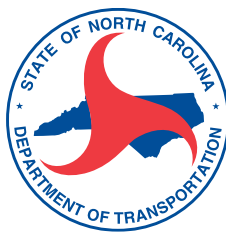


APPENDIX C: BENEFIT COST ANALYSIS (BCA)

THE BRITE BRIDGES: Bridging Resources for Infrastructure and Thriving Economies Project



NCDOT BRITE BRIDGES PROJECT

Benefit-Cost Analysis Narrative

Division 1

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I. Project Description

The BRITE Bridges: Bridging Resources for Infrastructure and Thriving Economies project (or “Project”), situated in the scenic Inner Banks of northeast North Carolina, aims to enhance two critical bridges that are integral to the region's infrastructure and economic vitality. The Project is set against a backdrop of natural beauty and socio-economic challenges, with the Albemarle Sound serving as a central feature of the landscape. While rich in ecological diversity and rural charm, this area faces the stark contrast of high poverty rates amidst its tranquil setting.

The Project's scope includes vital preservation work on Bridge 930015 (National Bridge Inventory (NBI) 000000001870015), also known as the Albemarle Sound Bridge, and Bridge 070007 (NBI 000000000150007), locally referred to as the Three Rivers Bridge. Both bridges serve as essential conduits for local and regional traffic, linking communities and supporting the distribution of freight along US 17, and providing critical links between US 17 and US 64.

Albemarle Sound Bridge

Constructed in 1990, this bridge is a two-lane structure that includes a series of concrete trestle and post-tensioned segmental box spans. Despite regular maintenance, the bridge requires significant preservation to maintain its structural integrity and extend its lifespan by an estimated 75 years. The scope of work includes:

- Replacing the barrier rail to meet current standards.
- Repairing deck areas not addressed by polymer concrete overlay.
- Applying polymer concrete deck overlay and replacing expansion joints and seals.
- Repairing concrete spalls and delamination (material fractures), and injecting select cracks with epoxy resin.
- Applying silane treatment to concrete components and installing cathodic protection to prevent further deterioration.

Three Rivers Bridge

This bridge, built in 1968, features prestressed concrete girder and continuous steel plate girder superstructure spans. Past projects have focused on overlays and repairs, but further work is necessary to address ongoing issues and prolong the bridge's service life by another 75 years.

The preservation activities include:

- Repairing the barrier rail and treating or replacing the Latex Modified Concrete overlay as needed.
- Addressing expansion joints, spalls, delaminations, and cracking with appropriate repairs and treatments.
- Spot painting structural steel and replacing or refurbishing bearings.
- Enhancing substructure protection with cathodic measures and slope protection.

The BRITE Bridges project is not just about physical infrastructure; it's about bridging the gap between the region's natural allure and the socio-economic needs of its communities. By

improving these bridges, the Project seeks to support thriving economies and allow for sustainable development for the people of the Inner Banks.

The project’s purpose and need consist of addressing the poor condition of the existing bridges and preventing future closure to all vehicular traffic – thereby allowing the avoidance of significant detours and additional vehicle miles traveled. Without the project and significant capital investment, the bridges must be replaced. According to the National Bridge Investment Analysis System (NBIAS), the Three Rivers Bridge is forecasted to require full closure to traffic beginning in 2037. According to the North Carolina Department of Transportation Bridge Deterioration Model, the Albemarle Bridge’s superstructure will reach a condition rating of 2 in 2045, the substructure will reach a condition rating of 2 in 2032, and the deck will reach a condition rating of 2 in 2053 – resulting in an average condition rating of 2 in 2043.¹ After applying the average natural rate of deterioration for bridges with a condition rating of 2 (3.68 years), the bridge is estimated to be fully closed in 2047.

As a result, the preservation of these bridges would avoid future closure of the bridges, thereby resulting in the avoidance of substantial additional vehicle miles traveled in the Build scenario while yielding significant project benefits related to travel time savings, vehicle operating cost savings, safety benefits, highway external use cost savings, and avoided emission cost savings.

This benefit-cost analysis (BCA) quantifies and compares the net benefits and costs without and with the Project—the “No Build” and “Build” scenarios, respectively—and illustrates that over a 30-year analysis period, the Project’s monetized benefits exceed the costs, as summarized in Table 1.

Table 1: Benefit-Cost Analysis Summary (Dollars in Thousands)

<i>Description</i>	<i>Discounted (7%)*</i>
<i>Net Benefits</i>	\$1,354,870,859
<i>Costs</i>	\$95,959,518
<i>Benefit-Cost Ratio (BCR)</i>	14.12
<i>Net Present Value (NPV)</i>	\$1,258,911,341

*Except for CO₂ emissions, discounted at 3%, as per USDOT guidelines.

¹ Data provided by NCDOT bridge engineer.

II. Introduction

The Project is located in the Inner Banks of northeast North Carolina. The Albemarle Sound is the main geographic feature of the area. The area surrounding the project is rural, with abundant green space and natural resources. This includes prime farmland, wildlife refuges, swamps, creeks, rivers, and forests. The area is served by US 17, which is on the National Freight Network. The bridges provide first and last-mile distribution of freight from US 17.

While the area east of the project is heavily populated with tourists and second homes, the project area is designated as rural, and the population has a high poverty rate. The region has a rich cultural history and strong ties to agriculture, as the area was a major producer of cotton, peanuts, and soybeans.

The project area is designated as rural, with the Chowan and Washington County portion served by the Albemarle Rural Planning Organization (RPO) and the Bertie County portion served by the Peanut Belt RPO. RPOs were mandated by the North Carolina General Assembly in 2000 to lead the development of transportation planning documents and support the prioritization of projects. These activities mimic the elements that are federally required of Metropolitan Planning Organizations (MPOs).

The Albemarle Sound Bridge is located on North Carolina State Highway 32 between US 64 and Edenton. Constructed in 1990, the overall length of the bridge is 3.50 miles. The two-lane facility consists of 224 concrete trestle superstructure spans at the south end of the bridge, 162 concrete trestle superstructure spans at the north end of the bridge, and 31 spans of post-tensioned segmental concrete box superstructure between the trestle superstructure sections.

The Three Rivers Bridge carries NC 45 / NC 308 over Roanoke, Middle and Cashie Rivers, between US 17 and US 64. Constructed in 1968, the 1.1-mile-long bridge carries NC 45 / NC 308 over Roanoke, Middle and Cashie Rivers, between US 17 and US 64. Constructed in 1968, the two-lane facility consists of 16 prestressed concrete girder superstructure spans at the south end of the bridge, 76 prestressed concrete girder superstructure spans at the north end of the bridge, and 3 spans of continuous steel plate girder superstructure between the prestressed concrete girder superstructure sections.

III. Purpose

This document presents the Benefit-Cost Analysis (BCA) for the Project and quantifies and compares the Project’s associated costs and expected benefits. The BCA, completed using the Bridge Investment Program Benefit-Cost Analysis Tool (BIP BCA Tool), outlines the benefit calculations, project costs, the resulting overall benefit-cost ratio (BCR), and the Project’s net present value (NPV).

The BIP BCA Tool was prepared in accordance with the U.S. Department of Transportation’s (USDOT) *Benefit-Cost Analysis Guidance for Discretionary Grant Programs* published in January 2023. All monetary values are stated in 2021 dollars. The benefits analysis period is 30 years after each bridge's final year of construction. Construction on the Albemarle Bridge is expected to conclude in 2027, while construction is projected to conclude on the Three Rivers Bridge in 2028.

All values used in the BIP BCA Tool – aside from inputs for project construction costs, construction disbenefits, and bridge condition ratings for the Albemarle Bridge was provided by the National Bridge Inventory (NBI) and the National Bridge Investment Analysis System (NBIAS). This data includes bridge length, traffic volumes, net detour length, and detour average speed.

The Project benefits quantified here are partially offset by additional costs (“disbenefits”) related to delays caused by estimated construction phasing and traffic detours.

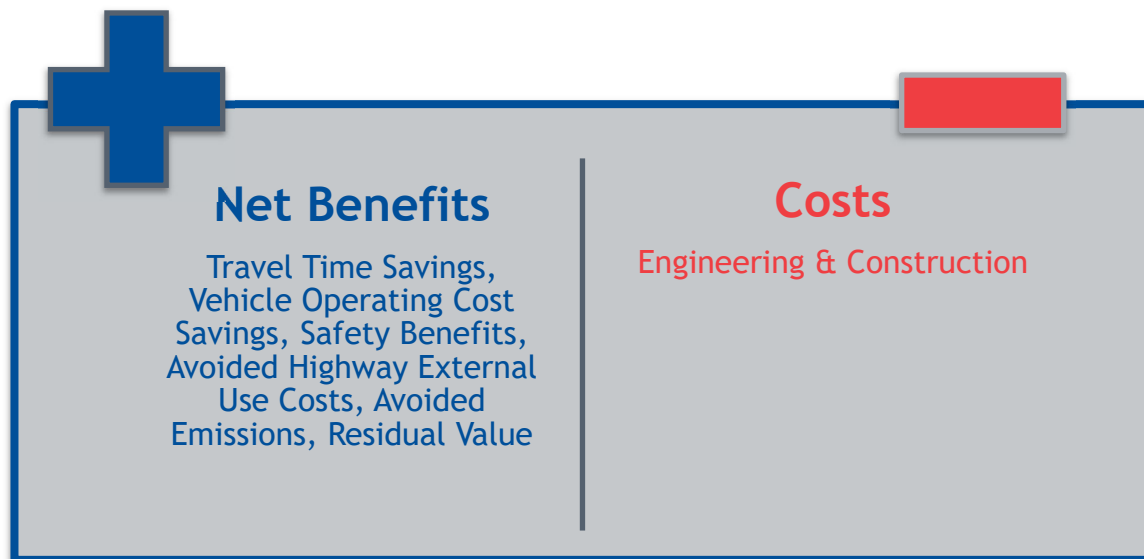


Figure 1: BCA Process

The project can be expected to generate benefits through its residual value, enhanced safety (reduced injuries and fatalities), improved economic competitiveness, reduced emissions, and improved quality of life. Emissions and quality of life benefits cannot readily be quantified, so they are discussed but not directly incorporated into the BIP BCA Tool.

The economic competitiveness factor for travel time savings comprised the most significant share of benefits. The economic competitiveness factor for vehicle operating costs is the second-greatest share of total benefits. Safety benefits through fewer crashes resulting in fatalities, injuries, and property damage only (PDO) comprised the third greatest share of benefits. See **Table 2** below for a breakdown of benefits by type.

Table 2: Project Benefits Summary (2021 Dollars in Thousands)

<i>Description</i>	<i>PV at 7%</i>
<i>Residual Value</i>	\$7,051,866
<i>Safety Cost Savings</i>	\$362,964,988
<i>Travel Time Cost Savings</i>	\$553,807,171
<i>Vehicle Operating Cost Savings</i>	\$439,512,708
<i>Avoided CO2 Damage Cost Savings</i>	\$59,653,043
<i>Avoided Non-CO2 Damage Cost Savings</i>	\$6,685,798
<i>Other Environmental</i>	\$373,901
<i>Other Benefits</i>	-\$75,178,618
<i>Total Benefits</i>	\$1,354,870,859

*Except for CO₂ emissions, which are discounted at 3% as per USDOT guidelines.

IV. Project Costs

A conceptual design and cost estimate was developed for the BRITE Bridges Project. Construction activities are expected to take place between 2025-2028, with construction on the Albemarle Bridge ending in 2027 and construction on the Three Rivers Bridge ending in 2028. The project’s total undiscounted construction cost is \$128.475 million, in 2021 dollars, with expenditures for preliminary engineering and construction taking place between 2023-2028. Construction costs include a 20 percent contingency. Separately, in 2021 dollars, the total cost for the Albemarle Bridge and Three Rivers Bridge is \$89.244 million and \$39.230 million in 2021 dollars. **Table 3** displays the combined total project costs for the bridges in 2023 dollars. **Table 4** displays Project costs in 2021 dollars and the estimated timing of expenditures.²

Table 3: Total Project Costs (\$2023)

Description	Project Cost
Mobilization	\$4,611,000
Construction Access	\$3,163,000
PS & E	\$9,997,496
Traffic Control	\$4,998,748
Inspection	\$9,997,496
Bridge	\$92,200,962
Contingency	\$18,440,192
Total	\$143,408,895

Table 4: Project Cost and Schedule of Expenditures (\$2021)

Description	Project Cost	2024	2025	2026	2027	2028
Mobilization	\$4,130,821	\$4,130,821	\$0	\$0	\$0	\$0
Construction Access	\$2,833,613	\$0	\$661,176	\$1,133,445	\$1,038,991	\$0
PS & E	\$8,956,381	\$8,956,381	\$0	\$0	\$0	\$0
Traffic Control	\$4,478,190	\$0	\$727,178	\$1,246,590	\$1,823,565	\$680,857
Inspection	\$8,956,381	\$0	\$1,454,355	\$2,493,181	\$3,647,130	\$1,361,715
Bridge	\$82,599,374	\$0	\$13,221,200	\$22,664,915	\$33,744,715	\$12,968,543
Contingency	\$16,519,875	\$0	\$2,644,240	\$4,532,983	\$6,748,943	\$2,593,709
Total	\$128,474,635	\$13,087,202	\$18,708,150	\$32,071,114	\$47,003,345	\$17,604,824

² Adjusted to 2021 Dollars using US GDP Chained Index, as per 2023 USDOT BCA Guidance.

V. Benefits and Disbenefits

The economic competitiveness factor for travel time savings comprised the most significant share of benefits. The economic competitiveness factor for vehicle operating cost savings is the second-greatest share of total benefits. Safety benefits through a decrease in crashes resulting in fatalities, injuries, and property damage only (PDO) comprised the third greatest share of benefits.

i. Condition Ratings

The NBIAS shows that the Albemarle Bridge is expected to be closed by 2062. However, NCDOT's Bridge Deterioration Model shows the Albemarle Bridge to be in significantly worse condition. **Table 5** displays the current and future condition ratings for the Albemarle Bridge.

Table 5: NCDOT Deterioration Model Condition Ratings for the Albemarle Bridge³

<i>Description</i>	<i>Current Score</i>	<i>Future Score / Year</i>	<i>Expected Year of Condition Rating 2</i>
<i>Deck</i>	6	4 / 2039	2053
<i>Superstructure</i>	6	4 / 2034	2045
<i>Substructure</i>	4	3 / 2026	2032

To estimate the expected year of closure for the Albemarle Bridge, the calculated average (2043) for the projected year in which each of the deck, superstructure, and substructure would fall to a condition rating of 2 was used to estimate the year of closure. Subsequently, the average natural rate of deterioration for bridges with a condition rating of 2 (3.68 years) was applied to find the year of closure (2047).⁴

The analysis used the default model value for the Three Rivers Bridge, as calculated by the NBIAS. According to the NBIAS, the Three Rivers Bridge is forecasted to require full closure to traffic beginning in 2037. The NCDOT Bridge Deterioration Model results for the Three Rivers Bridge are shown in **Table 6**, although they were not utilized in the analysis.

Table 6: NCDOT Deterioration Model Condition Ratings for the Three Rivers Bridge⁵

<i>Description</i>	<i>Current Score</i>	<i>Future Score / Year</i>	<i>Expected Year of Condition Rating 2</i>
<i>Deck</i>	6	4 / 2039	2053
<i>Superstructure</i>	6	4 / 2027	2038
<i>Substructure</i>	4	3 / 2029	2035

³ Ibid, 1.

⁴ BIP BCA Tool Manual.

⁵ Ibid, 1.

ii. Construction Disbenefits (Detours)

Regarding traffic control for construction on both bridges, all above-deck work would require the bridge to be closed, both for the safety of the workers and the quality of work. The base assumes that that all traffic will be detoured due to above-deck work in the Build scenario. Construction activities in the Build scenario are expected to occur between 2025-2028. Construction on the Albemarle Bridge is expected to begin in 2025 and conclude in 2027. Construction on the Three Rivers Bridge is expected to begin in 2027 and conclude in 2028. **Tables 7 and 8** display the estimated days and months of bridge closure that would cause full traffic detours during the construction phase of the Build scenario.

Table 7: Albemarle Bridge Project Days of Closure due to Construction

<i>Description</i>	<i>Weeks</i>
<i>Total Days</i>	644
<i>Total Months</i>	23

Table 8: Three Rivers Bridge Project Days of Closure due to Construction

<i>Description</i>	<i>Weeks</i>
<i>Total Days</i>	161
<i>Total Months</i>	6

Based on the estimated days of closure due to construction for each bridge, travel time disbenefits, safety disbenefits, and vehicle operating cost disbenefits were captured. Travel time disbenefits were captured in the BIP BCA Tool, while the safety and vehicle operating cost disbenefits due to additional detour-related vehicle miles traveled were added to the BIP BCA Tool separately.

iii. Residual Value

As a bridge preservation project, many of the Project's assets will have useful lives well beyond the BCA's 30-year analysis period over which benefits are quantified. The residual value represents the Project's remaining useful life past the analysis period and is deemed a benefit in the final year of the analysis. The project's preservation work is expected to extend the useful life of both bridges by approximately 75 years.⁶

vi. Detour Safety Benefit

A direct benefit of reduced vehicle miles traveled (VMT) is an expected decrease in the overall number of vehicular crashes. With fewer vehicles on the detour routes, the potential for collisions and, therefore, safety risk will be diminished.

⁶ NCDOT engineers' estimate.

National crash statistics per 1 million VMT were applied to the net reduction in VMT to estimate fatality and injury crashes avoided. The BCA utilizes estimates per 1 million VMT of 0.013 fatalities and 0.77 injuries, as provided by the Bureau of Transportation Statistics.⁷

iv. Operating and Maintenance Costs

Since the project only involves the preservation of the existing bridges, routine operating and maintenance costs on the bridges are expected to be roughly the same. Accordingly, operating and maintenance costs for both bridges are assumed to be the same in the No Build and Build scenario and, therefore, excluded from the BIP BCA Tool.

⁷ Bureau of Transportation 2021 Crash Statistics. Table 2-17.

VI: Benefit-Cost Analysis Results

This section displays the respective total discounted benefits, total discounted costs, and net present value (NPV) results for each of the four project bridges. **Table 9** displays the results for the Albemarle Bridge, and **Table 10** displays the results for the Three Rivers Bridge.

Table 9: Albemarle Bridge Results

<i>Calendar Year</i>	Discounted Benefits	Discounted Costs	NPV
<i>Pre-Benefits Period</i>	\$(98,195,020)	\$64,129,112	\$(162,324,132)
2028	\$-	\$-	\$-
2029	\$-	\$-	\$-
2030	\$-	\$-	\$-
2031	\$-	\$-	\$-
2032	\$-	\$-	\$-
2033	\$-	\$-	\$-
2034	\$-	\$-	\$-
2035	\$-	\$-	\$-
2036	\$-	\$-	\$-
2037	\$-	\$-	\$-
2038	\$-	\$-	\$-
2039	\$-	\$-	\$-
2040	\$-	\$-	\$-
2041	\$-	\$-	\$-
2042	\$-	\$-	\$-
2043	\$-	\$-	\$-
2044	\$-	\$-	\$-
2045	\$-	\$-	\$-
2046	\$-	\$-	\$-
2047	\$32,113,933	\$-	\$32,113,933
2048	\$30,856,817	\$-	\$30,856,817
2049	\$29,632,599	\$-	\$29,632,599
2050	\$28,375,293	\$-	\$28,375,293
2051	\$27,205,587	\$-	\$27,205,587
2052	\$26,071,253	\$-	\$26,071,253
2053	\$24,972,596	\$-	\$24,972,596
2054	\$23,909,734	\$-	\$23,909,734
2055	\$22,882,615	\$-	\$22,882,615
2056	\$21,891,044	\$-	\$21,891,044
2057	\$25,621,925	\$-	\$25,621,925
Total	\$195,338,376	\$64,129,112	\$131,209,264

Table 10: Three Rivers Bridge Results

Calendar Year	Total Benefits	Total Costs	NPV
<i>Pre-Benefits Period</i>	\$(40,710,568)	\$31,830,406	\$(72,540,974)
2029	\$-	\$-	\$-
2030	\$-	\$-	\$-
2031	\$-	\$-	\$-
2032	\$-	\$-	\$-
2033	\$-	\$-	\$-
2034	\$-	\$-	\$-
2035	\$-	\$-	\$-
2036	\$-	\$-	\$-
2037	\$77,040,574	\$-	\$77,040,574
2038	\$74,867,160	\$-	\$74,867,160
2039	\$72,660,715	\$-	\$72,660,715
2040	\$69,930,674	\$-	\$69,930,674
2041	\$67,727,089	\$-	\$67,727,089
2042	\$65,501,149	\$-	\$65,501,149
2043	\$63,287,341	\$-	\$63,287,341
2044	\$61,093,525	\$-	\$61,093,525
2045	\$58,926,480	\$-	\$58,926,480
2046	\$56,817,694	\$-	\$56,817,694
2047	\$54,720,687	\$-	\$54,720,687
2048	\$52,665,302	\$-	\$52,665,302
2049	\$50,654,978	\$-	\$50,654,978
2050	\$48,577,795	\$-	\$48,577,795
2051	\$46,641,167	\$-	\$46,641,167
2052	\$44,756,693	\$-	\$44,756,693
2053	\$42,925,713	\$-	\$42,925,713
2054	\$41,149,169	\$-	\$41,149,169
2055	\$39,427,656	\$-	\$39,427,656
2056	\$37,761,456	\$-	\$37,761,456
2057	\$36,150,583	\$-	\$36,150,583
2058	\$36,959,451	\$-	\$36,959,451
Total	\$1,159,532,483	\$31,830,406	\$1,127,702,077