. Net benefits are the difference in benefits and costs between a baseline case (no build) and the alternative case (build). Costs and benefits were both calculated in constant 2020 dollars. Model inputs are shown in Table 3; economic values of avoided emissions by year can be found in the BCA workbook.

Table 3: Model Inputs

Input	Value	Source
General		
Discount Year	2020	2022 USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Dollar Year	2020	
Discount Rate - CO2 Emissions	3%	
Discount Rate	7%	
Deflator	See Deflator Sheet	
Passenger Vehicle Occupancy	1.67	2022 USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Transit Vehicle Occupancy	20	FHWA Report on Computing Bus and Truck Occupancy Data (2019)[5] estimated motorcoach occupancy rate of 45 for North Carolina. To be conservative, an occupancy rate of 20 persons were used.
Auto Occupancy, All Travel	1.67	2022 USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Average Truck Share - 2023	13.3%	NCDOT
Average Truck Share - 2024	13.4%	NCDOT
Average Truck Share - 2025	13.5%	NCDOT
Average Truck Share - 2026	13.6%	NCDOT
Annual O&M, No Build, per bridge (2020$)	$19,177	NCDOT
Annual O&M, Build, per bridge (2020$)	$3,588	NCDOT
Annual traffic growth	2.0%	NCDOT
Value of Time All Purposes, 2020$ per person-hour	$17.80	2022 USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Value of Time Truck, 2020$ per person-hour	$32.00	
Vehicle Operating Cost per mile (2020$), auto	$0.45	
Vehicle Operating Cost per mile (2020$), truck	$0.94	

[5] FHWA, 2019. Developing a Statistically Valid and Practical Method to Compute Bus and Truck Occupancy Data, https://www.fhwa.dot.gov/policyinformation/tables/occupancyfactors/fhwa_pl_19_048.pdf

Input	Value	Source
Truck Operating Cost per hour (2020$) (excludes truck driver time)	$45.90	ATRI Operational Cost of Trucking 2022 - Table 8, https://truckingresearch.org/wp-content/uploads/2022/08/ATRI-Operational-Cost-of-Trucking-2022.pdf
Roadway Maintenance Cost per Mile, Rural Interstate (2000$) - Auto	$0.00	Source: FHWA Highway Cost Allocation Study, 2000 Addendum, Table 13
Roadway Maintenance Cost per Mile, Rural Interstate (2020$) - Auto	$0.00	Adjusted by GDP Deflator
Roadway Maintenance Cost per Mile, Rural Interstate (2000$) - 40 kip truck	$0.01	Source: FHWA Highway Cost Allocation Study, 2000 Addendum, Table 13
Roadway Maintenance Cost per Mile, Rural Interstate (2020$) - 40 kip truck	$0.01	Adjusted by GDP Deflator
Detour Savings		
Duration of Closures, No Build (days)	4.0	NCDOT
Length of Closures (days)	1	NCDOT
Duration of Delay (hours)	1.0	NCDOT says 2 on average, using to be conservative
Share of Vehicles that use detour	50%	NCDOT
Additional time for detours (hours)	0.167	GoogleMaps, see DetourSavings-BridgeClosure tab
Net Detour (miles)	2.6	GoogleMaps, see DetourSavings-BridgeClosure tab
Safety		
O - No Injury (2020$)	$3,900	2022 USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs
C - Possible Injury (2020$)	$77,200	
B - Non-incapacitating Injury (2020$)	$151,100	
A - Incapacitating Injury (2020$)	$554,800	
K - Killed (2020$)	$11,600,000	
U - Injured (severity unknown) (2020$)	$210,300	
# Accidents Reported (unknown if injured) (2020$)	$159,800	
Injury Crash (2020$)	$302,600	
Fatal Crash (2020$)	$12,837,400	
PDO per vehicle (2020$)	$4,600	
Environmental		
Grams per metric ton	1,000,000	

Benefits

The Project has quantifiable benefits for five of the six of the project outcome criteria listed in the NOFO: State of Good Repair; Safety; Mobility and Economic Competitiveness; Climate, Resiliency, and the Environment; Quality of Life. Innovation has no quantifiable benefits.

The benefits quantified in the following sections are for the Project in total. The results of individual BCAs of each bridge are shown in Table 8 through Table 13 in the Benefit-Cost Analysis Summary.

State of Good Repair

State of Good Repair benefits include residual value at the end of the analysis period, changes to annual O&M costs, road maintenance savings, and bridge repair cost savings.

Residual Value

The Project will have useful life remaining at the end of the 20-year analysis period, as determined by NCDOT and the BEA.[6] In addition to the culverts, which have a useful life of 75 years, right-of-way does not depreciate, bridges have a useful life of 50 years, and utilities have a useful life of 60 years. The non-labor cost of construction and utilities were assumed to be 80% of construction and utilities costs. The residual value is discounted from the last year of each bridge's analysis period. The total residual value is $5.9 million using a 7% discount rate.

Operations & Maintenance Savings

Project improvements will alter the required O&M for all five bridges. O&M under the "no build" is expected to amount to $19,200 per bridge per year, as provided by NCDOT. After reconstruction, O&M will decline to $3,711 per bridge per year. Overall, the Project will reduce O&M by $0.6 million over the 20-year analysis period, discounted at 7%.

Road Maintenance Savings

Under the build, road maintenance needs will be reduced as additional VMT arising from detours are eliminated. After construction, the Project will increase road maintenance savings by $4,200 over the 20-year analysis period, discounted at 7%.

Bridge Repair Cost Savings

The reconstructed bridges will avoid significant rehabilitation required in the "no build" scenario in 2023, 2027, 2032, 2037 and 2042. The cost of repairs, as shown in Table 4, are assumed to be the same for all five bridges due to their similar age and condition. When discounted at 7%, the Project will reduce bridge repair cost by $42.4 million over the 20-year analysis period.

[6] Table C from "BEA Rates of Depreciation, Service Lives, Declining-Balance Rates, and Hulten-Wykoff categories." http://www.bea.gov/scb/account_articles/national/wlth2594/tableC.htm

Table 4. Rehabilitation Cost per Bridge for the "No Build" Scenario

	2023	2027	2032	2037	2042
Epoxy Overlay	$0	$0	$500,700	$0	$500,700
Deck Replacement	$4,172,100	$0	$0	$0	$0
Joint Replacement	$1,045,500	$0	$0	$0	$0
Bearing Replacement	$0	$570,000	$0	$0	$0
Girder Repair	$0	$1,897,500	$0	$1,897,500	$0
Substructure Repair	$741,000	$0	$741,000	$0	$741,000
TCP	$500,000	$200,000	$500,000	$200,000	$500,000
Total Cost (2022$)	**$6,458,600**	**$2,667,500**	**$1,741,700**	**$2,097,500**	**$1,741,700**
Total Cost (2020$)	**$6,244,500**	**$2,579,000**	**$1,683,900**	**$2,027,900**	**$1,683,900**

Source: NCDOT

Safety

Safety benefits include reduced crashes from improved geometry and safety features on bridges, as well as from reduced area VMT from closures and detours avoided.

Reduced Highway Fatalities and Crashes

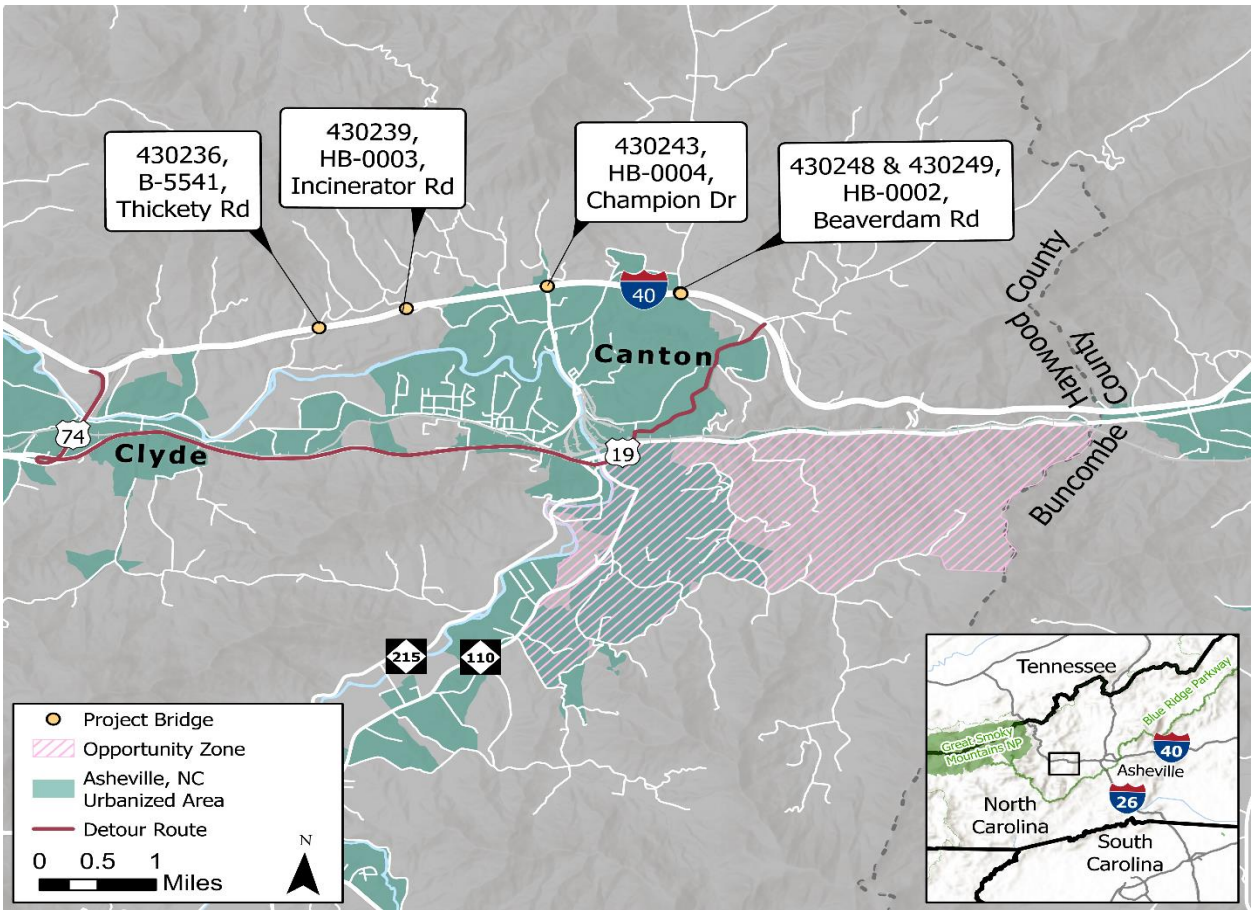
The reconstructed bridges will feature improved geometry, with larger lanes and shoulders than the current bridges. Through this, the Project will reduce the number and severity of traffic accidents during bridge crossings. Crashes within a 500-foot radius of each bridge were examined between 2017-2022. Two Crash Modification Factors (CMFs), as provided by NCDOT, were applied to both historical and predicted crash and injury rates: 0.32 to crashes that involved injuries and fatalities, and 0.15 to all property-damage-only crashes. There were no fatal crashes at the Project location between 2017 and 2022, as shown in Table 5. Crashes avoided were conservatively held constant throughout the analysis period.

Table 5: Historic Crashes in Project Area, 2017-2022

	Number of Crashes	
	Total	**Per Year**
O (No Injury)	36	7.2
I (Injury)	21	4.2
K (Killed)	0	0.0

The present value of reduced crashes and property damage is estimated at $2.1 million over the bridges' 20-year analysis period, using a 7% discount rate.

Figure 2. Local Detour Route



Source: NCDOT

Detour Safety Savings due to Closures Avoided

Based on discussions with NCDOT, in the "no build" scenario, the five bridges in the corridor would need substantial repairs periodically to remain operational, resulting in temporary traffic restrictions that would force up to half of the traffic to detour along a longer route. Each time this longer route is required for driving around a closure, the area will experience increased VMT for the duration of bridge repairs. Such bridge closures would occur every five years beginning in 2023 for four days each,[7] diverting 50% of traffic along a local route as shown in Figure 2. Each such temporary increase in VMT would be avoided with the "build" scenario. The average detour for a closure of one of these five bridges is 2.6 additional miles and 10 additional minutes per trip.

The annual average daily traffic (AADT), truck share, and growth rate for the corridor were provided by NCDOT. The rates of crashes that result in fatalities, injuries, and property damage

[7] NCDOT would use lane closures resulting in diversions and delays only during weekends approximately twice per impact year over a total of 4 days (96 hours).

(as found in 2022 Bureau of Transportation Statistics[8] and 2022 National Highway Traffic Safety Administration[9] data) were applied to the net annual VMT to derive an estimate for crashes prevented by avoiding detour-related VMT.

These crash rates, multiplied by VMTs avoided, were then valued based on USDOT BCA guidance for injury, fatal, and PDO crashes as shown in Table 3. The total reduction in highway fatalities, injuries, and PDO was equivalent to $0.6 million in benefits, discounted at 7%.

Mobility and Economic Competitiveness

Mobility and economic competitive benefits of the Project include auto and truck travel time and operating cost savings associated with closures avoided. Offsetting these benefits are the costs incurred from delays during construction.

Travel Time Savings

The Project will improve traffic flow across all bridges by reducing closures arising from periodic bridge rehabilitation. The reduction in closures will eliminate the additional 10 minutes spent in detours for 50% of traffic and an additional one hour for the remaining 50% of vehicles that do not take the detour.

An occupancy rate of 1.67 for autos was used to calculate the total person/hour travel time savings. Travel time is valued at $17.80 per hour per person and $32.00 per hour per truck driver, per USDOT BCA guidance. Travel time savings for Greyhound users is estimated and described in the Quality of Life section.

The present value of travel time savings is estimated at $28.3 million over the 20-year analysis period, using a 7% discount rate.

Vehicle Operating Savings

Under the "build" scenario, vehicles will avoid the VMT associated with detours during periods of major bridge rehabilitation. Projected vehicle operating savings from this reduced VMT was calculated using a vehicle operating cost of $0.45/mile, as recommended by USDOT BCA guidance. Auto operating savings amount to $0.8 million, discounted at 7%.

Truck Operating Savings

Trucks will also save on operating costs from avoiding of VMT associated with detours during rehabilitation. Truck operating savings was calculated using truck operating cost / mile of $0.94, as recommended by USDOT BCA guidance. The present value of this benefit stream is estimated at $0.3 million over the 20-year analysis period using a 7% discount rate.

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[8]Bureau of Transportation Statistics, "Motor Vehicle Safety Data," https://www.bts.gov/content/motor-vehicle-safety-data.

[9] National Highway Traffic Safety Administration data, March 2022. Available: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813266

Transit Operating Savings

Transit operations will also benefit from reduced VMT associated with bridge closures avoided under the "build" scenario. Transit operating savings assumes a vehicle operating cost/mile of $0.45 - a conservative approach equal to the USDOT recommended value for passenger vehicles. Transit operating savings amount to $190, discounted at 7%.

Construction Delays

During construction, users will experience delays resulting from lane closures. Our analysis assumes that corridor traffic will be affected during the final year of construction (2025 or 2026) and, consistent with the delays required by routine bridge repairs, would result in half of the traffic taking a longer detour and half sitting in an hour of delay over two days. Delays from construction result in auto and truck hours lost equivalent to $6.9 million in costs, discounted at 7%.

Climate Change, Resiliency, and the Environment

Under the "build" scenario, climate change, resiliency and environmental benefits include emissions savings from closures avoided and improved emergency response times. These savings are offset by emissions generated during the construction period.

Emissions Savings from Closures Avoided

Reductions in VMT and idling time as a result of the Project will reduce vehicle emissions. The reduction in VMT and idling time decrease the amount of annual nitrous oxides (NO_x), particulate matter ($PM_{2.5}$), sulfur dioxide (SO_2) and carbon dioxide (CO_2) in the atmosphere. Auto, truck, and bus emissions rates (g/mile) are estimated based on the California Air Resources Board (CARB) "On Road Emissions Rates[10]" model, which was run in order to estimate the long-term change in emissions rates. CARB-projected annual emission rates were used to estimate emission rates for this BCA's analysis period. California has some of the nation's strictest emissions standards; as a result, the rates used in this analysis are conservative.

The tons of reduced emissions were monetized using the recommended values as shown in Table 3. The value of CO_2 avoided was discounted at 3%; all other emissions were discounted at 7%. The emissions savings from the project total $0.1 million when discounted.

Emissions from Construction of Bridges and Culverts

Emissions generated during the construction period were estimated at 184 metric tons of CO2 equivalent for bridges[11] and 46 metric tons of CO2 equivalent for culverts.[12] The tons of

[10] California Air Resources Board, Emissions Inventory, https://arb.ca.gov/emfac/emissions-inventory/747eda1236e185f07668f8c5fabd093d532c0f50

[11] 430243

[12] 430236, 430248, 430249, 430239

emissions were monetized using the recommended values in Table 3. The present value of emissions from construction is estimated at $11,925 using a 3% discount rate.

Emergency Response

The Project will improve resilience by ensuring a passable route during weather emergencies and geotechnical failures on complementary routes, thereby allowing for the efficient evacuation of affected populations and reliable access for emergency responders.

Quality of Life

Transit riders will benefit from the travel time savings of avoided detours and delays associated with bridge closures.

Greyhound Time Savings from Closures Avoided

Persons using intercity buses in the corridor will also benefit from the avoidance of closures associated with intermittent bridge rehabilitation. The elimination of closures will reduce detours and traffic delays thus resulting in significant time savings even when riding mass transit.

An occupancy rate of 20 persons per bus was used to calculate the total person/hour travel time savings. Based on Greyhound bus schedules,[13] approximately 10 bus routes per week travel along the corridor. This estimate is conservative and assumes only one intercity bus operator. Travel time is valued at $17.80 per hour per person, per USDOT BCA guidance. The present value of transit travel time savings is estimated at $0.05 million over the 20-year analysis period using a 7% discount rate.

Innovation

The Project will leverage a range of innovative project development techniques and approaches to deliver the Project in an efficient and cost-effective manner. These innovative techniques include bridge bundling into the design process, contracting and construction of the bridges; the use of vehicular culverts to reduce cost and accelerate construction; and use of the "CM/GC method," wherein the Project will engage a construction manager during the design process to provide input on scheduling, pricing, and phasing that will help design a more constructable and cost-efficient project.

Costs

The cost estimate for the Project was developed by NCDOT. Total first costs of the Project, (including previously incurred costs, design, right-of-way (ROW), utilities, and construction costs) are $62.3 million in 2022 dollars, or $60.3 million in 2020 dollars. Project costs were allocated

[13] https://www.greyhound.com/en

based on the Project schedule as provided by NCDOT and discounted to 2020 using a 7% discount rate. Spending per year for the total Project is shown in Table 6. The capital cost of the project, discounted at 7%, totals $45.1 million.

Table 6: Costs per Year, 2022 Dollars

Year	Previously Incurred Costs	Design	ROW	Utilities	Construction	Total (2022$)	Total (2020$) Discounted at 7%
2022	$1,279,800	$1,745,600	$82,250	$0	$0	$3,107,600	**$2,624,300**
2023	$0	$729,400	$191,600	$600,000	$6,664,100	$8,185,000	**$6,459,900**
2024	$0	$0	$51,200	$150,000	$21,790,400	$21,991,500	**$16,220,800**
2025	$0	$0	$0	$0	$22,913,200	$22,913,200	**$15,795,100**
2026	$0	$0	$0	$0	$6,132,400	$6,132,400	**$3,950,800**
Total	**$1,279,800**	**$2,475,000**	**$325,050**	**$750,000**	**$57,500,000**	**$62,329,100**	**$45,050,900**

**Note: totals may not sum due to rounding*

Benefit-Cost Analysis Summary

The benefits and costs described in the preceding sections are shown in Table 7. Benefits and costs are shown in 2020 dollars and discounted to 2020 using a 7% discount rate. As shown in Table 7, the Project is cost-effective. Because each bridge has independent utility, separate benefit-cost analyses were also developed, as shown in Table 8, Table 9, Table 10, and Table 11.

Table 7: Total Project Benefit-Cost Analysis

	7% Discount Rate
	Total, $2020 M
Project Benefits	**$74.2**
State of Good Repair	
Residual Value	$5.9
O&M Savings	$0.6
Road Maintenance Savings due to Closures Avoided	$0.004
Bridge Repair Cost Savings	$42.4
Safety	
Reduced Highway Fatalities and Crashes	$2.1
Detour Safety Savings due to Closures Avoided	$0.6
Mobility and Economic Competitiveness	
Travel Time Savings due to Closures Avoided	$28.3
Truck Operating Savings due to Closures Avoided	$0.3
Vehicle Operating Savings due to Closures Avoided	$0.8
Transit Operating Savings due to Closures Avoided	$0.0
Construction Delays	-$6.9
Climate Change, Resiliency, and the Environment	
Emissions Savings from Closures Avoided	$0.1
Emissions from Construction of Bridges and Culverts (ISI)	-$0.01
Emergency Response	Qualitative
Quality of Life	
Greyhound Time Savings from Closures Avoided	$0.05
Innovation	Qualitative
Project Costs	**$45.1**
Capital Costs	$45.1
Net Benefits	$29.1
Benefit-Cost Ratio	**1.65**

Table 8: BCA for Bridge B-5541/430236

	7% Discount Rate
	Total, $2020 M
Project Benefits	**$15.8**
State of Good Repair	
Residual Value	$1.5
O&M Savings	$0.1
Road Maintenance Savings due to Closures Avoided	$0.0
Bridge Repair Cost Savings	$8.5
Safety	
Reduced Highway Fatalities and Crashes	$0.1
Detour Safety Savings due to Closures Avoided	$0.2
Mobility and Economic Competitiveness	
Travel Time Savings due to Closures Avoided	$6.8
Truck Operating Savings due to Closures Avoided	$0.1
Vehicle Operating Savings due to Closures Avoided	$0.2
Transit Operating Savings due to Closures Avoided	$0.0
Construction Delays	-$1.6
Climate Change, Resiliency, and the Environment	
Emissions Savings from Closures Avoided	$0.03
Emissions from Construction of Bridges and Culverts (ISI)	
Emergency Response	Qualitative
Quality of Life	
Greyhound Time Savings from Closures Avoided	$0.01
Innovation	Qualitative
Project Costs	**$11.6**
Capital Costs	$11.6
Net Benefits	$4.2
Benefit-Cost Ratio	**1.37**

Table 9: BCA for Bridge HB-0002/430248 and 430249

	7% Discount Rate
	Total, $2020 M
Project Benefits	**$25.1**
State of Good Repair	
Residual Value	$1.9
O&M Savings	$0.2
Road Maintenance Savings due to Closures Avoided	$0.0
Bridge Repair Cost Savings	$16.9
Safety	
Reduced Highway Fatalities and Crashes	$0.5
Detour Safety Savings due to Closures Avoided	$0.2
Mobility and Economic Competitiveness	
Travel Time Savings due to Closures Avoided	$6.8
Truck Operating Savings due to Closures Avoided	$0.1
Vehicle Operating Savings due to Closures Avoided	$0.2
Transit Operating Savings due to Closures Avoided	$0.0
Construction Delays	-$1.7
Climate Change, Resiliency, and the Environment	
Emissions Savings from Closures Avoided	$0.0
Emissions from Construction of Bridges and Culverts (ISI)	
Emergency Response	Qualitative
Quality of Life	
Greyhound Time Savings from Closures Avoided	$0.0
Innovation	Qualitative
Project Costs	**$14.3**
Capital Costs	$14.3
Net Benefits	$10.8
Benefit-Cost Ratio	**1.76**

Table 10: BCA for Bridge HB-0003/430239

	7% Discount Rate
	Total, $2020 M
Project Benefits	**$17.4**
State of Good Repair	
Residual Value	$1.5
O&M Savings	$0.1
Road Maintenance Savings due to Closures Avoided	$0.0
Bridge Repair Cost Savings	$8.5
Safety	
Reduced Highway Fatalities and Crashes	$1.3
Detour Safety Savings due to Closures Avoided	$0.2
Mobility and Economic Competitiveness	
Travel Time Savings due to Closures Avoided	$7.4
Truck Operating Savings due to Closures Avoided	$0.1
Vehicle Operating Savings due to Closures Avoided	$0.2
Transit Operating Savings due to Closures Avoided	$0.0
Construction Delays	-$1.7
Climate Change, Resiliency, and the Environment	
Emissions Savings from Closures Avoided	$0.0
Emissions from Construction of Bridges and Culverts (ISI)	
Emergency Response	Qualitative
Quality of Life	
Greyhound Time Savings from Closures Avoided	$0.0
Innovation	Qualitative
Project Costs	**$11.2**
Capital Costs	$11.2
Net Benefits	$6.3
Benefit-Cost Ratio	**1.56**

Table 11: BCA for Bridge HB-0004/430243

	7% Discount Rate
	Total, $2020 M
Project Benefits	**$15.9**
State of Good Repair	
Residual Value	$1.0
O&M Savings	$0.1
Road Maintenance Savings due to Closures Avoided	$0.0
Bridge Repair Cost Savings	$8.5
Safety	
Reduced Highway Fatalities and Crashes	$0.2
Detour Safety Savings due to Closures Avoided	$0.2
Mobility and Economic Competitiveness	
Travel Time Savings due to Closures Avoided	$7.4
Truck Operating Savings due to Closures Avoided	$0.1
Vehicle Operating Savings due to Closures Avoided	$0.2
Transit Operating Savings due to Closures Avoided	$0.0
Construction Delays	-$1.7
Climate Change, Resiliency, and the Environment	
Emissions Savings from Closures Avoided	$0.0
Emissions from Construction of Bridges and Culverts (ISI)	
Emergency Response	Qualitative
Quality of Life	
Greyhound Time Savings from Closures Avoided	$0.0
Innovation	Qualitative
Project Costs	**$8.0**
Capital Costs	$8.0
Net Benefits	$7.8
Benefit-Cost Ratio	**1.97**

Appendix A: References

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