Memorandum

To: Luke Wehseler, PE, Project Manager
Minnesota Department of Transportation

From: Nick Semeja, PE
Erik Kappelman

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Subject: Highway 210 Brainerd, Minnesota Equity, Safety, and Multimodal Connectivity Project – 2023 RAISE Grant Application

Introduction

This memorandum summarizes the assumptions, methodology and results developed for the benefit-cost analysis of the No Build and Build Alternatives evaluated as part of the Highway 210 Brainerd, Minnesota Equity, Safety, and Multimodal Connectivity Project – 2023 RAISE grant Application. The objective of a benefit-cost analysis (BCA) is to bring all the direct effects of a transportation investment into a common measure (dollars), and to account for the fact that benefits accrue over an extended period while costs are incurred primarily in the initial years. The primary elements that can be monetized are travel time, changes in vehicle operating costs, vehicle crashes, environmental impacts, quality of life, capital costs and remaining capital value, and maintenance costs. The benefit-cost analysis can provide an indication of the economic desirability of an alternative, but decision-makers must weigh the results against other considerations, effects, and impacts of the project.

The Project is a roadway repair/rehabilitation project in downtown Brainerd that modernizes existing transportation infrastructure, improves traffic safety and operations, and enhances non-motorized users' safety and mobility. The Project impacts a four-mile segment of Minnesota Highway 210 (Hwy 210, also known as Washington Street) from Baxter Drive to Pine Shores Road. As the primary thoroughfare of the largest town in a 60-mile radius, Hwy 210 balances numerous modes of transportation including automobiles, heavy commercial vehicles, buses, bicycles, and pedestrians. The posted speed limit, along the Project corridor, varies from 35 mph to 50 mph. The 2021 annual average daily traffic (AADT) volumes along the Project range from approximately 12,200 vehicles per day (vpd) to 29,100 vpd and the 2021 Heavy Commercial Average Annual Daily traffic (HCAADT) counts range from 710 to 1,150 freight vpd.

Description of Alternatives

For the purpose of this analysis, a No Build and Build Alternative were under consideration.

No Build Alternative

The No Build Alternative consists of leaving the Highway 210 corridor in its current geometric configuration. Preservation activities that are occurring under the Build are not assumed to take place under a No Build scenario. The pavement condition will reach a minimal rating by year 2025, resulting in increased pavement roughness and lower travel speeds for vehicles travelling on the corridor for the remainder of the analysis period. The Hwy 210 Mississippi River bridge is also nearing the end of its service life and will cause disruptions for users.

Build Alternative

The proposed project will replace or rehabilitate the existing ageing pavement along the project length of the corridor. Additionally, roundabouts will be constructed at the intersections of Highway 25 and NE 8th Ave along Highway 210. Other operational improvements include the replacement of five signal systems at the intersections of Hwy 210 with Baxter Dr, NW 4th St, N 4th St, N 8th St, and Gillis Ave. to improve signal timings corresponding to the current traffic demands, and the removal of the unwarranted signal systems at 4th Ave NE and 8th Ave NE.

Wider sidewalks and pedestrian "bump-outs" will be included along the corridor to enhance pedestrian safety along with medians and rectangular rapidly flashing beacons (RRFBs). The Hwy 210 bridge at the Mississippi River will be re-decked to extend its service life for passenger vehicles, heavy trucks, and multimodal users. Replacement of five signal systems will occur at the intersections of Hwy 210 with Baxter Dr, NW 4th St, N 4th St, N 8th St, and Gillis Ave. to improve signal timings corresponding to the current traffic demands. Lastly, the Build will remove unwarranted signal systems at 4th Ave NE and 8th Ave NE.

BCA Methodology

The following methodology and assumptions were used for the benefit-cost analysis:

1. **Main Components**: The main components analyzed included:
   - Travel time/delay (vehicle hours traveled – VHT)
   - Operating costs (vehicle miles traveled – VMT)
   - Crashes by severity
   - Environmental and air quality impacts
   - Quality of life benefits
   - Initial capital costs: These costs were broken into distinct categories in accordance with service life (consistent with the recommendations of MnDOT Office of Transportation System Management, August 2022[1]) and were applied evenly over the duration of the construction period.

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[1] Table 5: http://www.dot.state.mn.us/planning/program/benefitcost.html

- Remaining Capital Value: The remaining capital value (value of improvement beyond the analysis period) was considered a benefit and was added to other user benefits. Project components were assumed to have a linear depreciation of service life over the benefit-cost analysis period.
- Operating and maintenance costs: These costs included routine maintenance on the pavement being reconstructed along the corridor.

2. **Analysis Years**: The analysis assumed that construction would take place over a two-year period and be completed in 2027. Therefore, year 2028 was assumed to be the first full year of benefits that will be accrued from the project. Benefits are calculated for the standard 20-year time frame, 2028 to 2047. The present value of all benefits and costs was calculated using 2021 as the year of constant dollars.

2. **Economic Assumptions**: The value of time, vehicle operating costs, emissions costs, pedestrian amenity values, and cost of crashes were obtained from the *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*, dated January 2023. The analysis was completed using an assumed discount rate of seven percent.

3. **Development of Travel Time Savings and Vehicle Operating Costs**: The intersection improvements (change in traffic control device to roundabouts and signal timing enhancements) are expected to have an impact on intersection delays along the corridor. Intersection delay was obtained from the Intersection Control Evaluation (ICE) Reports developed through the study process (delay tables provided in BCA Workbook) for the No Build and Build scenarios under existing and forecast year traffic conditions.[2] Intersection delay per vehicle was applied to daily entering traffic volumes to determine a total daily delay before being annualized.

   By year 2025, the Highway 210 corridor will degrade to a minimal pavement condition rating. As the pavement continues to deteriorate and the surface becomes more uneven, travel speeds for vehicles are expected to decrease along the corridor. It was assumed that travel speeds would decrease by 5 mph for each segment of the corridor with respect to the posted speed limit.[3]

   Increased vehicle operating costs are expected for Highway 53 users under a No Build scenario due to the degrading pavement condition. A difference in per-mile operating costs was determined based on Table 7-4 and Table 7-5 in NCHRP Report 720, *Estimating the Effects of Pavement Condition on Vehicle Operating Costs.*[4]

   Outcomes from the analysis estimate full-year travel time and vehicle operating costs for the No Build and Build Alternatives in years 2021 and 2045 (existing and forecast count years). Benefits for years between existing year 2021 and forecast year 2045 were interpolated based

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[2] Existing year Build data was not available. It was assumed delay per vehicle was similar to reported delay per vehicle under year 2045 Build conditions, which can be considered a conservative assumption.
[3] Travel speeds under Build conditions were assumed to match the existing posted speed limits along the corridor.
[4] https://www.nap.edu/download/22808

on a linear annual growth rate, and benefits for years beyond year 2045 were extrapolated using the same annual growth rate. Savings due to the reduction of travel time and operating costs were calculated using costs per hour and mile traveled that account for vehicle occupancy and different vehicle types.

4. **Vehicle Occupancy and Vehicle Types**: The composite cost per mile used in the BCA accounted for the percentage split of autos and trucks in the travel area. The composite cost per hour accounted for vehicle occupancy ratios, and the percent split of autos and trucks traveling in the area. Key assumptions for these areas included:
   - The truck percentage used in the analysis was 5.0 percent and was based on recent daily traffic and heavy truck counts provided in the MnDOT Traffic Mapping Application.[5]
   - Vehicle occupancy that was used in the analysis is consistent with values provided by the *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*, dated January 2023. The analysis assumed 1.67 people per automobile and 1.00 people per truck.

5. **Safety Analysis**: The Build Alternative improves the Highway 210 corridor safety with the addition of the roundabouts, pedestrian considerations, and a center median. All these improvements are expected to generate safety benefits by reducing the number of crashes along the corridor. Ten-year crashes at locations suggested for improvements were gathered to develop annual crashes by severity for the No Build Alternative. Crash records used in the analysis are provided in the BCA Workbook.

   Crash modification factors used in the BCA were obtained for the specific project improvements and are sourced in the BCA Workbook. To determine estimated reduction of existing intersection crashes, the CMF was applied to crashes tied to each intersection. Year 2045 crashes for the No Build Alternative were estimated based on AADT growth on the corridor. Similar assumptions used to estimate existing year Build Alternative crashes by severity were applied to produce year 2045 estimates.

   The safety benefit for reduction in intersection crashes was quantified for an existing year and forecast year 2045 and interpolated/extrapolated based on a liner annual growth rate to determine total safety benefits for the period from year 2028 to 2047. Crash cost assumptions are consistent with values and methodologies published in the *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*, dated January 2023. Detailed calculations on crash cost estimates are outlined in the attached BCA workbook.

6. **Environmental and Air Quality Impacts**: Changes in emissions are expected to be impacted by the time vehicles spend idling at the study intersection(s) as well as the longer travel times due to lowered speeds. The change in vehicle delay between No Build and Build conditions was obtained from the travel time analysis and converted to equivalents of vehicle-miles traveled (VMT) by applying fuel consumption for idling vehicles to average miles per gallon

[5] https://www.dot.state.mn.us/traffic/data/tma.html

for passenger cars. The change in VMT equivalents was then applied to emission rates by vehicle type. Average emission rates per vehicle type were obtained from the Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) version 3. Emission rates per vehicle type are provided in the attached BCA Workbook.

Total change in emissions and vehicle operating costs per mile traveled by mode were valued in accordance with the Benefit Cost Analysis Guidance for Discretionary Grant Programs, dated January 2023.

7. **Quality of Life Benefits:** Benefits were quantified for the reconstructed and widened sidewalks along the corridor. Under a No Build scenario, the sidewalks along Highway 210 are deteriorating and are running out of useful life. However, the BCA only quantified the average expansion of sidewalk, which is expected to be four feet.

   Pedestrian counts along the Highway 210 corridor were obtained from ICE Reports completed through the study process. On the two-mile section between 8th Street NW and 5th Ave NE, an average of 30 pedestrians walked along Highway 210 between intersections across the ten-hour count period when data was collected. Based on the corridor length and number of intersections where amenity benefits were evaluated, the maximum assumed walk distance of 0.86 miles, and the value of sidewalk expansion by foot, annual quality of life benefits associated with the sidewalk reconstruction and expansion were valued. The number of pedestrians was kept constant throughout the analysis period, which can be considered conservative assuming regional growth in the area is likely.

8. **Operating and Maintenance Costs**: Routine annual roadway maintenance costs associated with maintaining the additional roadway infrastructure under the Build Alternative were considered in the BCA. An annual maintenance cost of $8,100 per lane mile, which derived from maintenance reports for highways in Minnesota, was applied to the preserved corridor pavement.
9. **Calculation of Remaining Capital Value**: Because many components of the initial capital costs have service lives well beyond the 20-year analysis period, the remaining capital value was calculated for the Build Alternative. These values were expressed in terms of 2021 dollars and were added to other project benefits in accordance with USDOT guidance. In determining remaining capital value of the initial capital cost, the costs of the Build Alternative were separated into the following categories:
   - Major Structures
   - Grading and Drainage
   - Sub-Base and Base
   - Surface
   - Miscellaneous Costs – Includes mobilization, removals, temporary pavement and drainage, traffic control, contingency, and program delivery. These were assumed to be sunk costs and assigned zero remaining capital value.

   Project components in each cost category were assumed a service life based on recommendations provided by MnDOT Office of Transportation System Management.

10. **Factors Not Quantified**: Several factors were not quantified as part of the analysis that could potentially add to the benefits assumed in the BCA. These factors include the following:
    - Potential diversion due to poor bridge and pavement condition under a No Build scenario.
    - Travel time, operating cost, and safety impacts to non-vehicular users due to poor pavement condition.
    - Induced demand for pedestrian and cycling trips due to enhanced sidewalk and trail network.
    - Quality of life benefits associated with RRFBs, enhanced pedestrian crossings, ADA improvements, and curb extensions/bumpouts (it was unknown at the time of this analysis where certain pedestrian improvements were taking place)

BCA Results

The benefit-cost analysis provides an indication of the economic desirability of a scenario, but results must be weighed by decision-makers along with the assessment of other effects and impacts. Projects are considered cost-effective if the benefit-cost ratio is at least 1.0. The larger the ratio number, the greater the benefits per unit cost. Results of the benefit-cost analysis are shown in Table 1. See Attachment A for the complete benefit-cost workbook.

Table 1 - Total Project Results

	Initial Capital Cost (2021 Dollars)	Project Benefits (2021) Dollars	Benefit-Cost Ratio (7% Discount Rate)	Net Present Value (2021 Dollars)
No Build vs. Build	$33.8 million	$99.2 million	2.93	$65.4 million

Attachment
BCA Workbook