Benefit Cost Analysis Technical Memorandum

1. Introduction

This benefit-cost analysis (BCA) was conducted for the proposed Illinois International Port - Calumet River (IIPCR) Bridges Rehabilitation for submission to the U.S. Department of Transportation (USDOT) as a requirement of a discretionary grant application for the FY 2022 Bridge Investment Program (BIP) grant opportunity. The analysis was conducted in accordance with the benefit-cost methodology as outlined by USDOT in the Benefit-Cost Analysis Guidance for Discretionary Grant Programs, released in March 2022 (Revised).

The purpose of this project is to rehabilitate four bascule-type lifting bridges over the Calumet River well beyond their service lives. This analysis assumes that the bridges will cease operation in 2025 if no action is taken (No-Build). The project analysis period of 30 years begins in 2024, with benefits starting in 2027 following the completion of the rehabilitation (construction is scheduled 2024 to 2026). The subsequent operational period after the project is put in service begins in 2027 and ends in 2053.

After discounting, this project has a favorable Benefit-Cost Ratio of 2.4. This memorandum describes the methods used to calculate the project benefits, costs, and BCA results. Table 1 summarizes the project benefits, and costs.

Table 1 Executive Summary of Discounted Benefits and Costs

Benefits and Costs	Discounted Value (2020 $ mil)
Travel Time Savings	$239,011,098
Vehicle Operating Cost Savings	$93,899,869
Safety Crash Cost	$150,192,092
Environmental Sustainability	$696,395
Maintenance & Operations Savings	($3,993,625)
Residual Asset Value	$14,206,453
Total Benefits	**$494,012,281**
Total Costs	**$205,653,467**
Benefit/Cost Ratio	**2.4**

2. Traffic Projections

This analysis used output from the regional Travel Demand Model (TDM) generated by the Chicago Metropolitan Agency for Planning (CMAP) for the Build and No-Build scenarios. The No-Build scenario assumes that the four bridges over the Calumet River slated for rehabilitation will close indefinitely starting in 2025 without the project. All traffic previously using the four bridges will have to be rerouted – local traffic will reroute to nearby river crossings, such as the Skyway, while longer-distance traffic (especially commercial trucks) will reroute to avoid the more highly congested area, in some cases traveling around the City of Chicago entirely. The Build scenario assumes that the four bridges will be rehabilitated starting in 2024 and completed in 2026, with benefits commencing in 2027.

TDM outputs, such as Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT), were developed for the City of Chicago and do not capture VMT or VHT outside of the City limits. Table 2 and Table 3 show the projections for VMT and VHT, respectively, generated by the CMAP travel demand model. Auto VMT and VHT are lower in the Build scenario compared to the No-Build scenario due to the diversions around the closed bridges in the No-Build scenario. Auto traffic is highly sensitive to broken links in the travel network because personal trips, such as commute to work, travel to grocery store, etc., is relatively localized.

Truck VMT and VHT are lower in the No-Build scenario than the Build scenario. This is because truck travel tends to be longer-distance and can more easily reroute, in many cases traveling partially or entirely outside of the City of Chicago. The four bridges are located as close as 0.5 miles from the Chicago city line (also the Illinois state line), meaning that rerouted longer-distance trips are more likely to avoid traveling in the City entirely. Those miles and hours that are rerouted outside of the City of Chicago are not represented in the modeled results, and so the VMT and VHT estimates for truck travel may underestimate total VHT and VMT impacts in the No-Build scenario.

Table 2 Vehicle Miles Traveled for Build and No-Build Scenarios

	2019	2025		2050	
		No-Build	Build	No-Build	Build
Annual Auto VMT	10,044,038,640	10,574,781,792	10,551,621,000	11,584,623,504	11,532,990,048
Annual Truck VMT	1,034,498,753	981,224,478	984,249,923	1,117,884,645	1,122,385,845
Total VMT	11,078,537,393	11,556,006,270	11,535,870,923	12,702,508,149	12,655,375,893

Table 3 Vehicle Hours Traveled for Build and No-Build Scenarios

	2019	2025		2050	
		No-Build	Build	No-Build	Build
Annual Auto VHT	342,155,666	362,189,808	361,636,662	428,293,473	426,159,321
Annual Truck VHT	34,132,429	32,172,391	32,233,601	39,686,745	39,816,581
Total VHT	376,288,095	394,362,199	393,870,263	467,980,217	465,975,902

3. Project Benefits

There were six benefits from the IIPCR Bridges Rehabilitation that were quantified for this BCA. These benefits were travel time savings, vehicle operating cost savings, safety benefits (crash reductions), environmental sustainability, and residual asset value. Maintenance and operations were included as a negative benefit.

Travel Time Savings

The CMAP travel demand model was used to calculate VHT in the base year (2019), year of bridge closure which would result from inaction (2025), and the TDM horizon year of 2050. Growth in traffic between 2027 and 2053 was interpolated based on the estimates for 2025 and 2050 derived from the TDM.

The closure of the four bridges would result in significant diversions and rerouting of auto and truck traffic, generating additional vehicle hours of travel. This analysis used the difference in VHT between the Build and No-Build scenarios to account for time saved by maintaining the bridge crossings open to traffic from 2027 to 2050. Because the TDM only projected to 2050, VHT was held constant from 2050 – 2053 at 2050 levels for both scenarios.

Default value-of-time figures were used from the BCA guidance to monetize the estimations of time saved by maintaining the bridge crossings (e.g., $17.80 per person-hour with an average occupancy of 1.67 persons per vehicle, or $29.73 per vehicle-hour for passenger vehicles). Based on these default values, a benefit of almost $1 billion nominal or $239 million discounted to 2020 dollars was estimated. The annual nominal and discounted travel time savings over the project operational period can be found in the “VHT to VOTT Savings” and the “BCA Summary Discounted” tabs, respectively, in the BCA workbook.

It should be noted that the CMAP travel demand model only captured travel in the City of Chicago. Because some commercial trucks travel longer distances reaching areas outside of the city, the model diverts some of these truck trips outside of the city, resulting in a smaller VHT in the No-Build scenario as compared to the Build scenario. This may undercount the increase in VHT incurred by commercial truck operators in the No-Build scenario, thus understating actual savings in the Build scenario.

Vehicle Operating Cost Savings

The CMAP travel demand model was used to calculate VMT in the base year (2019), year of bridge closure which would result from inaction (2025), and the travel demand model horizon year of 2050. Growth in traffic between 2027 and 2053 was interpolated based on the estimates for 2025 and 2050 derived from the travel demand model.

The closure of the four bridges would result in significant diversions and rerouting of auto and truck traffic, generating additional vehicle miles of travel. This analysis used the difference in VMT between the Build and No-Build scenarios to account for vehicle mileage saved by maintaining the bridge crossings open to traffic from 2027 to 2050. Because the TDM only projected to 2050, VMT was held constant from 2050 – 2053 for both scenarios.

Default operating cost values based on mileage were used from the BCA guidance to monetize the estimations of vehicle operations costs saved by maintaining the bridge crossings (e.g., $0.45 per mile for light duty vehicles). Based on these default values, a benefit of $357 million nominal and $94 million discounted to 2020 was estimated. The annual nominal and discounted vehicle operating cost savings over the project operational period can be found in the "VMT to VOC Savings" and the "BCA Summary Discounted" tabs, respectively, in the BCA workbook.

It should be noted that the CMAP travel demand model only captured travel in the City of Chicago. Because some commercial trucks travel longer distances reaching areas outside of the city, the model diverts some of these truck trips outside of the city, resulting in a smaller VMT in the No-Build scenario as compared to the Build scenario. This may undercount the increase in VMT incurred by commercial truck operators in the No-Build scenario, thus understating actual savings in the Build scenario.

Safety Benefits (Crash Reductions)

The IIPCR Bridges are important roadway links in the local area. Without rehabilitation, the bridges would eventually be closed, and the current and future traffic that would have used those bridges would be forced to undertake circuitous detours. The main safety benefits estimated for the IIPCR Bridges rehabilitation were calculated under the association between VMT and crash probability. The safety benefits focus on the differences in VMT between the Build and No-Build scenarios, applying a crash-per-VMT probability factor to estimate the total increased number of crashes under the No-Build scenario.

Using the safety data and VMT estimates for the City of Chicago over the past 10 years (2010-2019), the total crashes by crash type and total VMT were used to calculate 10-year average crash rates by crash type. Table 4 summarizes the crashes by type and the resulting crash rates for Chicago.

Table 4 Chicago Crash Data (2019)

	Fatal	Injury	PDO	Total
2010 – 2019 Total Crashes	1,206	158,136	718,578	877,920
10-Year Average Crashes per 100 Million VMT	1.1	143.4	651.7	796.2

Source: IDOT Crash Data (2019), Travel Demand Model

For the 30-year period of analysis, the future annual VMT was estimated using the TDM. The number of fatal crashes, crashes resulting in an injury, and PDO crashes were estimated for the Build and No-Build Scenarios by combining the VMT estimates with the 10-year average crash rate. Then, the differences in estimated crashes between the Build and No-Build Scenarios were multiplied by the corresponding 10-year average crash rate (crashes per VMT). This analysis assumes the fatal, injury, and PDO crash rates over the period of analysis will be similar to the 10-year historical average.

The annual number of fatal, injury and PDO crashes in the Build and No-Build scenarios over the project's operational period can be found in the "Crash Rates" and "Crashes and Crash Cost Savings" tabs in the BCA workbook. These assumptions on annual crashes by crash type were multiplied by the costs provided in the BCA guidance ($12,837,400 per fatal crash, $302,600 per injury crash, and $8,041 per property damage only crash). The property damage only crash value was estimated by combining the $4,600 per vehicle value in the BCA guidance with the average 1.748 vehicles per crash value calculated by the National Highway Transportation Safety Administration (NHTSA).[1]

These assumptions resulted in an expected benefit of approximately $566.6 million nominal or $150.2 million when discounted to 2020 dollars. Assumptions and calculations can be found in the "Crash Rates" tab. The annual nominal and discounted crash cost savings over the project operational period can be found on the "Crashes and Crash Cost Savings" and the "BCA Summary Discounted" tabs, respectively, in the BCA workbook.

Environmental Sustainability

Emissions reductions benefits were calculated based off of the reduced VMT resulting from maintaining the bridge linkages and avoiding diversions. This analysis applies the running emission rates pertaining to Nitrogen Oxides (NOx), Particulate Matter ($PM_{2.5}$), Carbon Dioxide (CO_2) and Sulfur Dioxide (SO_2) for passenger cars and trucks as a function of travel speeds for the "Build" and "No-Build" scenarios. Running emissions rates in grams per VMT for passenger cars and trucks are based on the Caltrans Cal-B/C 2022 INFRA/RAISE Sketch Model v8.1.[2]

The Caltrans model assumes that vehicles will get marginally cleaner into the future. Other assumptions included:

- In 2053, as compared to expected emissions rates per mile for cars in 2024, CO_2 will decrease by 29 percent, NOX will decrease by 80 percent, SO_2 will decrease by 29 percent, and $PM_{2.5}$ will decrease by 88 percent.
- In 2053, as compared to expected emissions rates per mile for trucks in 2024, CO_2 will decrease by 46 percent, NOX will decrease by 73 percent, SO_2 will decrease by 47 percent, and $PM_{2.5}$ will decrease by 87 percent.

Assumptions and calculations can be found in the "Environmental Factors" tab (showing emissions by model year); "Environmental Factors 2" tab (showing emissions reduction factors by year); "Emissions per VMT" tab (showing the expected emissions per VMT for the Build and No-Build scenarios);

[1] NHTSA. "The Economic and Societal Impact Of Motor Vehicle Crashes, 2010 (Revised)." May 2015 (Revised) https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812013
[2] https://dot.ca.gov/programs/transportation-planning/division-of-transportation-planning/data-analytics-services/transportation-economics#:~:text=Cal%2DB/C%202022%20INFRA/%20RAISE%20Corridor%20Model%20v8.1%20(XLSM)

"Emissions Total" tab (showing total emissions for the Build and No-Build scenarios); and "Emissions Costs" tab (showing the monetized value of the emissions for the Build and No-Build scenarios).

The emissions per mile were converted into metric tons and multiplied by the costs provided in the BCA guidance (e.g., $58 per metric ton of CO_2 per year in 2027). This resulted in an expected benefit of approximately $1.4 million nominal or $0.7 million discounted to 2020 dollars. The annual nominal and discounted emission cost savings over the project operational period can be found on the "Emissions Costs" and the "BCA Summary Discounted" tabs, respectively, in the BCA workbook.

Because of the decrease in VMT and VHT for commercial truck traffic in the No-Build scenario estimated by the CMAP travel demand model, NO_X and $PM_{2.5}$ emissions are higher in the Build scenario compared to the No-Build scenario. In reality, NO_X and $PM_{2.5}$ may actually *increase* in the No-Build scenario with trucks diverting outside of the Chicago city limits. However, the model only captured trips within the City of Chicago. Thus, this estimate may understate the actual environmental benefits.

Maintenance and Operations

In the Build scenario, maintenance and operations of the bridges is expected to cost $500,000 per year or $125,000 per bridge. Over the course of the operational period, this is expected to cost $13.5 million in nominal or $4 million discounted to 2020. In the No-Build scenario, this analysis assumes that the bridges will be decommissioned in 2025 and no maintenance and operations costs will be incurred.

Residual Asset Value

This analysis estimates that the four bridges will have a useful life of 50 years after rehabilitation. This estimate is likely conservative of their actual useful life, which may exceed 75 years. Nonetheless, this resulted in an expected benefit of approximately $132.5 million nominal or $14.2 million when discounted to 2020. The annual nominal and discounted emission cost savings over the project operational period can be found on the "Project Capital and O&M Costs" and the "BCA Summary Discounted" tabs, respectively, in the BCA workbook.

Project Benefit Summary

Table 5, below, provides a summary of the life cycle costs associated with the IIPCR Bridges. These include travel time savings, vehicle operating cost savings, safety benefits (crash reductions), environmental sustainability, maintenance and operations (treated as a negative benefit), and residual asset value benefits. Estimates are provided in both nominal and discounted 2020 dollars and more specific details are available in the BCA workbook.

Table 5 Summary of Project Life Cycle Benefits

Year	Undiscounted Benefits	Discounted benefits ($2020)
2024	$0	$0
2025	$0	$0
2026	$0	$0
2027	$38,886,800	$24,216,745
2028	$41,145,351	$23,946,969
2029	$43,423,435	$23,626,379
2030	$45,721,657	$23,250,259
2031	$48,040,237	$22,832,024
2032	$50,379,259	$22,378,197
2033	$52,738,871	$21,894,693
2034	$55,119,224	$21,386,833
2035	$57,521,511	$20,860,021
2036	$59,944,149	$20,317,477
2037	$62,387,986	$19,763,533
2038	$64,853,117	$19,201,554
2039	$67,338,850	$18,634,018
2040	$69,846,908	$18,064,604
2041	$72,376,788	$17,495,319
2042	$74,928,649	$16,928,272
2043	$77,503,379	$16,365,683
2044	$80,099,695	$15,808,425
2045	$82,718,476	$15,258,276
2046	$85,359,882	$14,716,446
2047	$88,024,080	$14,183,970
2048	$90,712,660	$13,662,309
2049	$93,422,963	$13,151,029
2050	$96,155,074	$12,650,733
2051	$96,156,202	$11,824,595
2052	$96,155,420	$11,051,717
2053	$96,154,645	$10,329,373
Total	**$1,887,115,267**	**$483,799,453**

4. Project Costs

Project capital cost estimates provided in this BCA are given in 2020 dollars. A detailed breakdown of capital costs can be found within the BCA Spreadsheet on the “Project Capital and O&M Costs” tab.

Capital costs for the IIPCR Bridges Rehabilitation accounts for a total of approximately $288 million or $72 million per bridge. The construction is scheduled to begin in 2024 and end in 2026 with $96 million expended per year. When discounted to 2020 dollars, the total construction costs are equivalent to $205,653,467.

Project Life Cycle Costs Analysis

Table 6, below, provides a summary of the life cycle costs associated with the IIPCR Bridges Rehabilitation project. These include capital costs, which would occur from 2024 to 2026. Estimates are provided in both nominal and discounted 2020 dollars and more specific details are available in the BCA workbook.

Table 6 Summary of project life cycle costs

Year	Undiscounted Costs	Discounted Costs ($2020)
2024	$96,000,000	$73,237,940
2025	$96,000,000	$68,446,673
2026	$96,000,000	$63,968,853
Total	**$288,000,000**	**$205,653,467**

5. BCA Results

This section provides the overall results of the BCA, which combine the monetary gains from the benefits and the monetary project costs.

Table 7 presents the Net Present Value (NPV) which is the overall cash value of the benefits minus the costs, and the Benefit Cost Ratio (BCR) which is the value of the overall benefits value divided by the costs.

Table 7 Project Benefit Cost Analysis Summary

Costs and Benefits	Nominal Total Value	NPV Discounted to $2020 (7%)
Costs		
Capital Construction	$288,000,000	$205,653,467
Total Costs	**$288,000,000**	**$205,653,467**
Benefits		
Travel Time Savings	$962,033,812	$239,011,098
Vehicle Operating Cost Savings	$357,176,740	$93,899,869
Safety Crash Cost Benefits	$566,587,111	$150,192,092
Environmental Sustainability Benefits	$1,317,604	$696,395
Maintenance & Operations Savings	($13,500,000)	($3,993,625)
Residual Asset Value	$132,480,000	$14,206,453
Total Benefits	**$2,006,095,267**	**$494,012,281**
Net Present Value (NPV)	$1,718,095,267	**$288,358,814**
Benefit Cost Ratio (BCR)	**7.0**	**2.4**