Technical Memorandum: Benefit-Cost Analysis of the iBRAGG Project

Date: May 15, 2020

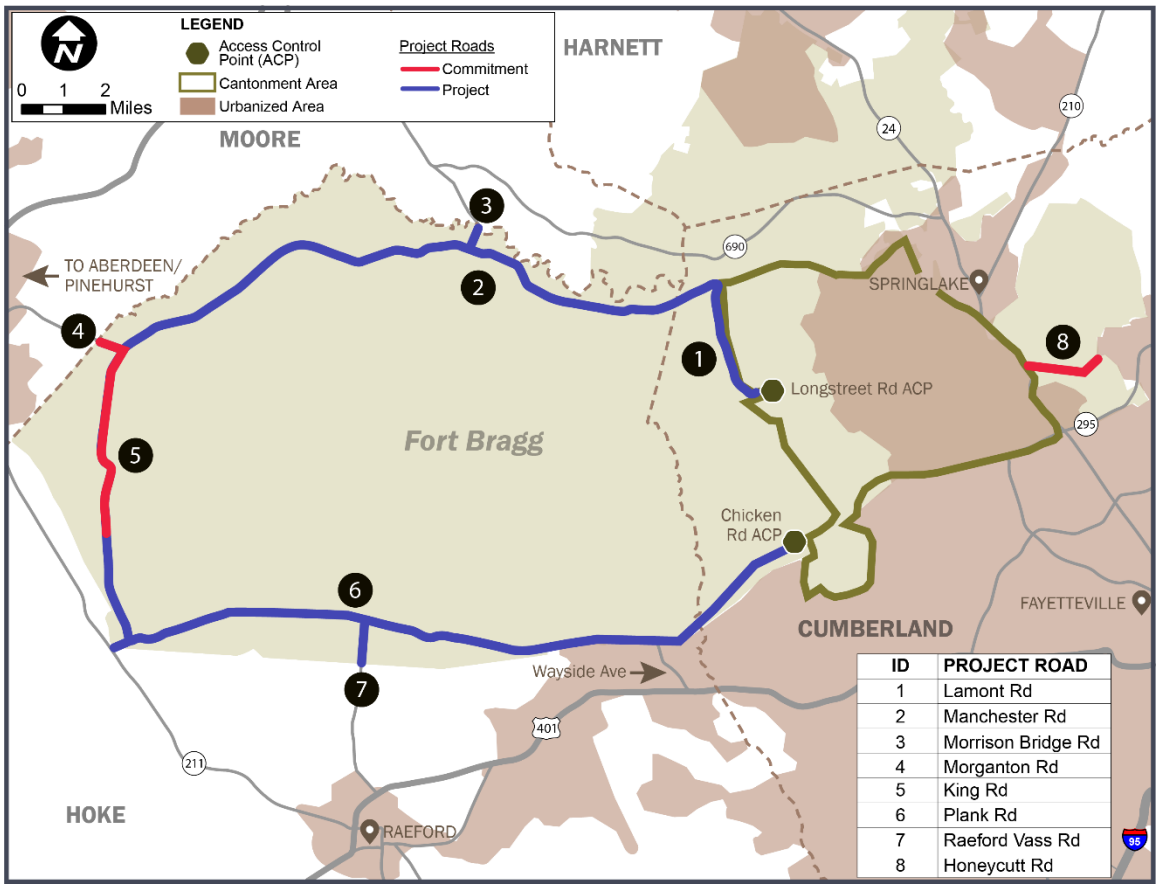
Subject: Benefit-Cost Analysis for the iBRAGG Project

Project Description

The *improving Bragg Roads and Access for Greater Growth* Project ("iBRAGG" or "the Project" hereafter) will repair and rehabilitate approximately 47 miles of publicly accessible roadways within United States Army Garrison (USAG) Fort Bragg, but outside of the cantonment and other secured areas. These roads, which include Lamont Road, Manchester Road, Morrison Bridge Road, Morganton Road, King Road, Plank Road, and Raeford Vass Road (as illustrated in Figure 1) were originally constructed for military training use. Today, they are used both for military training activities and as commuter routes for destinations within Fort Bragg and the Fayetteville metropolitan area. These roads are characterized by deteriorating pavement conditions, pavement edge drop-offs, substandard guardrails, inadequate signage, and vegetation encroaching on roadway clear zones and erosion; all leading to unsafe and inefficient travel. In their current state, the roads do not meet North Carolina Department of Transportation (NCDOT) design specifications. By bringing these roads into a state of good repair, the Project will bring enhanced rural-urban economic connectivity; improve travel time; reduce the incidence and severity of vehicular accidents; save taxpayer money by more efficiently operating and maintaining the roads; and enhance emergency response capabilities.

The Project will allow NCDOT to take over long-term road repair and maintenance responsibilities. Upon confirmation that the Project roads have been brought into a state of good repair, consistent with NCDOT design specifications, Fort Bragg will petition the NCDOT to add the roads to the State Highway System. This addition will be accomplished in accordance with NCDOT road addition procedures, which includes approval by the NCDOT Board of Transportation.

Figure 1 – Roads to be Maintained by NCDOT



Source: NCDOT and Fort Bragg

Transportation Challenge

Fort Bragg is a critical military facility, as well as an economic anchor for the Fayetteville metropolitan area. Fort Bragg has an annual economic impact of $6.9 billion,[1] and supports a population of 276,450 (2019) active duty soldiers, reservists, Department of Defense civilians and contract employees, retirees, and family members. Over time, Fort Bragg is becoming more integrated into the Fayetteville metropolitan area and the regional economy through a shared labor pool, contracting, and coordination of public services and activities. As the region has grown, the Project roads, originally built to support the Army's training activities, carry a higher volume of traffic than envisioned when they were constructed.

Currently, the Project roads are used daily by the general public to access destinations in the Fayetteville metropolitan area, in addition to employment centers and services within Fort Bragg. Commuter traffic, for which Fort Bragg is neither an origin nor a destination, has grown in recent years. Travelers use the Project roads to avoid nearby congested arterials and to reduce vehicle miles travelled

[1] Refer to the Fort Bragg Overview provided in the Supplemental Materials

Consequently, a rising volume of trips are being made on poorly maintained roads that do not meet NCDOT's design specifications. The roads are cracking, rutting, crumbling, have inadequate shoulders with unsafe drop-offs, and have developed potholes. As a consequence, a rising volume of travel comprised of base-related and non-base related trips are being made on poorly maintained roads that do not meet NCDOT's current standards.

Aside from commuter travel, the Project roads play a critical role in the movement of military equipment and training exercises. Due to this dual functionality, Fort Bragg is unable to fully close the Project roads to non-base traffic even when their condition is not safe for commuter travel. King Road has been closed to the public since 2018 due to its poor condition; however, barricades and signage meant to deter commuter traffic is often ignored or removed by travelers. A permanent barrier cannot be installed because this road is used for emergency response vehicles and for military training activities The road's closure means some commuters take longer routes than they would if the road was open to all traffic; therefore, King Road's reconstruction would save commuters mileage and travel time.

State of Good Repair

The project roads are in poor condition, as shown in Figure 2. The roads are cracking, rutting, crumbling, have little or no shoulder, and have developed potholes. The transfer of maintenance and repair responsibilities to NCDOT shifts this activity to an agency that is better equipped to maintain the roads to a higher quality and at a lower cost. Road quality in this instance is measured primarily in terms of safer design and smoother pavement that results in less wear and tear on vehicles.

Figure 2 – Pavement Condition along King Road

In order to bring the roads to a state of good repair, the Project needs to address several design elements, including drainage, vegetation, guardrails, culvert replacement, pavement width, pavement condition, shoulders, signing, and pavement markings. Table 1 lists the roads and improvements included in this project.

Table 1- Road Improvements

Road Name	Road Segment	Length (miles)	Description of Improvements
Lamont Road	Manchester Road to Longstreet Road	3.29	Drainage, signing, vegetation management, guardrail, pavement rehabilitation, resurfacing, shoulder reconstruction and pavement markings.
Manchester Road	Lamont Road to Connecticut Road	15.88	Drainage, signing, vegetation management, guardrail, full depth pavement reclamation, resurfacing, widening, shoulder reconstruction and pavement markings.
Morrison Bridge Road	Manchester Road to Fort Bragg Boundary at Little River	0.59	Drainage, signing, vegetation management, resurfacing, shoulder reconstruction and pavement markings.
Morganton Road	Manchester Road to Fort Bragg Boundary at SR 2033	0.65	Drainage, signing vegetation management, pavement rehabilitation, resurfacing, shoulder reconstruction and pavement markings.
King Road	Manchester Road to Plank Road	7.23	Drainage, signing, vegetation management, guardrail, full depth reclamation, pavement rehabilitation, resurfacing, widening, pipe replacement at Wolf Pit Creek, ditch stabilization, shoulder reconstruction and pavement markings.
Plank Road	Chicken Road ACP to Fort Bragg Boundary at SR 1219	17.96	Drainage, signing, vegetation management, full depth pavement reclamation, pavement repairs, resurfacing, widening, shoulder reconstruction and pavement markings.
Raeford Vass Road	Plank Road to Fort Bragg Boundary at SR 1300	1.05	Drainage, signing, vegetation management, resurfacing, shoulder reconstruction and pavement markings.
Honeycutt Road	Texas Pond	N/A	Culvert replacement and guardrail improvements

An impact matrix in Table 2 describes the Project's benefits.

Table 2 – Project Matrix

Current Status/Baseline & Problem to be Addressed	Change to Baseline or Alternatives	Types of Impacts	Affected Population	Economic Benefit (Net Present Values, $2018 M) Discounted at 7%	Page Reference in BCA
Existing roads around Fort Bragg are in a state of disrepair, resulting in vehicle wear and tear, crashes, emergency response delays, and ongoing maintenance that is performed by the military instead of NCDOT. In addition, King Road's closure to non-base traffic results in some commuters taking longer routes to and from Fayetteville.	By reconstructing the Project roads, they are brought up to a state of good repair and are able to be maintained by NCDOT at a lower cost. The improved roads save vehicle maintenance costs, improve travel speeds and safety, save truck operating time, avoid future costs of flooding, and save emissions. With King Road open to commuters, they avoid detours that results in travel time savings, vehicle operating cost savings, and crashes and emissions avoided.	**Safety**			
		Reduced Highway Fatalities and Crashes	Roadway users and nonusers	$25.9	8
		Emergency Response and Access	Fort Bragg residents and personnel; regional residents served by Fort Bragg Fire Stations 8 and 10	$2.4	9
		King Rd. Detour Safety Savings	Commuters to and from Fayetteville using King Road	$2.2	10
		Economic Competitiveness			
		Delays During Construction	Auto and truck roadway users	-$2.6	13
		Travel Time Savings	Auto and truck roadway users	$6.1	14
		King Rd. Detour Travel Time Savings	Commuters to and from Fayetteville using King Road	$1.4	15
		Truck Operating Savings	Truck roadway users	$0.4	14
		King Rd. Detour Vehicle Operating Cost Savings	Commuters to and from Fayetteville using King Road	$3.3	15
		Congestion Relief	Auto and truck roadway users	Qualitative	15
		State of Good Repair			
		Vehicle Maintenance Savings	Auto roadway users	$5.1	16
		Emergency Vehicle Maintenance Savings	North Carolina taxpayers	$0.9	17
		Resilience Repair Cost Savings	North Carolina taxpayers	$3.2	17
		Residual Value	North Carolina taxpayers, NCDOT	$3.0	17
		Environmental Sustainability			
		Emissions Savings (auto - includes King Rd. Detours)	All users and nonusers	$0.0	17
		Emissions Savings (truck)	All users and nonusers	$0.0	18
		Quality of Life			
		Regional Mobility	Residents within region	Qualitative	18
		Operating & Maintenance			
		O&M Savings (Costs)	North Carolina taxpayers, NCDOT	$7.1	19

Introduction

This technical memorandum estimates the long-term benefits associated with the Project. The long-term benefits presented relate to five goals identified in the BUILD 2020 Notice of Funding Opportunity (NOFO):[2] Safety, Economic Competitiveness, State of Good Repair, Environmental Sustainability, and Quality of Life. The results are the discounted streams of anticipated benefits and costs and the Benefit-Cost Ratios for the Project.

The Project described in this application would support the region's economy over the long-term by providing the workforce and residents of North Carolina with improved roadway facilities to and around Fort Bragg, generating travel time savings, auto and truck emissions reductions, accident reductions, and wear and tear reductions on vehicles from poorly maintained roads.

The balance of this discussion describes the assumptions and methods used to develop the benefit-cost analysis and estimate the value of the long-term benefits generated by the investment. As directed in the BUILD guidance, the benefits of the capital investment have been estimated over a 20-year analysis horizon. The last element of the Project's construction would be completed in June 2023, and an overall benefits period of 2023-2043 was used (partial years of operations assumed in 2023 and 2043).

Benefits are estimated in accordance with guidance provided by U.S. Department of Transportation (USDOT) for benefit-cost analysis. If no USDOT guidance was available, the Project team consulted industry research for the best practice and information on which to base the assumptions and methodology.

The benefits quantified in the benefit-cost analysis are described in the following pages in 2018 dollars discounted to 2020. Benefits for each Project element are described within the benefit categories.

Analysis Assumptions

A list of assumptions for the Project is provided in the BCA workbook (see Inputs tab in the file BCA.xlsx) as well as in Table 3.

Table 3- BCA Calculation Inputs

Input	Value	Source
General		
Discount Rate	7%	2020 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Discount Year	2020	
Dollar Year	2018	
Construction Start	2021	
Construction End	2023	
Operations Start	2023	
Ops year 1	58%	
Ops year 21	42%	

[2] See BUILD 2020 Notice of Funding Opportunity, https://www.transportation.gov/sites/dot.gov/files/2020-02/BUILD%202020%20NOFO_0.pdf

Actual annual likelihood of the "500-year storm" like Matthew Note that Matthew's intensity was considered a 500-year storm, but its actual frequency is more often than that.	5%	Floyd (1999), Matthew (2016), and Florence (2018) can be considered 500-year storms that occurred within 20 years. Based on this history, conservatively assuming one storm of this caliber will occur every 20 years moving forward.
Deflator	See "Deflator" Sheet	https://www.whitehouse.gov/wp-content/uploads/2020/02/hist10z1_fy21.xlsx
Auto Occupancy	1.67	2020 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Auto Occupancy, Weekday peak	1.48	2020 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Annual O&M per road mile after reconstruction, 2019$	$26,500	NCDOT Division 8
Annual O&M per road mile after reconstruction, 2018$	$25,996	NCDOT Division 8, adjusted by GDP Deflator
O&M savings if NCDOT maintains the roads instead of Fort Bragg	40%	See Approved or Executed IGSAs tab
Miles of road	46.65	NCDOT
Annualization Factor	260	Assumes weekday travel
ADT annual growth	1.5%	NCDOT and Fort Bragg
Average speed increase assumed with new roads	2.0%	Engineering judgement
Economic Vitality		
Value of Time All Purposes, 2018$	$16.60	2020 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Value of Time Truck, 2018$	$29.50	
Truck operating savings per hour (2018$)	$46.16	Table 9 ATRI Operational Cost of Trucking 2019. Includes fuel, oil, truck/trailer lease, repair, maintenance, driver benefits, tires, and insurance. Excludes driver time (valued in travel time savings); https://truckingresearch.org/wp-content/uploads/2019/11/ATRI-Operational-Costs-of-Trucking-2019-1.pdf
Vehicle Operating Cost per mile (2018$), auto	$0.41	2020 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
Vehicle Operating Cost per mile (2018$), truck	$0.96	
Safety		
O- No injury (2018$)	$3,200	2020 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
C - possible injury (2018$)	$63,900	
B - non-incapacitating injury (2018$)	$125,000	
A - incapacitating (2018$)	$459,100	
K - killed (2018$)	$9,600,000	
U - Injured (severity unknown) (2018$)	$174,000	
# Accidents Reported (unknown if injured) (2018$)	$132,200	
Injury Crash (2018$)	$250,600	
Fatal Crash (2018$)	$10,636,600	
PDO per vehicle (2018$)	$4,400	
Environmental		
VOC Value of Emissions (2018$) per short ton	$2,100	2020 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
NO_x Value of Emissions (2018$) per short ton	$8,600	
$PM_{2.5}$ Value of Emissions (2018$) per short ton	$387,300	
SO_x Value of Emissions (2018$) per short ton	$50,100	
Passenger Car Gasoline Consumption Per mile	0.04149	http://www.epa.gov/otaq/consumer/420f08024.pdf
Short tons per Metric Ton	1.1015	2020 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
LDGV Emissions Rates g/hr VOC	2.683	nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100EVXV.TXT
LDGV Emissions Rates g/hr NOX	3.515	

Truck Emissions Rate g per hour VOC (average of 8a and 8b trucks)	3.868	Source: https://www3.epa.gov/otaq/consumer/420f08025.pdf, Class 8 trucks include long-haul semi-tractor trailer rigs ranging from 33,001 lbs to >60,000 lbs
Truck Emissions Rate g per hour Nox (average of 8a and 8b trucks)	39.0515	
Truck Emissions Rate g per hour PM2.5 (average of 8a and 8b trucks)	1.092	
Social Cost of Carbon		
	2018$ per metric ton	
2017	$1.00	2020 Benefit-Cost Analysis Guidance for Discretionary Grant Programs
2020	$1.00	
2025	$1.00	
2030	$1.00	
2035	$2.00	
2040	$2.00	
2045	$2.00	
2050	$2.00	

Benefits

Safety

The Project elements have three primary safety benefits. The monetization of these safety benefits are described in this section.

First, the Project's construction will result in a safer facility by reducing the number of crashes and resulting fatalities, injuries, and property damage.

Second, the Project will result in improved emergency response times for two fire stations located along the Project roads and reduce the incidence of vehicle and equipment maintenance issues. Bringing the roads to a state of good repair will improve response time- potentially saving lives.

And finally, the Project will avoid some drivers taking longer routes because King Road is closed to local traffic. Those drivers will avoid risking crashes through shorter travel distances when King Road is brought into a state of good repair.

The value of injuries, death, and property damage avoided were valued based on the KABCO score. KABCO refers to the letters used to designate five levels of crash severity used by police at a crash scene, and each type of injury has a different associated economic cost. The costs of each injury are shown in Table 3.

Reduced Highway Fatalities and Crashes

Based on crash history (February 2015-February 2020) collected through an AECOM safety analysis, the Project area has experienced 124 injuries and damage to 444 vehicles over the past five years. The Project is expected to reduce crashes by 20 percent per year compared to the current facilities.[3] The injuries and property damage only (PDO) avoided annually are shown in Table 4 and were valued based on the KABCO score as shown in Table 3. The reductions were conservatively held constant throughout the analysis period.

[3] Based on NCDOT crash reduction factors

Table 4 – Annual Fort Bragg Ring Road Crash Reduction Summary by Severity

Crash Cost Summary		
Severity	**Number of injuries**	**Reduction per year (20%)**
K-Killed	4	0.16
A-Incapacitating	46	1.84
B-Non-Incapacitating	52	2.08
U-Unknown if injury	22	0.88
PDO-Property damage only (per vehicle)	444	17.76
Total Injuries (Incl. K)	124	4.96

Source: AECOM safety analysis.
For more information, see "SafetyMemo.pdf" in the Supplemental Materials.

The total reduction in injuries, deaths, and crashes was valued at $25.9 million, discounted at 7 percent.

Emergency Response and Access

Emergency services provide vital services to communities, such as fire response and emergency medical care. The ability for emergency services to respond quickly is essential to reducing damages and decreasing injuries and fatalities. Currently, emergency response is delayed due to the poor condition of the Project roads.

Two fire stations are located along the Project roads: Station 8 is at the corner of Manchester and King and Station 10 is on Plank Road. See the map in Figure 3.

According to Fort Bragg's Fire Chief, "Those roads call for a slower response due to the condition of the roads. The numerous potholes and missing sections of asphalt require us to take a more cautious approach so that we do not cause damage to the apparatus or worse cause us to be involved in an accident due to losing control of the vehicle being operated. This occurs on every response and is more problematic at night due to not being able to see the roadway conditions like you can in daylight."

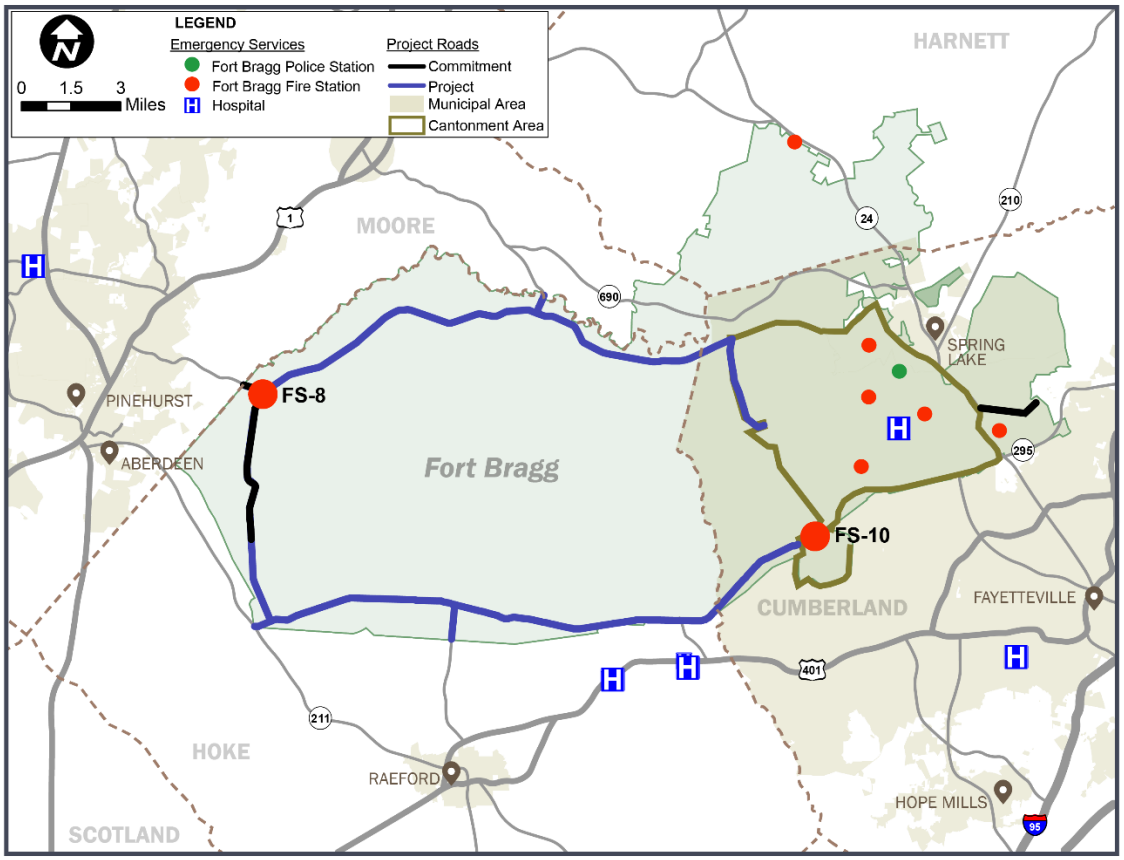
Due to the poor road conditions, the analysis assumes that response is delayed by one minute for approximately half of the calls received at the two stations. Using only half of the calls is conservative as the Chief noted all calls are impacted.

The FEMA method[4] for estimating the loss of emergency services was used to estimate the benefits of the Project. Only fire benefits were included, although it is likely that ambulances also would have slower response times in the Project area due to the roads. The population estimate was provided by Fort Bragg and assumes an equal distribution of service population for each of the 11 stations on base.

With the roads reconstructed, the net results are positive safety benefits for the Project due to the faster response time to fires.

[4] Presented in the USDOT's *Benefit-Cost Analysis Guidance for Discretionary Grant Programs* (December 2018) and described in FEMA's *Benefit-Cost Analysis Re-Engineering (BCAR), Development of Standard Economic Values* Version 6.0, December 2011

Figure 3 – Emergency Response



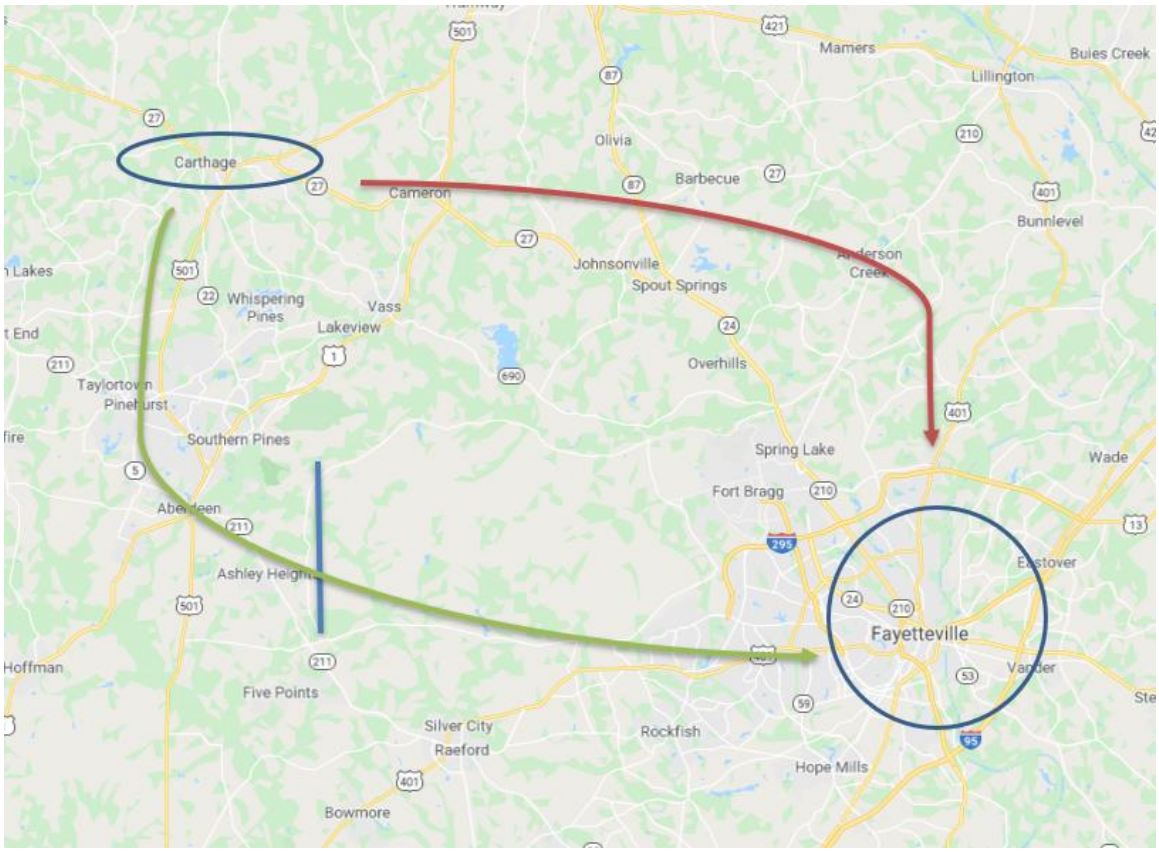
Discounting at 7 percent, the faster emergency response and access yield $2.4 million in benefits.

King Road Detour Safety Savings

The Project will save VMT by opening King Road for all traffic, including commuters. King Road has been closed to the public since 2018 due to its poor condition.

With King Road closed to the general public, some drivers who would prefer to use it for commuting are forced to take longer routes, incurring safety risks and additional vehicle miles traveled. Example routes are shown in Figure 4; safety and travel time benefits are estimated only for a portion of commuters using the southern route between approximately the Town of Carthage and the City of Fayetteville.

Figure 4 – Commuting Routes from Carthage to Fayetteville



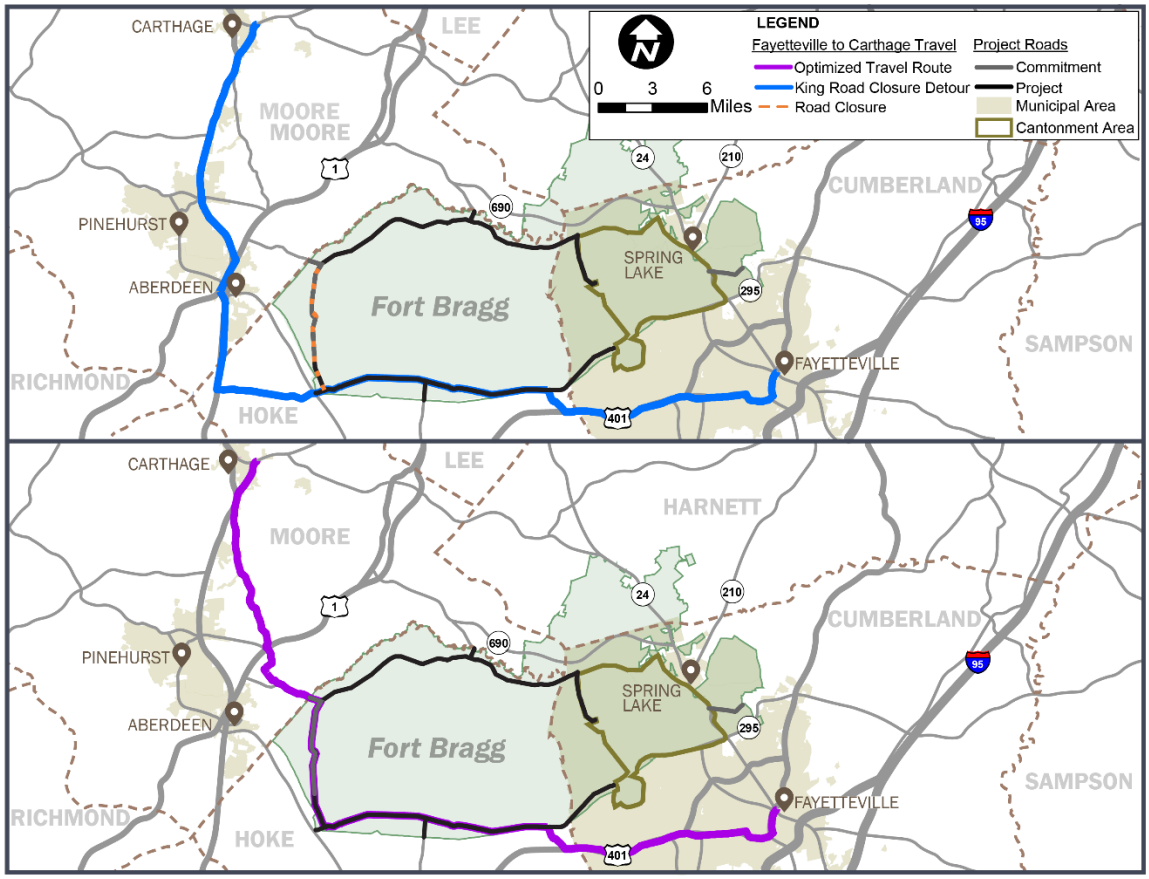
Source: GoogleMaps.
Notes: King Road (blue line) would be a route for drivers between approximately Fayetteville and Carthage (both circled) by a northern route (red) and a southern route (green). Southern route users may benefit from King Road's reconstruction.

US Census OnTheMap[5] data estimates that, in 2017, residents of the Carthage, NC area held 2,098 jobs in Fayetteville. Because some of those drivers could use a northern route via 27/24/210 instead of a southern route via 501/22, the number of drivers by route was estimated using a weighted average of the trip time, resulting in approximately 40 percent using the southern route and 60 percent using the northern route. The southern route users could use King Road; these are the drivers who would benefit from the Project's construction. Despite King Road currently being closed to commuters, barricades and signage meant to deter commuter traffic is often ignored or removed by travelers (see Figure 5). Therefore, this analysis assumes 50 percent of commuters who would drive the southern route to Fayetteville will utilize the closed King Road "detour." King Road Build and No Build routes are shown in Figure 6.

[5] Source: U.S. Census Bureau, OnTheMap Application and LEHD Origin-Destination Employment Statistics (Beginning of Quarter Employment, 2nd Quarter of 2002-2017).

Figure 5 – Removed Barricade to Deter Commuter Traffic on King Road

Figure 6– Southern No Build (Detour/blue) and Build (purple) Routes to Fayetteville



Assuming one job per auto per person, the travel times for the southern routes in the Build and No Build are shown in Table 5.

Table 5 –Detour Routes Additional One-Way Time and Mileage

	Miles	Travel Time (hrs)
Build	51.7	1.375
No Build	55.8	1.417
Net	4.1	0.417

Source: GoogleMaps estimate for morning peak, Monday morning at 6:30am

The avoided VMT totals 93,482 and VHT totals 9,487 per year. The avoided VMT and VHT with the Project are held constant throughout the analysis period. Note that the analysis applies 2017 jobs (one job per person and one person per auto) and 2020 travel times with no escalation starting in 2023 and assumes no growth over the analysis period.

The rates of crashes that result in fatalities, injuries, and PDO are applied to the VMT avoided to derive the estimated crashes avoided from reduced VMT. The crash rates for fatalities and injured persons are found from the 2017 Crash Stats, as shown in Table 6.

Table 6 - Crashes by Type per 100,000,000 VMT

	Rate per 100,000,000 VMT
Fatalities	1.16
Injured persons	85

Source: USDOT, NHTSA Traffic Safety Facts 2017, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812806

PDO crashes are based on the share of fatal, injury, and PDO crashes over 2015-2017 that result in PDO from the USDOT's 2017 NHTSA Traffic Safety Facts. In total, 70.3 percent of crashes result in PDO; this share is held constant throughout the analysis period. This analysis conservatively assumes one fatality per fatality crash and one injury per injury crash. The crash rates were used to estimate the number of crashes, injuries, and PDO that result from the diversion VMT and are valued using the KABCO scale.

The total annual value for crash severity is based on USDOT guidance and the National Highway Safety Council estimates for the value of avoiding a crash. These estimates are applied to the number of crashes avoided to estimate the total value of crashes avoided from auto VMT avoided. Fatalities are valued at $9.6 million, injuries at $174,000, and PDO at $4,400 (in 2018 dollars).

The total reduction in fatalities and crashes due to detour reductions results in benefits of $2.2 million, discounted at 7 percent.

Economic Competitiveness

The Project includes a number of economic competitiveness benefits, including travel time savings, truck operating savings, and detour savings. The disbenefits of delays during construction are also quantified and described in this section.

Delays During Construction

The analysis assumes that construction delays on the Fort Bragg ring roads would result from 20 mph lower average speeds for 18 months and that detours of approximately 5 miles will also be incurred for two months per construction year as construction is phased around the base.

Construction delays for the Fort Bragg Ring Roads total $2.6 million discounted at 7 percent.

Travel Time Savings

With the upgrade of the Fort Bragg Ring Roads to a state of good repair, vehicles can safely travel at a slightly faster speed. As noted by Fort Bragg and NCDOT, drivers already speed on the ring roads, creating dangerous conditions for themselves and other drivers, particularly when large equipment uses the roads.

To estimate the current average speeds on the roads, data collected in January 2018 on Lamont Road near McKellars Road were analyzed and showed that vehicles traveled at an average of 126 percent of the posted speed limit. This average speed increase was assumed for all segments of the Project. It is assumed that travelers could safely travel at 2 percent higher speeds in the Build than No Build.

Comparing the segment lengths, traffic volumes, current average speeds and projected average speeds with the Project constructed results in travel time savings. The speed limits, current average speeds, Build average speeds, AADT, truck share, and segment length are summarized in Table 7.

Table 7 – Fort Bragg Ring Road Traffic Characteristics by Segment

Route Name	Posted Speed Limit (mph)	Current Average Speed	BUILD Average Speed**	AADT	Truck %	Segment Length*
Lamont Road	35	44	44.88	7200	4%	3.29
Manchester Road	55	69	70.5	5500	5%	15.88
King Road	55	69	70.5	2300	4%	7.23
Plank Road	55	69	70.5	7000	3%	17.96
Morrison Bridge Road	45	57	57.7	3500	4%	0.59
Connecticut Avenue	50	63	64.1	1700	4%	0.65
Raeford Vass Road	35	44	44.9	2300	3%	1.05
					Total	46.65

*based on NCDOT estimate
**assumes average speeds can safely increase by 2%

Based on the truck percentages by segment, travel time savings was apportioned to autos and trucks. Autos were assumed to have an auto occupancy rate of 1.67 per BCA guidance. The value of time used for auto passengers is $16.60 per hour representing all travel purposes. Truck time is valued at $29.50 per hour. The traffic volumes are expected to grow at 1.5 percent per year, according to Fort Bragg and NCDOT.

The travel time savings amounts to $6.1 million discounted at 7 percent.

Truck Operating Savings

The travel time savings on the Fort Bragg Ring Roads result in operating cost savings for trucks. The operating cost per hour for trucks was found in the ATRI Operational Cost of Trucking,[6] which is inclusive of fuel, oil, truck/trailer lease, maintenance, driver benefits, tires, and insurance, and totals $46.16 per hour. Driver time was excluded because it was already included in the Travel Time Savings benefit. Multiplying the daily travel time savings by the truck percentages by

[6] Table 9 ATRI Operational Cost of Trucking 2019. Includes fuel, oil, truck/trailer lease, repair, maintenance, driver benefits, tires, and insurance.

segment as shown in Table 7, annualizing by 260, and multiplying by the truck operating cost per hour results in the truck operating savings.

The total operating savings for trucks on the Fort Bragg Ring Roads amounts to $0.4 million discounted at 7 percent.

King Road Detour Travel Time Savings

The Project will save vehicles time when commuters are able to use King Road for travel between (approximately) the Carthage area and Fayetteville. Some drivers currently detour using a longer route, costing travel time and miles. Shown in Figure 4 are the No Build and Build routes used by vehicles to get to Fayetteville.

Factoring the increased time by the number of vehicles and value of time as shown in Table 3 results in the avoided travel time for detoured autos. The analysis assumes commuters use 100 percent autos and that commuters drive alone (1 person per auto). The total travel time savings for avoided detours amounts to $1.4 million discounted at 7 percent.

King Road Detour Vehicle Operating Cost Savings

The Project will save VMT when commuters can use King Road as a shorter and more direct route, thereby resulting in vehicle operating cost savings. Vehicle operating costs are $0.41 per mile as found in Table 3 from the 2020 Benefit-Cost Analysis Guidance for Discretionary Grant Programs. The vehicle operating cost savings that result from avoiding detours totals $3.3 million when discounted at 7 percent.

Congestion Relief

The regional road network is experiencing increasing levels of congestion due to the increased economic and population growth. According to FAMPO's 2045 Metropolitan Transportation Plan, approximately 6.5 miles of the regional roadway network, primarily along Bragg Boulevard (NC 24/87) in Spring Lake, Raeford Road (US 401), Skibo Road (US 401 bypass), and South Reilly Road, experience failing Levels Of Service (LOS) in the 2015 base year. By 2045, regional roadway congestion is expected to grow to almost 17 miles of roadways with failing LOS.[7] Some commuters use Fort Bragg's road network to avoid these and other congested regional roads.

An estimate of the commuter traffic was developed for specific turning movements at two intersections along the Project roads. These turning movements represent vehicle trips entering and exiting Fort Bragg from and to off-post, but moving away from the cantonment area and employment centers within the base. Table 8 shows the commuter traffic volumes for both intersections, as well as the commuter traffic percentage of the total intersection traffic.

[7] See the 2045 MTP Highway Projects by 2015 Base Year Level of Service Map in the Supplemental Materials

Table 8 – Estimated Non-Military Traffic and Commuter Traffic Percentage Using Project Roads (2018)

Intersection	Vehicle Type	AM Peak Hour	PM Peak Hour	13-hours	Movements Considered Commuter Traffic
Wayside Road and Plank Road	Truck	12 (46%)	11 (35%)	143 (47%)	Left turn onto Plank Road Westbound
	Passenger	345 (22%)	324 (25%)	3,110 (28%)	Right turn onto Wayside Avenue Southbound
Morrison Bridge Road and Manchester Road	Truck	1 (3%)	1 (4%)	10 (2%)	Right turn onto Manchester Road Westbound
	Passenger	34 (3%)	41 (4%)	317 (2%)	Left turn onto Morrison Bridge Road Northbound

The Wayside Road and Plank Road intersection has a higher level of cut-through commuter traffic because it is highly accessible to urban areas in Fayetteville and Cumberland County, where the surrounding roads are substantially congested during the AM and PM peak periods. The Morrison Bridge Road and Manchester Road intersection is used by a substantially smaller number of commuters because Vass Road (NC 690) provides comparable east-west access with substantially less traffic congestion than the roadways on the south side of Fort Bragg.

Reconstruction of the Project roads would reduce congestion by allowing more commuters to use a route with additional capacity thereby reducing congestion in areas that are already experiencing it and helping alleviate future congestion in the region.

State of Good Repair

The project brings the roads up to a state of good repair, resulting in lower ongoing maintenance costs and damage to personal and emergency vehicles. The project investments also have a useful life longer than the analysis period.

Vehicle Maintenance Savings

The Project will improve the quality of the roadways around Fort Bragg, resulting in savings for drivers whose vehicles get damaged by the rough roads without the Project.

To estimate the cost of wear and tear on vehicles avoided by improving the quality of the pavement, the analysis made the following assumptions based on the research literature. The typical trip length in the corridor is 11.4 miles, or approximately a quarter of the improved corridor length, as many drivers use the Project roads for commuting purposes, in addition to shorter local trips. The excess cost per mile of driving in poor conditions is 3 cents per mile. TRIP, a national transportation research group, reports that drivers in the Fayetteville area pay an average of $383 annually due to poor roads.[8] This value was divided by the average number of vehicle miles

[8] Pavement Conditions and Extra Vehicle Operating Costs for Urban Areas of 500K or More, Report: http://www.tripnet.org/docs/Urban_Roads_TRIP_Report_October_2018.pdf Appendices: http://www.tripnet.org/docs/Urban_Roads_TRIP_Report_Appendices_October_2018.pdf

traveled per registered vehicle in North Carolina, according to FHWA statistics, of 14,384.[9] The cost avoided by improving the roads is thus the annual traffic volume (number of trips) in the corridor multiplied by 11.4 miles per trip and $0.03 per mile.

When discounted at 7 percent, this stream of benefits yields $5.1 million in vehicle maintenance savings from improving the roads.

Emergency Vehicle Maintenance Cost Savings

The Project will improve the roads used by not only local traffic but by emergency responders. In fact, the fire chief for Fort Bragg reports that they have a lot of issues with tire punctures, lug nuts getting sheared off, and front end alignment beyond normal wear and tear which they associate with the poor road conditions. They were able to provide vehicle maintenance cost reports for 28 months over 2018-2020 with data on repair costs associated with the road condition. The repairs are estimated at $230,700 for 28 months or an average of $98,900 per year. This analysis assumes these repair costs would be avoided after the roads are reconstructed. Discounted at 7 percent, the emergency vehicle maintenance cost savings totals $0.9 million.

Resilience Repair Cost Savings

The Project roads suffered damages ranging from sink holes to total wash outs in September and October 2016 from extremely heavy rains followed a week later by Hurricane Matthew. As a result, Manchester Road was closed to traffic and officials diverted traffic to NC 690, NC 87, and US 401. Later that year, Fort Bragg provided $7 million to repair these roads in response to the damage caused by these events. Due to the work performed after Hurricane Matthew, no damage was reported on these roads following Hurricane Florence. Although the repairs were successful, this is a temporary fix due to the underlying poor conditions of the Project roads. The Project will address this challenge on a long-term basis.

Assuming a 5.0% annual likelihood of similar repairs following a storm such as Hurricane Floyd, Matthew, or Florence, which would no longer be necessary after the Project is built, the total resilience repair costs avoided total $3.2 million when discounted at 7 percent.

Residual Value

Reconstruction of the roadways would have residual value after the end of the 20-year analysis period, because the useful life of certain Project elements is longer than 20 years. Highways and streets have a useful life of 60 years, and sewer systems (utilities) also have a useful life of 60 years.[10] It was assumed that 80 percent of the highway and utilities costs are non-labor expenses and they depreciate using straight-line depreciation. The remaining value of the assets was discounted from the final analysis year (2043).

The residual value for the Project discounted at 7 percent is $3.0 million.

Environmental Sustainability

Auto Emissions Savings

Improvements to the Project roads result in travel time savings for users and therefore reduced emissions. Annual volatile organic compounds (VOC) and nitrogen oxides (NO_X) savings were

[9] Carinsurance.com, Average Miles Driven Per Year by State, November 26, 2019, https://www.carinsurance.com/Articles/average-miles-driven-per-year-by-state.aspx

[10] Bureau of Economic Analysis Rate of Depreciation, Service Lives, Declining-Balance Rates, and Hulten-Wykoff Categories, http://www.bea.gov/scb/account_articles/national/wlth2594/tableC.htm

estimated based on rates found from the EPA.[11] The tons of reduced emissions were monetized using the recommended value of emissions from USDOT 2020 guidance as shown in Table 3. The travel time savings (inclusive of the King Road Detour travel time savings) were used to estimate emissions savings.

In total, the Project results in auto emissions savings of $17,300, discounted at 7 percent.

Truck Emissions Savings

Trucks are also expected to experience travel time savings when the Project is operational. Based on emissions rates per idling hour as found in EPA guidance,[12] the tons of VOC, NO_X, and particulate matter with a diameter less than 2.5 micrometers ($PM_{2.5}$) were estimated. The tons of reduced emissions were monetized using the recommended value of emissions from USDOT 2020 guidance as shown in Table 3.

Truck emissions savings total $6,900, discounted at 7 percent.

Quality of Life

Regional Mobility

Safer and better roads improve the daily life for those living and working at or around Fort Bragg. The reconstruction of the Project roads allows for improved regional mobility and network connectivity, resulting in better access to the region for commuters, residents, military personnel and tourists. This improved mobility saves users time and transportation costs, allowing for greater efficiency in the regional Fayetteville economy.

Costs

Capital Costs

The capital costs for the Project include the costs for final design, right of way (ROW), utilities, and construction. The costs of each Project element are shown in Table 9.

Table 9 – Project Construction Costs, in 2020 dollars

	2020$
Design	$118,640
ROW	$0
Utility Relocation	$110,500
Construction	$27,768,769
Total Cost	**$27,997,909**

Source: NCDOT

The capital costs are applied over an 18 month construction period, beginning in December 2021 and ending in June 2023. A contingency of 20 percent was included in the estimate for all project roads; the Honeycutt Road culvert replacement includes 10 percent contingency.

[11] EPA, Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks, EPA420=F-8-025, October 2008, nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100EVXV.TXT

[12] EPA, Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks, EPA420=F-8-025, October 2008, nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100EVXV.TXT. Class 8 trucks include long-haul semi-tractor trailer rigs ranging from 33,001 lbs to >60,000 lbs

The capital costs were converted to 2018 dollars and discounted at 7 percent; the total capital costs for the Fort Bragg Ring Roads are $23.2 million.

Operating and Maintenance Cost Savings

Upon repair and rehabilitation of the Project roads, the responsibility for repairing and maintaining the roads will be transferred from Fort Bragg to NCDOT. With the addition of the Project roads to the State Highway System, the roads will be maintained to an acceptable standard of performance at a lower cost than if Fort Bragg maintained them to that same standard. This will result in ongoing savings for taxpayers as NCDOT is well-equipped and experienced in constructing repairing, and maintaining roads; Fort Bragg, on the other hand, prioritizes military activities over road maintenance. NCDOT is estimated to spend 40% less on road repair and maintenance than Fort Bragg would send on the same activities. This 40% figure was estimated during the development of the MOA and IGSA; documentation is included in the BCA workbook (see Approved or Executed IGSAs tab). [13] NCDOT has estimated annual costs after the transfer at approximately $1.2 million per year, resulting in a net savings of $793,300 per year over the 20 year analysis period.

The total O&M savings over the analysis period discounted at 7 percent is $7.1 million.

Summary

Table 10 summarizes the discounted value of the benefits and costs discussed in this memorandum for the Project. Taken in total and using a 7 percent discount rate, the Project provides $58.4 million dollars of benefits over the 20-year Project analysis period. Compared to a similarly discounted cost estimate, the Benefit Cost Ratio (BCR) for the Project is 2.51, a solid return on these critical investments. The net benefits total $35.2 million.

[13] Approved October 1, 2018 and executed May 2, 2019 reflecting a cost reduction of 40%

Table 10 – Total Project Benefit-Cost Analysis (2023-2043 in 2018 $M)

	Discounted at 7%
Costs	
Capital Costs	$23.2
Total Costs	***$23.2***
Benefits	
Safety	
Reduced Highway Fatalities and Crashes	$25.9
King Rd. Detour Safety Savings	$2.2
Emergency Response and Access	$2.4
Sub-Total Safety Benefits	***$30.4***
Economic Competitiveness	
Delays During Construction	-$2.6
Travel Time Savings	$6.1
King Rd. Detour Travel Time Savings	$1.4
King Rd. Detour Vehicle Operating Cost Savings	$3.3
Truck Operating Savings	$0.4
Congestion Relief	Qualitative
Sub-Total Economic Competitiveness	***$8.6***
State of Good Repair	
Residual Value	$3.0
Vehicle Maintenance Savings	$5.1
Emergency Vehicle Maintenance Savings	$0.9
Resilience Repair Cost Savings	$3.2
Sub-Total State of Good Repair	***$12.2***
Environmental Sustainability	
Emissions Savings (auto - includes King Rd. Detours)	$0.02
Emissions Savings (truck)	$0.01
Sub-Total Environmental Sustainability	***$0.02***
Quality of Life	
Regional Mobility	Qualitative
Sub-Total Quality of Life	**$0.0**
O&M Savings (Costs)	$7.1
Net O&M	***$7.1***
Total Benefits	***$58.4***
BC Ratio	**2.51**
Net Benefits	**$35.2**

List of Supporting Information

AECOM, BCA.xlsx (Excel spreadsheet with BCA calculations by benefit type and summary)

AECOM Safety Analysis: SafetyMemo.pdf

ATRI Operational Cost of Trucking 2019, https://truckingresearch.org/wp-content/uploads/2019/11/ATRI-Operational-Costs-of-Trucking-2019-1.pdf

Bureau of Economic Analysis Rate of Depreciation, Service Lives, Declining-Balance Rates, and Hulten-Wykoff Categories, http://www.bea.gov/scb/account_articles/national/wlth2594/tableC.htm

EPA, 2008, Idling Vehicle Emissions for Passenger Cars, Light-Duty Trucks, and Heavy-Duty Trucks, EPA420=F-8-025, October 2008, nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100EVXV.TXT

TRIP, “Bumpy Road Ahead: America’s Roughest Rides and Strategies to Make Our Roads Smoother,” October 2018, http://www.tripnet.org/docs/Urban_Roads_TRIP_Report_October_2018.pdf and Appendices: http://www.tripnet.org/docs/Urban_Roads_TRIP_Report_Appendices_October_2018.pdf

U.S. DOT, 2020 Benefit-Cost Analysis Guidance for Discretionary Grant Programs, https://www.transportation.gov/sites/dot.gov/files/2020-01/benefit-cost-analysis-guidance-2020_0.pdf

U.S. DOT, BUILD 2020 Notice of Funding Opportunity, https://www.transportation.gov/sites/dot.gov/files/2020-02/BUILD%202020%20NOFO_0.pdf