Memorandum

To:	Jarrod Walker, Freight & Economic Development Liaison Nebraska Department of Transportation
From:	Nick Semeja, PE Matt Flanagan
Date:	May 19, 2022
Subject:	I-80 Capacity, Safety, and Reliability Enhancements – 2022 MPDG Grant 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 I-80 Capacity, Safety, and Reliability Enhancements – 2022 MPDG 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 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, operating and maintenance costs, remaining capital value, and capital 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.

Project Overview

The Nebraska Department of Transportation (NDOT) is planning to reconstruct, expand, and improve safety along Interstate 80 (I-80). The project limits are in Lancaster and Seward Counties between mile posts 387.54 and 395.15, a distance of 7.61 miles. The project begins 0.6 miles west of N-103 and extends east to the NW 56th Street grade separation, which is near the western border of the City of Lincoln (population 295,618).

Description of Alternatives

For the purpose of this analysis, two alternatives, No Build and Build, were evaluated and are described below.

No Build Alternative

The No Build Alternative assumes no major capital construction projects will occur to improve the condition of the I-80 corridor. Two bridge structures initially constructed in 1962 along I-80 are

anticipated to reach the end of their design life by year 2045 (Structure #S080 39165LR over South Branch Middle Creek & Structure S080 39294LR over Middle Creek). These structures will require full deck replacements in year 2045 and various maintenance and repair activities until then. As part of the No Build Alternative, it was assumed that major capital investments will not be made and that the bridges would close in year 2045[1]. This analysis identified and monetized the impacts of a detour from I-80 to US 6, also known as I-80 Alt, due to future anticipated closure of bridges on the I-80 corridor.

Additional details on detour routes and costs associated with these detours are provided in Section 4 of this memorandum.

Build Alternative

The Build Alternative consists of the following specific design elements considered in this BCA:

- Reconstruction of the two bridges noted above along I-80
- Reconstruction and expansion of I-80 from four-lanes to six-lanes
- Install 28-foot paved median with concrete barrier along entire length of project corridor
- Reconstruction of the Highway N-103 Interchange (modernize ramp lengths)

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 operating costs
   - Crashes by severity
   - Environmental and air quality impacts
   - Initial capital costs: Capital costs were expected to be incurred in years 2024-2027
2. **Analysis Years**: This analysis assumed that the Build Alternative would be constructed over a four-year period starting in year 2024 with completion in year 2027. Construction activities are expected to occur in throughout all four years (2024-2027), with the majority of the I-80 mainline work expected in 2026 and 2027. Year 2028 was assumed to be the first full year that benefits will be accrued from the project. The analysis primarily focused on annual benefits for the thirty-year period from 2028 to 2057[2], while some user costs were quantified during the construction phases of the project.

[1] It was assumed that routine maintenance on the bridges would still occur under the No Build to fix local deck failures and other nonrecurring issues.
[2] A thirty-year benefit cost analysis period was assumed since the project includes a full reconstruction of pavement and will provide a service life far beyond the analysis period.

3. **Economic Assumptions**: Value of time, vehicle operating costs, emissions costs, and cost of crashes were obtained from the *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated March 2022 (Revised)[3]. The present value of all benefits and costs was calculated using 2020 as the year of current dollars. This analysis assumes a real discount rate of 7 percent per year.

4. **Development of Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT)**: Year 2022 and year 2042 I-80 corridor VMT and VHT were developed using existing and forecast Annual Average Daily Traffic (AADT) volumes and anticipated route choices under the No Build and Build Alternatives. Existing year 2022 and forecast year 2042 corridor AADTs were obtained through coordination with NDOT Planning, Traffic Forecasting and Modeling staff. This analysis assumes a linear annual average growth rate of 1.55 percent per year along I-80 and was obtained from the NDOT Travel Demand Model. Existing corridor length data and travel time data were obtained using Google Maps.

   It was assumed that construction on the I-80 mainline would take place during a seven-month period during 2026 and 2027, and that the posted speed limit would be reduced from 75 mph to 65 mph. Differences in travel times due to this speed limit reduction were quantified for each phase of the project and considered a disbenefit for the Build Alternative. This disbenefit impacts both directions of travel, 24 hours per day during that period. Similar disbenefits were quantified during major rehabilitation activities anticipated for the Build Alternative but with a construction duration of three months per year instead of seven months.

   After consultation with NDOT Roadway Design Division staff, the bridges along I-80 (Structure #S080 39165LR over South Branch Middle Creek & S080 39294LR over Middle Creek) were assumed to close in year 2045 based on remaining service life under the No Build Alternative. Detour routes and associated mileage and travel times were determined using Google Maps and were compared to trip distances and travel times along the I-80 route, as described in the BCA workbook. The BCA Workbook also contains detailed information regarding bridge service life assumptions, detour routes, trip distances and travel times.

   Travel times and trip distances were applied to year 2022 and year 2042 daily traffic volumes to determine total VHT and VMT, respectively. Benefits for the years between 2022 and 2042 were interpolated using an annual growth rate, and benefits for years beyond 2042 were extrapolated using the same growth rate. Total user costs per alternative is the sum of all user costs for the period from 2026 to 2057 (i.e., includes construction years and thirty years beyond the opening of the last bridge project). Benefits due to change in VMT and VHT were calculated using costs per mile and per hour that account for vehicle occupancy and different vehicle types.

5. **Vehicle Occupancy and Vehicle Types**: The composite cost per mile used in the benefit-cost analysis accounted for both vehicle occupancy and percent split of automobiles and trucks traveling in the area. Key assumptions for these areas included:

[3] https://www.transportation.gov/sites/dot.gov/files/2022-03/Benefit%20Cost%20Analysis%20Guidance%202022%20%28Revised%29.pdf

- The corridor-wide truck percentage used in the analysis was 25 percent and was based on year 2022 daily traffic and heavy truck counts obtained through coordination with NDOT Planning, Traffic Forecasting and Modeling staff.
- Vehicle occupancy that was used in the analysis is consistent with values provided by *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated March 2022 (Revised). The analysis assumed occupancy of 1.67 people per automobile and 1.00 people per truck.

6. **Safety Analysis:** The Build Alternative improves safety in the project area by providing the following elements quantified in this Benefit-Cost Analysis:

- Addition of concrete barrier throughout the entire project corridor
- Expanding capacity from a four to six-lane facility (three through lanes in each direction)
- Reconstructing interchange ramps and adding 1,000' of tapered design acceleration lanes

Three-years of crash data along the I-80 corridor was obtained for years 2017 through 2019 from NDOT to determine average annual number of crashes by severity[4]. Reductions in crashes along the I-80 corridor were estimated using the following Crash Modification Factors (CMFs) taken from the CMF Clearinghouse database: Install Median Barrier (CMF ID: 42)[5], Install Median Barrier (CMF ID: 43)[6], Increase from four to six Lanes (CMF ID: 7933)[7] and Modify Length of Acceleration Lane (CMF ID: 5216)[8]. These CMFs are summarized below:

- "Install Median Barrier" (CMF ID: 42) - The crash modification factor was applied to all fatal segment crashes (non-junction crashes only). This CMF predicts an annual reduction of 43 percent in all types of fatal crashes.
- "Install Median Barrier" (CMF ID: 43) - The CMF was applied to all type A, B and C segment crashes (non-junction crashes only). This CMF predicts an annual reduction of 30 percent for all applicable crashes.
- "Increase From 4 Lanes To 6 Lanes" (CMF ID: 7933) - The CMF was applied to all type K, A, B, C, and PD segment crashes (non-junction crashes only). This CMF predicts an annual reduction of 29.8 percent for all applicable crashes.
- "Modify Length of Acceleration Lane" (CMF ID: 5216) - The CMF equation is an exponential function which relies on the change in length of the acceleration lane as the input variable and is applicable to all crash types. CMF was calculated for applicable ramp junctions where existing crashes were located. Existing acceleration lane lengths were determined using measurements from Google Earth aerial imagery.

Expected number of crashes in year 2042 were calculated by multiplying the base year crashes by the percent change in traffic volumes between the base year (this analysis assumed 2019 being the center of the crash analysis period due to available AADT data) and forecast year 2042. Forecast year crash costs were calculated for the No Build Alternative and Build

[5]CMF ID: 42: http://www.cmfclearinghouse.org/detail.cfm?facid=42
[6] CMF ID: 43: http://www.cmfclearinghouse.org/detail.cfm?facid=43
[7] CMF ID: 7993: https://www.cmfclearinghouse.org/detail.cfm?facid=7933
[8] CMF ID: 5216: http://www.cmfclearinghouse.org/detail.cfm?facid=5216

Alternative. Crash costs were obtained by applying the appropriate crash modification factors to the No Build Alternative crash costs.

The safety benefit associated with the installation of the concrete barrier, capacity expansion, and the extension of acceleration lanes were calculated for years 2022 and 2042 and interpolated (or extrapolated) based on an annual growth rate to determine total safety benefits for the period from years 2028 to 2045 (prior to detours routing traffic off I-80).

The crash cost savings associated with the detour due to closure of the bridges along I-80 were monetized by calculating existing crash rates by crash severity along the detour routes using 2017-2019 crash data obtained from the NDOT NTIP Crash Portal[9] and AADT data obtained from the NDOT Annual Average Daily Traffic Counts GIS Map[10]. Crash costs for existing year 2022 and forecast year 2042 were calculated based on the change in VMT between the No Build Alternative and Build Alternative caused by the diversions described in Section 4 of this memorandum, "Development of Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT)." The shift of traffic to the detour route is expected to result in increased crash costs for the No Build since severe crash rates on the I-80 freeway corridor are lower than those on the two-lane undivided design of I-80 Alt (detour route). Crash costs for years 2046-2057 were extrapolated based on the existing year 2022 and forecast year 2042 annual crash costs. Crash data for years 2017-2019 is presented in the BCA Workbook.

Crash cost assumptions are consistent with values and methodologies published in the *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated March 2022 (Revised).

7. **Environmental and Air Quality Impacts:** Annual VMT is expected to be impacted by the bridge closures along I-80 (Structure #S080 39165LR over South Branch Middle Creek & S080 39294LR over Middle Creek). The change in VMT between the No Build Alternative and Build Alternative was caused by the diversions described in Section 4 of this memorandum, "Development of Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT)." Average emission rates per vehicle type were obtained from the Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) version 3[11]. 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 March 2022 (Revised).

8. **Operating and Maintenance Costs**: Changes in annual roadway maintenance costs are expected due to the additional lane-miles on the corridor under the Build Alternative. In addition to routine annual maintenance, major rehabilitation activities are expected over the lifespan of the Build Alternative to keep the project serviceable. These activities were only assumed for the Build Alternative since it was assumed pavement maintenance and rehabilitation would no longer occur under No Build conditions. A schedule of major rehab

[9] NDOT NTIP Crash Portal: https://ntip.nebraska.gov/Map
[10] NDOT Annual Average Daily Traffic Counts GIS Map: https://gis.ne.gov/portal/apps/mapviewer/index.html?webmap=9da1b7650dfe4f07af4911a5bdf95e6a
[11] Average emission rates per vehicle type were obtained from the Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) version 3: https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves

activities with their costs per lane-mile is shown in Table 1. Additional details are provided in the BCA workbook.

Table 1 – Major Rehab Activities Per Lane Mile for Build Conditions (2020 Dollars)

Project Year	Cost
7	$5,500
10	$66,000
15	$22,000
19	$192,500
24	$5,500
27	$93,500
31	$5,500
35	$220,000
41	$7,700
45	$302,500
48	$7,700

9. **Calculation of Remaining Capital Value**: Because many components of the initial capital costs have service lives well beyond the 30-year analysis period, the remaining capital value was calculated for the Build Alternative. This value was expressed in terms of 2020 dollars and was added to other project benefits in accordance with USDOT guidance. The assumed service life for the Build Alternative was 50 years, which was based on typical ages of concrete roadway until a full reconstruction is required assuming the major rehabilitation activities provided in Table 1 are carried out throughout the project life. Considering the last full construction of the I-80 corridor pavement was carried out in the 1960s, a service life of 50 years can be considered conservative. In determining the remaining capital value of the Build Alternative, the project was assumed to have a linear depreciation from the time construction was completed to the end of the benefit-cost analysis period.
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:
    - Increased travel time reliability in the study area due to a reduction in crashes from safety improvements and enhanced pavement condition.
    - Flattening of backslopes to help with the removal of snow traps and melting
    - Correction of inslopes to ensure proper roadway drainage
    - New pavement markings that are more visible and reflective during adverse driving conditions
    - Installation of outside guard-rail along I-80 Mainline

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 2. See Attachment A for the complete benefit-cost analysis workbook.

Table 2 – Total Project Results

	Initial Capital Cost (2020 Dollars)	Project Benefits (2020 Dollars)	Benefit-Cost Ratio (7% Discount Rate)	Net Present Value (2020Dollars)
No-Build vs. Build	$81.0 million	$247.0 million	3.05	$166.0 million

Attachment A

Benefit-Cost Analysis Worksheet