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MEMORANDUM

To:	Rusty Bost, City of Gastonia
From:	Jonathan Guy
	Kimley-Horn and Associates, Inc.
Date:	May 11, 2020
Subject:	Benefit Cost Analysis Technical Documentation for BUILD Grant Application for the Lineberger Connector

Introduction and Background

This technical memorandum serves as a supplement to the benefit-cost analysis (BCA) for the BUILD Grant application for the Lineberger Industrial Site. It has been prepared in response to the requirements of the United States Department of Transportation's Better Utilizing Investments to Leverage Development (BUILD) application.

The project analyzed in the BCA is the Lineberger Connector, a marquee roadway connection in Gastonia and Lowell, North Carolina. Further project details are available in the BUILD application.

This memo is a companion piece to the BCA spreadsheet that is being submitted simultaneously with the BUILD application and details the actual calculations of benefits and costs.

Determination of Benefit Cost Analysis Time Period

Based on DOT guidelines, the benefit-cost period was set at 20 years from the opening of the Lineberger Connector project (approximately 2024). This represents a period during which the long-term impacts can be confidently forecasted. The initial costs of construction are applied to the year during which construction begins. The immediate job creation and subsequent economic productivity that occurs as a result of construction activities is also applied during the year in which construction begins. Annual project costs and benefits are calculated beginning in the opening year and for each subsequent year in the 20-year analysis period.

All costs and benefits were estimated in 2020 dollars. Costs and benefits are valued in the year they occur and discounted to year 2020 to represent value. A discount rate of 7% was used per USDOT guidelines.

Description of Base Case Scenario and Build Alternative

Assumption: This BCA compares the base case of the transportation network (existing conditions with programmed roadway projects) without the construction of the Lineberger Connector project to the "build alternative" of the transportation network enhanced by the Lineberger Connector project (Build).

The base case scenario is further described as:

- Identical roadway networks and intersections, and the operation of these networks, for the duration of the analysis period with the exception of programmed roadway improvements
- Population, employment, and household growth are consistent with regional forecasts for years beyond 2020
- Traffic volume growth that is consistent with observed regional growth trends

The build case scenario is further described as:

- Consistent model assumptions, parameters, and inputs with the base case alternative except for the changes in the transportation network or other data that are directly attributable to the Build Scenario
- Construction and opening of the Lineberger Connector
    - Construction for the Lineberger Connector project is anticipated to begin in 2021 and the project will open in 2024
- Once opened, the Lineberger Connector project will provide a direct connection to the future proposed development of the Lineberger property.

Near-term job creation and economic productivity will occur as a result of construction activities. The roadway and intersection improvements will also have long-term effects on housing, employment, jobs, property values, and other economic productivity factors over the respective service life of the project.

Sensitivity

A number of the calculations and estimates used in this BCA are subject to variability due to uncertainty within some key assumptions. Where possible, efforts were made to use values and constants from nationally recognized and accepted sources (i.e. Environmental Protection Agency, Department of Transportation, etc.). In some cases, after careful consideration of a range of values and forecasts, the more conservative estimates were used so as not to misrepresent the quantifiable benefits. This methodology and the corresponding results represent an attempt to comprehensively and accurately estimate the quantifiable benefits of this project.

Benefit Cost Analysis Methodology

The remainder of this technical memorandum introduces the general assumptions and specific inputs that were used in the BCA. Each calculated benefit was categorized under one of the long-term outcomes as suggested in the DOT guidelines: value of travel time savings, vehicle costs savings, safety benefits, emissions reduction benefits, other issues benefits estimation. The individual benefits

and costs were used to describe a total monetary benefit for each long-term outcome and for the project. Costs and benefits were also computed for near-term economic impacts.

It should be noted that there are a number of benefits under each category that were not easily quantifiable. The BUILD application qualitatively describes these additional benefits that are not fully captured with the BCA.

GENERAL ASSUMPTIONS

There are many assumptions that served as the basis for calculated costs and benefits. This section of the technical memorandum describes these key assumptions and how they were used in the BCA.

1. The Lineberger Connector Road is expected to increase the VMT on Cox Road, US 74, Lowell Road, and S Main Street but is expected to decrease the VMT on I-85. The projected land uses around the Lineberger Connector Road will likely attract local traffic to and from Gaston County and away from Mecklenburg County, therefore a reduction in the total VMT is expected. For this BCA, we used a trip generation and trip distribution to estimate the change in VMT. Approximately 40% of the site trips for the Lineberger property are expected to be local trips, 25% are expected to come from the east along I-85 and 35% are expected to come from the west along I-85 prior to Mecklenburg County. The Lineberger property is expected to generate 6,783 daily trips. Therefore, the following calculations and assumptions were used to calculate the change in VMT.

    - Distance from Charlotte to Gastonia~22 miles
        - 6,783 Daily trips * 40% of trips being taken away from I-85*44 round trip miles from Gaston County to Mecklenburg County=119,381
    - Local distances traveled to the site~10 miles
        - 6,783 Daily trips * 60% of trips being added to the network * 20 round trip local miles from around Gaston County= 81,396
    - Therefor the net VMT= 119,381-81,396= ***37,985 less VMT.***

2. The benefits for many equations may be quantified using the calculated net VMT for each year and a rate or equation that relates VMT to the specific cost or benefit.

3. The increased travel time for each study road network was assumed to be 5 minutes, except on I-85 in which the decreased travel time was assumed to be 1 minute. It is likely that 5 minutes is a conservative estimate because the Lineberger Connector will provide more connectivity for drivers, therefore decreasing the number of time consuming congested trips.

4. Based off the site network and site layout for the Lineberger property 5% of the trips for the connector are proposed to be personal while 95% are expected to be business trips.

VALUE OF TRAVEL TIME SAVINGS

The value of travel time savings is vital to networks that provide increase connectivity throughout a corridor. The Lineberger Connector is expected to provide a decrease in travel times along Interstate 85 by increasing network connectivity and local job growth.

The Lineberger Connector will be a vital component to the greater Gaston County road network once the S. Main Street and Cox Road overpasses are closed due to the widening of I-85. Without the

Lineberger Connector, several local roads and adjacent interchanges will be overwhelmed with traffic due to a significant increase in traffic demand.

The Lineberger property development has the potential to pull traffic off I-85 by creating jobs and destinations to Gaston County. This would mean less vehicles will travel from Gaston County to Mecklenburg County, thus decreasing daily vehicles miles traveled and demand on I-85.

VEHICLE OPERATING COSTS SAVINGS

The Lineberger Connector has the potential to decrease vehicle operating costs by decreasing the expected traffic volume on I-85 as well as providing better roadway connections between Lowell and Gastonia. The vehicle operating costs were used per **Table A-5: Vehicle Operating Costs(s)** found in the *Benefit-Costs Analysis Guidance for Discretionary Grant Programs.* By maintaining local traffic within Gaston County, there is a significant potential for vehicle operating costs savings. The vehicle costs savings were calculated for light duty trucks, further savings would be made for heavy trucks.

SAFETY BENEFITS

The DOT supports projects that predictably reduce the number, rate, and severity of surface transportation-related crashes, injuries, and fatalities among drivers. The quantitative safety measures of the Lineberger Connector project include a reduction in injury and property damage only (PDO) crashes.

The anticipated injury and PDO crash reductions of the Lineberger Connector project are attributable to the introduction of a right-turn lane. The Crash Modification Factors (CMF) Clearinghouse provides information on the expected impact of a given countermeasure on the safety performance of a location based on statistically significant data from peer reviewed research papers for sites that received that countermeasure. The CMF for installing a raised median is 0.70, indicating that a 30% reduction in overall collisions can be expected for a corridor where a right-turn lane is installed. This includes the corridor along Lowell Road.

The average annual number of injuries was broken down by severity to better estimate the anticipated benefits. The cumulative number of average annual injuries is reported in Table 3, and the cumulative number of vehicles involved PDO crashes is reported in Table 7. The annual expected injuries avoided and property damage avoided for each year of the analysis were calculated using the current annual averages and the CMF of 0.70. The annual number of injuries avoided is reported in Table 4 and the annual reduction in vehicles involved in PDO crashes is reported in Table 8. Finally, a cost associated with each injury or vehicle in a PDO crash was derived using guidance from the BUILD Benefit-Cost Analysis Resource Guide on the value of injuries based on severity of crash. This table is recreated as Table 1 and Table 2 of the Safety Calculations Worksheet.

The typical injury and PDO reduction savings equations are:

$$InjuriesAvoided_i = Rate_{Injury} \times \ (1 - CMF_i)$$

$$InjurySavings_i = InjuriesAvoided_i \times Value_{injuries}$$

$$PDOAvoided_i = Rate_{PDO} \times (1 - CMF_i)$$

$$PDOSavings_i = PDOAvoided_i \times Value_{PDO}$$

$$Savings_{InjPDO,i} = InjurySavings_i + PDOSavings_i$$

Where:

$InjuriesAvoided_i$ = Number of injuries avoided in any year

$Rate_{Injury}$ = annual average number of injuries along the corridor

$InjurySavings_i$ = cost savings for injury reductions in any year

$Value_{Injuries}$ = average cost of injury by severity, multiplied by the probability of that severity

$PDOAvoided_i$ = Number of vehicles in PDO crashes avoided in any year

$Rate_{PDO}$ = average annual number of vehicles in PDO crashes along the corridor

$PDOSavings_i$ = cost savings for vehicles in PDO crashes in any year

$Value_{PDO}$ = average cost per vehicle of a property damage only crash by severity, multiplied by the probability of that severity

$Savings_{InjPDO,i}$ = total injury and PDO cost savings in any year

The resulting injury and PDO cost savings are reported in Table 6 and Table 10 of the Safety Calculations Worksheet. The Lineberger Connector component of this project will also involve specific intersection improvements that will provide a safety benefit to intersection specific problems. There isn't a CMF in the clearinghouse for these intersection level improvements, so we cannot quantitatively report on the safety benefit of these changes but believe there will be additional safety gains due to these changes.

EMMISSIONS REDUCTION BENEFITS

The DOT supports projects that promote environmental sustainability through improved energy efficiency, reduced dependence on oil, and reduced greenhouse gas emissions. The quantitative sustainability measures of the Lineberger Connector project include air quality impacts, water quality impacts, and fuel consumption impacts.

The Lineberger Connector project is projected to lead to decreases in emissions of greenhouse gases and particulate matter, based on the decrease in daily VMT. Using guidance from the DOT, the emissions that were measured in this analysis include carbon dioxide (CO_2), volatile organic compounds (VOC), nitrogen oxides (NO_x), particulate matter (PM), and sulfur dioxide (SO_x). Air

quality benefits were calculated as the value of emissions released per decrease in VMT. The decrease in VMT each year of the project life was previously described under the general and the emissions rate per VMT was found in the Environmental Protection Agency's "Average Annual Emissions and Fuel Consumption for Gasoline-Fueled Passenger Cars and Light Trucks" p.4, published in 2008. This table is recreated as Table 1 of the Sustainability Calculations Worksheet.

The benefits were calculated by relating the amount of emissions to the societal costs per unit of emission. This societal cost of each emission type was calculated using values from the BUILD Benefit-Cost Analysis Resource Guidance and recreated as Table 2 and Table 3 in the Sustainability Calculations Worksheet. The typical equations used to calculate air quality savings are:

$$CO2_i = \left(NetVmt_i \times {}^{CO2}/_{VMT}\right) \times Cost_{CO2}$$

$$VOC_i = \left(NetVmt_i \times {}^{VOC}/_{VMT}\right) \times Cost_{VOC}$$

$$NOX_i = \left(NetVmt_i \times {}^{NOX}/_{VMT}\right) \times Cost_{NOX}$$

$$PM_i = \left(NetVmt_i \times {}^{PM}/_{VMT}\right) \times Cost_{PM}$$

$$SOX_i = \left(NetVmt_i \times {}^{SOX}/_{VMT}\right) \times Cost_{SOX}$$

$$AirQuality_i = CO2_i + VOC_i + NOX_i + PM_i + SOX_i$$

Where:

$CO2_i$ = Value of total CO_2 emissions savings in any year

VOC_i = Value of total VOC emissions savings in any year

NOX_i = Value of total NO_x emissions savings in any year

PM_i = Value of total PM emissions savings in any year

SOX_i = Value of total SO_x emissions savings in any year

$NetVmt_i$ = the difference between the VMT in the build network compared to the base network

$CO2/VMT$ = average CO_2 emitted per VMT

VOC/VMT = average VOC emitted per VMT

NOX/VMT = average NO_x emitted per VMT

PM/VMT = average PM emitted per VMT

SOX/VMT = average SO_x emitted per VMT

$Costs_{CO2}$ = societal costs per unit emission

$Costs_{VOC}$ = societal costs per unit emission

$Costs_{NOX}$ = societal costs per unit emission

$Costs_{PM}$ = societal costs per unit emission

$Costs_{SOX}$ = societal costs per unit emission

$AirQuality_i$ = total air quality negative benefits

Net annual metric tons of emissions that result from the slight change in VMT are calculated in Table 4 of the Sustainability Worksheet. These emissions were captured as negative benefits in Table 5 of the Sustainability Calculations Worksheet.

A minor additional release of pollutants into community waters can also be expected due to the slight increase in VMT. This includes oil and fuel runoff into water resources and damage to water resources from emission materials. The average water quality impact cost per VMT was taken from the Victoria Transportation Institute's "Transportation Costs and Benefits Analysis II" of water quality impacts (available here http://www.vtpi.org/tca/tca0515.pdf). This impact is provided in Table 6 of the Sustainability Calculations Worksheet. The water quality impacts (negative benefits) of the Connect Judd Parkway project were calculated as:

$$WaterQualityCosts_i = WaterCost \times NetVmt_i$$

Where:

$WaterQualityCosts_i$ = additional water quality impacts in any year

$WaterCost$ = average water quality impact cost per VMT of passenger car travel

$NetVmt_i$ = the difference between the VMT in the build network compared to the base network

The annual water quality costs savings are reported in Table 7 and Table 8 of the Sustainability Calculations Worksheet.

The net energy consumption of the Lineberger Connector project includes the change in direct energy consumption (fuel) and indirect energy consumption. Direct energy consumption (fuel and oil related costs) was not included here as they were quantified under the economic competitiveness negative benefits. The indirect energy consumption for personal cars per vehicle miles traveled was found in "Transportation Decision Making: Principles of Project Evaluation and Programming", Chapter 15: Impacts on Energy Use, Pages 384-386, Table 15.4 and Table 15.6, published in 2007. These tables are recreated (in part) in Table 9 of the Sustainability Worksheet. The total indirect energy consumption was calculated by multiplying this rate by the net annual VMT. The total indirect energy consumption was then translated into a negative benefit by applying an average cost per barrel of crude oil used:

$$NetIndirEnergy_i = IndirEnergy_{Cost} \times NetVmt_i \times Cost_{barrel}$$

Where:

$NetIndirEnergy_i$ = *Negative benefits in indirect energy consumption*

$InDirEnergy_{cost}$ = *average cost per unit of indirect energy consumed*

$NetVmt_i$ = *the difference between the VMT in the build network compared to the base network*

$Cost_{barrel}$ = *Cost per barrel of crude, $84.31 (as an energy consumption equivalent)*

The annual indirect energy consumption is reported in Table 10 and the value of this negative benefit is reported in Table 11 of the Sustainability Calculations Worksheet.

OTHER ISSUES AND BENEFITS ESTIMATION

Work Zone Impacts

The proposed Lineberger Connector is expected to have minimal impacts on US 74, Cox Road, Lowell Road, and S Main Street during construction.

Resilience

The Lineberger Connector will be designed to withstand different threats and vulnerabilities.

Noise Pollution

This Lineberger Connector Road is not expected to increase the noise levels in the greater Gastonia or Lowell area because the project is surrounded by I-85 to the south and a railroad to the north. Thus, the impact of the traffic, at a design speed, is not expected to increase the noise levels in the area.

Emergency Services

With the construction of this project the connectivity for Emergency Services will increase. The construction of the Lineberger Connector should not interfere with existing emergency services routes either.

Property Value Increases/Quality of life

The properties in the immediate vicinity of the Lineberger Connector component of this project are forecasted to see an increase in land value. A proxy for percentage increase in land value was found based on the average value per acre of industrial and the average value per acre of agricultural land. This ratio was then multiplied by the current land value of the properties that will be rezoned as a result of this project.

At Grade Rail Crossing Improvements

Improvements to the at grade rail crossing along the site access near Lowell Road (NC 7) are planned for this project. Improvements include a right-turn lane on Lowell Road at the site access,

which could reduce the queue on Lowell Road when a train is at the at grade crossing on the site access. The development is also anticipated to improve the cross section of the at grade crossing to include three lanes at the crossing. This allows for vehicles to queue in a turn lane at Railroad Street, thus reducing spill back on the site access onto Lowell Road. Additionally, the crossing surface between the roadway and railroad tracks will be improved as a part of the improvements for this project. Lastly, the improved rail road crossing will have quadrant gates, which helps prevent vehicles from by passing the railroad gates. This adds additional safety to the intersection.

Costs

Capital costs for the Lineberger Connector project are estimated at $29,934,938. The project, which is a critical connector between Gastonia and Lowell, is the genesis for continued economic growth for this region of Gaston County. The project sponsors seek approximately $18,110,358 in BUILD grant funding to complete the funding for project development and construction. As shown in **Table 1.0** below, the remaining sources are anticipated from local, state, or private investment funding sources. The Cities of Gastonia and Lowell are committed to this project's development. Both communities understand the necessity of this project to improve overall long-term mobility, community growth, and continued economic success within the Charlotte Metro region.

Table 1.0 – Funding Sources

Type	Source	Amount	Percent of Total	Status
Federal	BUILD	$18,110,358	≈60%	Ongoing with this application
Local	City of Gastonia	$5,699,580	≈19%	-
Private	Property Owner/Developer	$6,125,000	≈21%	-

Table 2.0 shows the timing of expenditure of the various funding sources through the development years of the project. Committed local funds are more than enough to advance the project to construction. A detailed project budget is in the Project Readiness section of this application on page 14.

Table 2.0 - Expenditure by Year

Funding Source	Amount	2021	2022	2023	2024
Federal	$18,110,358	$1,006,000	$2,912,250	$9,259,589	$4,932,519
Local	$5,699,580	$3,000,000	$2,000,000	$600,000	$99,580
Private	$6,125,000	$3,000,000	$2,000,000	$1,000,000	$125,000
Total	$29,934,938	$7,006,000	$6,912,250	$10,859,589	$5,157,099

Specific project costs included initial costs of ROW, engineering and construction, utility relocation costs, and contingency. These costs are documented in the BUILD application.

Benefit Costs Analysis Summary

As shown in the table below, the project is expected to have a high benefit to cost ratio. The benefit mostly lies in the annual travel time savings by pulling jobs and industry to Gaston County.

Benefit Type		Key Benefits Quantified	Undiscounted Net Benefits	3% Discount of NPV of Benefits	7% Discount of NPV of Benefits
Long-Term Outcomes					
Operating Costs	Additional pavement costs	Decrease in pavement repair costs from decrease in auto VMT on I-85	$332,033	$230,555	$150,298
Travel Time.Operting Costs	Vehicle operating costs	Additional vehicle operating costs from decreased VMT	$96,318,905	$66,881,212	$43,599,601
	Travel time savings	Time savings from travel time reduction	$5,572,525	$3,869,409	$2,522,453
other	Noise Costs	Additional noise due to additional Auto VMT	$298,830	$207,499	$135,268
Emmisions/Reduction Benefits	Air Quality (Non-Carbon)	Decrease in mobile source emissions	$2,683,597	$1,863,417	$1,214,754
	Air Quality (Carbon)	Decrease in mobile source emissions	$77,364	$77,364	$77,364
	Indirect energy consumption, water quality (auto)	Decreasein mobile source run-off and VMT-dependent manufacturing	$7,526,328	$5,226,076	$3,406,859
Safety Benefits	Reductions in injuries and PDO crashes	Improved intersections	$6,519,602	$4,571,364	$3,016,366
Near-Term Jobs Creation and Economic Activity					
Property Value Increase			$48,752,719	$44,615,644	$39,796,741
		Total Benefits	**$168,081,903**	**$127,542,541**	**$93,919,704**
		Total Costs	**$29,934,938**	**$29,934,938**	**$29,934,938**
		Benefit/Cost Ratio	**5.61**	**4.26**	**3.14**