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Memorandum

To: Lyndon Robjent, PE, Publics Work Director
Carver County

From: Nick Semeja, PE, Associate

Date: March 19, 2021

Subject: US 212 Rural Freight Mobility and Safety Project – 2021 INFRA Program Application Benefit-Cost Analysis Memorandum

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 US 212 Rural Freight Mobility and Safety Project – 2021 INFRA Grant Program 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, 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 primary issues to be addressed by the project are the travel time, operations, safety, and environmental benefits associated with trips moving reliably across the US 212 corridor through Carver County, Minnesota. Currently, the portion of US 212 from the cities of Norwood Young America to Cologne is a rural two-lane undivided highway with limited shoulders. This section is adjoined by a four-lane expressway facility on the west and a soon to be constructed four-lane expressway facility on the east; thus, serving as a major bottleneck for freight and commuter traffic traveling through the southwestern Twin Cities metro area. The study corridor is characterized by near-capacity daily traffic volumes, significant levels of freight and heavy vehicle activity, and numerous safety concerns.

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 included leaving the US 212 corridor from the cities of Norwood Young America to Cologne in its current geometric and operational condition, with no modifications or restrictions to current access. Regional roadway improvements that are currently programmed were included as part of the regional transportation network.

Build Alternative

The proposed project replaces approximately 2.7 miles of the existing two-lane undivided section with a four-lane divided roadway. Several spot mobility and safety improvements were also assumed throughout the study corridor. The comprehensive list of improvements that were considered in the BCA is summarized below:

- Conversion from two-lane undivided to four-lane divided expressway with restricted side-street left turn movements at all at-grade access locations from Cologne to roughly 0.5 miles west of CSAH 51
- US 212 and CSAH 51 intersection – conversion from at-grade, side-street stop control to grade separated interchange
- US 212 and County Road (CR) 153 intersection – conversion from side-street stop control to reduced conflict intersection (RCI) with restricted side-street left-turn movements
- US 212 and access to Carver County government building – conversion from side-street stop control to reduced conflict intersection (RCI) with restricted side-street left-turn movements
- US 212 and CSAH 36 intersection – conversion from side-street stop control to three-quarter access (i.e. removing left turns from side-street only)

The Build Alternative also included the same programmed improvements to the regional transportation system that were assumed in the No Build Alternative.

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
   - 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, July 2020[1]) and were applied evenly over the duration of the construction period.
   - 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.

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

- Maintenance and rehabilitation costs: These costs included major rehabilitation activities over the project lifespan and annual routine maintenance.

2. **Analysis Years**: This analysis assumed that construction would take place from year 2024 to 2025. Therefore, year 2026 was assumed to be the first full year that benefits will be accrued from the project. The analysis focused on the estimated benefits for the twenty-year period from 2026 to 2045. The present value of all benefits and costs was calculated using 2019 as the year of current dollars.

3. **Economic Assumptions**: The value of time, emissions costs, and cost of crashes were obtained from the *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated February 2021[2]. Remaining capital value assumptions were consistent with rates from *Recommended remaining capital value factors for use in benefit-cost analysis in SFY 2021*[3], Minnesota Department of Transportation (MnDOT), Office of Transportation System Management, July 2020 (values were adjusted to reflect discount rate). Local vehicle operating costs for autos and trucks were obtained from *Recommended standard values for use in cost-effectiveness & benefit-cost analysis in SFY2021*[4], Minnesota Department of Transportation (MnDOT), Office of Transportation System Management, July 2020. The analysis was completed using assumed discount rate of seven percent.

4. **Travel Demand Model**: The analysis used the Carver County Regional Travel Demand Model to compare the No Build and Build Alternatives. This TDM was developed in 2017 and has a forecast planning horizon of year 2040. The Carver County model was developed using the base Twin Cities Regional Activity Based Model. The model utilizes Metropolitan Council socioeconomic control totals for household, population, and employment for year 2040 outlined by the Thrive MSP 2040 planning process documents. The model was validated based on the Federal Highway Administration's Model Validation and Reasonableness Checking Manual. The subarea of the model used for the analysis is shown in Figure 1 on the following page.

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[2] https://www.transportation.gov/sites/dot.gov/files/2021-02/Benefit%20Cost%20Analysis%20Guidance%202021.pdf
[3] http://www.dot.state.mn.us/planning/program/appendix_a.html
[4] https://www.dot.state.mn.us/planning/program/pdf/Table%20A.1%20SV%20L-ML-H%201-July-2020.pdf

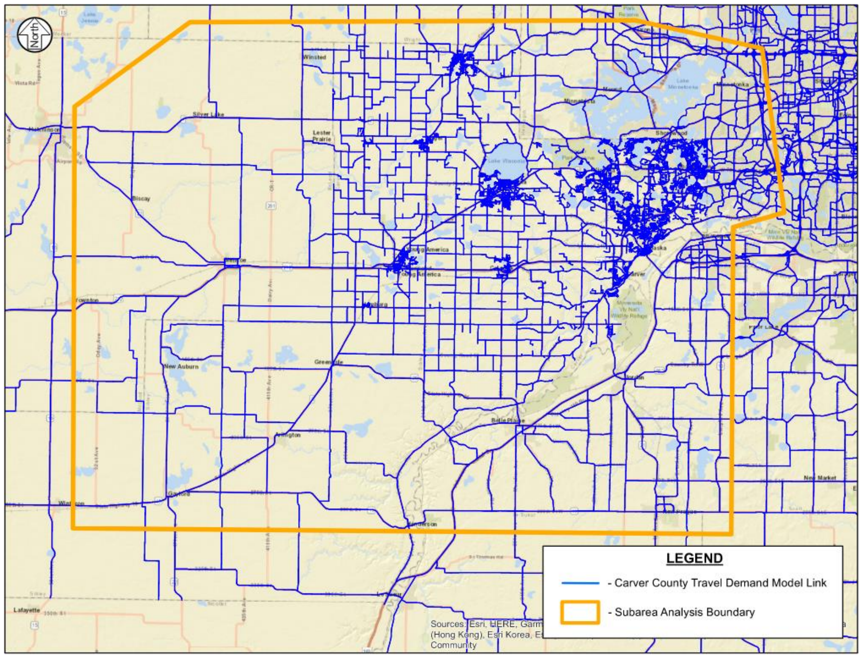

Figure 1. Travel Demand Model Subarea

5. **Development of Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT)**: Regional year 2014 and 2040 VMT and VHT from the Carver County Regional Travel Demand Model were summarized for the No Build and Build Alternative. The regional model captured trip impacts related to increased free-flow speed and capacity on US 212 and network trip diversion.

   Microsimulation analysis was also conducted to evaluate the change in operations at the proposed CSAH 51 interchange. Macroscopic models are not suitable for analyzing changes in operations at the nodal level, so microsimulation was relied on to perform a more granular analysis. Synchro/SimTraffic models were developed for morning and afternoon peak hours to evaluate total user travel time under each operating condition. Year 2019 and year 2040 volumes were developed for both the No Build and Build Alternatives based on travel pattern shifts from the regional travel demand model. The change in intersection/interchange entering volumes between alternatives should be reflected in the regional modeling analysis, eliminating the risk of double counting user costs associated with trips. Total network VHT was summarized for each year under both alternatives and added to regional VHT from the travel demand model.

   Benefits for the years between 2014 and 2040 were interpolated based on model results using an annual growth rate. VMT and VHT for years beyond year 2040 were extrapolated using the same annual growth rate. Savings due to reduction of VMT and VHT were calculated using costs per mile and per hour that account for vehicle occupancy and different vehicle types.

6. **Vehicle Occupancy, Vehicle Types and Peak Hours**: The composite cost per mile used in the benefit-cost analysis 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 13.4 percent, based on year 2016 vehicle classification counts performed by MnDOT.
- Vehicle occupancy that was used in the analysis is consistent with values provided by *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated January 2020. The analysis assumed occupancy of 1.67 people per automobile and 1.00 people per truck.

7. **Safety Analysis:** The Build Alternative improves the US 212 corridor by converting it from a two-lane undivided roadway to a four-lane expressway. Reconstruction to a four-lane expressway is expected to generate safety benefits by transferring daily traffic from the existing facility to a historically safer four-lane divided roadway. Additionally, the spot improvements consisting of RCIs and grade separation were also assumed to produce safety benefits at the corresponding intersections. The analysis used three-year existing (2018-2020) crash data along the US 212 project area to develop annual crashes by severity for the No Build Alternative.

   The BCA referenced *A Study of the Traffic Safety at Reduced Conflict Intersections in Minnesota*[5], Minnesota Department of Transportation, Office of Traffic, Safety and Technology, to estimate crash impacts associated with conversions to RCIs. The study performed extensive before and after crash analyses at eight RCI locations in Minnesota. Crash impacts reported in the study were preferred for use in the BCA due to the study's thoroughness, the similar nature of geometrics and location of RCIs in the study compared to the US 212 corridor, and driver behavior at RCIs being better reflected using local data. Crash modification percentages by severity are summarized in Table 10 of the study and were used to estimate crash increases/decreases by severity at the US 212 RCI conversion locations.

   Note that the study in reference reported a 100 percent reduction in fatal crashes. The BCA was conservative by using the serious injury crash reduction percentage of 67 for fatal crashes, despite the study observing a 100 percent reduction in fatal crashes and an 86 percent reduction in severe crashes (K+As).

   Crash modification factors from CMF Clearinghouse were obtained for the other proposed US 212 improvements: convert an at-grade intersection into a grade-separated interchange, replace direct left-turns with right-turns/U-turns (for locations with restricted mainline and side-street left-turns), install right-in-right-out operations at stop-controlled intersection, and conversion from a two-lane roadway to a four-lane divided roadway. To determine estimated reduction of existing intersection crashes, CMFs for relevant improvements were applied to crashes tied to each intersection. Estimated reductions in crashes due to the conversion from a two-lane undivided to a four-lane divided roadway were applied to the remaining non-intersection crashes along the US 212 segments being converted. Year 2040 crashes for the No Build Alternative were estimated based on VMT growth on the US 212 project extents. Similar assumptions used to estimate existing year Build Alternative crashes by severity were applied to produce year 2040 estimates. Detailed calculations and sources for each CMF are outlined in the attached BCA Workbook.

   Finally, it was recognized through the regional travel demand model output that the capacity expansion on US 212 is expected to draw a significant number of trips from other roadways.

[5] https://www.dot.state.mn.us/roadwork/rci/docs/trafficsafetyatrcistudy.pdf

The change in VMT on other roadways is likely to produce a change in crashes on routes where trips are diverting to/from due to the change in vehicle exposure. Thus, a change in VMT on key diversion corridors was calculated using output from the regional model (diversion corridors, calculations, a volume delta map, and raw crash data for each corridor are shown in the BCA Workbook). The change in VMT was applied to existing crash rates[6] by severity on each corridor to determine an expected change in crashes by severity on key diversion routes. The overall regional growth between years 2014 and 2040 was applied to existing annual crashes by severity to obtain forecast year 2040 crashes by severity for the No Build and Build Alternatives.

The safety benefit was quantified for years 2014 and 2040 and interpolated/extrapolated based on an annual growth rate to determine total safety benefits for the period from year 2026 to 2045. Crash cost assumptions for the KABCO scale are consistent with values and methodologies published in the *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated February 2021.

8. **Environmental and Air Quality Impacts:** Annual VMT is expected to be impacted by capacity expansion along US 212. The change in VMT between No Build and Build conditions was obtained from the regional travel demand model and 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 was valued in accordance with the *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated February 2021.

9. **Maintenance and Rehabilitation Costs**: It is expected that reconstructing the US 212 corridor will reduce the required future rehabilitation and maintenance activities to keep the roadway serviceable. Future maintenance activities were obtained for the No Build and Build scenarios from MnDOT Office of Materials and Road Research staff. The provided rehabilitation and maintenance schedules for each scenario are listed below.

<u>No Build Scenario</u>

- Medium (4") bituminous mill & overlay at year 0 (year 2021) ($350,000 per lane mile)
- Thin (2") bituminous mill & overlay at year 14 ($250,000 per lane mile)
- Medium (4") bituminous mill & overlay at year 24 ($350,000 per lane mile)
- Unbonded concrete overlay at year 37 ($800,000 per lane mile)

<u>Build Scenario</u>

- Thin (2") bituminous mill & overlay at year 20 ($250,000 per lane mile)
- Medium (4") bituminous mill & overlay at year 35 ($350,000 per lane mile)

Routine annual roadway maintenance costs associated with maintaining the additional roadway infrastructure under the Build Alternative were considered as an additional cost to

[6] Seven-year crash data from years 2014 through 2020 on key diversion routes was used to obtain a larger sample size on lower-volume corridors.

the Build Alternative. An annual maintenance cost of $8,100 per lane mile, which derived from maintenance reports for similar facility types within the Twin Cities metro area, was applied in this analysis. This maintenance cost included costs associated with striping, snow plowing, minor repairs, and shoulder maintenance. Other maintenance costs between the alternatives were assumed to be similar.

10. **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. This value was expressed in terms of 2019 dollars and was added to other user benefits in accordance with USDOT guidance. In determining remaining capital value, the initial costs of the proposed alternative were separated into the following categories:

    - Right of Way
    - Major Structures
    - Grading and Drainage
    - Sub-Base and Base
    - Surface
    - Miscellaneous Costs – Includes all previously incurred costs, engineering, mobilization, removals, utility relocation, 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.

11. **Factors Not Quantified**: Several factors were not quantified as part of the analysis because review of initial data indicates low potential to yield substantial benefit. These factors included the following:

    - Trips lying outside the specified subarea may accrue benefits that were not accounted for.
    - Operating cost savings from improved vehicle efficiency due to increased average vehicle speeds in Build Alternative.
    - Travel time savings due to a reduction of nonrecurring congestion (e.g. due to crashes, inclement weather, work zones, etc.) from increased roadway capacity.
    - Crash reductions at local access locations (other than those specified in the analysis) on US 212 due to restricted left-turn movements.

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 greater than 1.0. The larger the ratio number, the greater the benefits per unit cost. Results of the benefit-cost analysis are shown for the project in Table 1 below. See Attachment A for the complete benefit-cost analysis workbook.

Table 1 – Total Project Results

	Initial Capital Cost (2019 Dollars)	Project Benefits (2019 Dollars)	Benefit-Cost Ratio (7% Discount Rate)	Net Present Value (2019 Dollars)
No Build vs. Build	$26.1 million	$69.5 million	2.7	$43.4 million

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Attachment A

Benefit-Cost Analysis Worksheet