APPENDIX D

Project Benefit – Cost Analysis

3rd Street NE Bridge Replacement and Rail Raise

Benefit Cost Analysis Supplementary Documentation

BUILD Discretionary Grants Program FY19

City of Minot, North Dakota

July 15, 2019

Contents

Tables

1 Executive Summary

The Benefit-Cost Analysis conducted for this grant application compared the costs associated with the proposed investment to the benefits of the project. To the extent possible, benefits have been monetized. A qualitative discussion is also provided when a benefit is anticipated to be generated but is not easily monetized or quantified.

The project for which this BUILD grant is requested – The 3rd Street NE Bridge Replacement and Rail Raise (the Project) – is located in the city of Minot, North Dakota, over the Mouse River.

The location is a major arterial north-south corridor connecting residential and downtown areas, and also features a BNSF rail bridge and mainline tracks which are a part of BNSF's Northern Transcon route that runs between Chicago, IL, and Seattle, WA. Altogether, the location serves an average of 40 trains and 9,000 vehicles per day.

The 3rd Street NE Bridge does not meet current state guidelines for minimum clear width and also restricts the clearance of the BNSF Railway lines. Additionally, the curved alignment, steep grade, and an adjacent skewed intersection create a safety hazard. The crash rate at this location is nearly three times the state average.

The area is also susceptible to flooding from the Mouse River. During the 2011 flood event, the 3rd Street NE Bridge was closed for 15 days leaving open only two north-south corridors (with one restricted to emergency vehicles only). BNSF closed or delayed service in the area for 22 days. The trains were rerouted to other BNSF tracks, causing longer travel times and related delays throughout the network. Similarly, the Amtrak Train that utilizes BNSF's rail tracks discontinued services on the Empire Builder Route for 45 days due to the flood and it was another 120 days before service was restored to Minot after repairs were completed to the Amtrak Station.

The proposed bridge replacement project will improve the specifications (such as the alignment and clearance) of the bridge to reduce crash rates. The project will also replace the BNSF railroad bridge over the Mouse River to raise multiple rail lines in the same location to reduce the risks from flooding.

The upgrades will reduce future damage due to flooding events, reduce out-of-service time, reduce repair costs, improve freight transport efficiency, and reduce the costs of doing business. Crash rates are projected to decrease due to improved safety measures on the roadway bridge. The project will also reduce the environmental impacts experienced during flood events, such as pollutants contaminating the supply of water.

A table summarizing the changes expected from the project, and the associated quantified benefits, is provided below.

Table ES - 1: Summary of Infrastructure Improvements and Associated Benefits

Current Status or Baseline & Problems to be Addressed	Changes to Baseline / Alternative	Impact Categories	Description	Summary of Results (Discounted at 7%)
The 3rd Street NE Bridge is a major arterial north-south corridor connecting residential and downtown areas in Minot, ND. The location also features a BNSF rail bridge and mainline tracks. A total of 40 trains and 9,000 vehicles per day pass through this location. The 3rd Street NE Bridge is considered functionally obsolete due to geometry, age, and deterioration. The area is also susceptible to flooding from the Mouse River and resulting disruptions to traffic crossing the 3rd Street NE Bridge as well as freight rail traffic, and passenger rail traffic	The proposed project will replace the 3rd Street NE Bridge and the BNSF railroad bridge over the Mouse River to accommodate the raise of multiple rail lines in the same location to reduce the risks from flooding.	Improved Safety of Road Traffic.	Reduced roadway accidents due to improved geometry of the upgraded bridge.	**$0.0**
		Improved Infrastructure Resiliency.	Reduced infrastructure repair costs following a flooding event, including repairs of rail bridge, rail tracks, and rail station buildings and platforms after a flooding event.	**$1.4**
		Residual Value of Assets.	Residual value of the roadway bridge, the rail bridge, and improved rail tracks at the end of the benefit period.	**$2.6**
		Reduced Freight Train Service Suspension During a Flooding Event.	Reduced train operating costs, freight inventory costs from freight train delays, as well as reduced lost freight deliveries from freight train cancellation.	**$38.5**
		Reduced Loss of Passenger Train Services During a Flooding Event.	Reduced Amtrak services suspensions through the entire Amtrak passenger rail network.	**$0.3**
			Reduced Amtrak services suspensions at the Amtrak station in Minot, North Dakota.	**$0.1**
		Operating Cost Savings During a Flooding Event.	Operating costs savings to automobile users from avoided bridge closure and detours.	**Less than $0.1**
		Reduced Travel Time During a Flooding Event.	Reduced travel times for passenger cars and trucks from an avoided longer detour route.	**Less than $0.1**
		Reduced Emissions During a Flooding Event.	Reduced emissions from automobiles as a result of roadway bridge closure and detours.	**Less than $0.1**

Note: All monetary values of project benefits in the table are in millions of 2017 dollars over the period 2025-2054 discounted using a real discount rate of 7 percent.

The period of analysis used in the estimation of benefits and costs is 35 years, including 5 years of planning and construction (2020-2024) and 30 years of operation (2025-2054). The total Project costs include $73.5 million in future capital costs with the anticipated project components shown in Table ES - 2.

Table ES - 2: Capital Costs Components, in Millions of 2017$

Component	2020	2021	2022	2023	2024	Total
3rd Street Bridge Reconstruction	$2.5	$16.9	-	-	$5.6	**$25.0**
Amtrak Platform Relocation	$0.1	-	$0.9	-	$0.3	**$1.3**
BNSF Civil Work (Non-Track)	$1.0	-	$4.4	$4.4	-	**$9.7**
BNSF Track Work	$3.7	-	$16.8	$16.8	-	**$37.4**
Total Project Costs	**$7.4**	**$16.9**	**$22.1**	**$21.2**	**$5.9**	**$73.5**

Table ES - 2 provides a summary of the analysis results and metrics that were obtained from calculations of the Project's benefits and costs. Based on the analysis presented in the rest of this document, the Project is expected to generate $42.9 million in discounted benefits and $56.1 in discounted costs, using a 7 percent real discount rate. Therefore, the Project is expected to generate a **Net Present Value of -$13.2 million and a Benefit/Cost Ratio of 0.8.**

It is noted, however, that the BCA findings for the rail bridge and tracks yields a **Net Present Value of $5.6 million and a Benefit/Cost Ratio of 1.15,** and the BCA findings for the 3rd Street NE Bridge shows a **Net Present Value of -$18.8 million and a Benefit/Cost Ratio of 0.05.** Details are presented in Section 8.

Table ES - 3: Overall Results of the Benefit Cost Analysis, in Millions of 2017$

Project Evaluation Metric	Undiscounted	Discounted at 7%	Discounted at 3%
Total Benefits	$175.8	$42.9	$90.2
Total Costs	$73.5	$56.1	$65.3
Net Present Value	**$102.3**	**-$13.2**	**$25.0**
Benefit / Cost Ratio	**2.39**	**0.76**	**1.38**
Internal Rate of Return (%)	5.1%		
Payback Period (years)	14.1	>30 yrs	21.1

Table ES – 4 presents project benefits quantified and monetized by category. The table demonstrates that the vast majority of project benefits (nearly 90 percent of total benefits) are accounted for by avoided disruptions to freight train services. Residual value of assets accounts for about 6 percent of total benefits while savings in infrastructure repair costs account for about 3.3 percent of total benefits. Other benefits evaluated in this BCA are relatively small in magnitude ($0.1 million each or less).

Table ES - 4: Estimates of Monetized Benefits by Merit Criteria Outcomes, in Millions of 2017$

Merit Criteria	Benefit Category	Over the Project Study Period		
		Constant 2017$	Discounted at 7%	Discounted at 3%
Safety	Improved Safety of Road Traffic.	$0.1	$0.0	$0.1
State of Good Repair	Improved Infrastructure Resiliency.	$5.2	$1.4	$2.8
	Residual Value of Assets	$29.4	$2.6	$10.1
Economic Competitiveness	Reduced Freight Train Service Suspension During a Flooding Event.	$139.7	$38.5	$76.4
	Reduced Loss of Passenger Train Services During a Flooding Event - Amtrak Network	$0.9	$0.3	$0.5
	Reduced Loss of Passenger Train Services During a Flooding Event - Amtrak in Minot	$0.4	$0.1	$0.2
	Operating Cost Savings During a Flooding Event.	$0.0	$0.0	$0.0
	Reduced Travel Time During a Flooding Event.	$0.1	$0.0	$0.0
Environmental Sustainability	Reduced Emissions During a Flooding Event.	$0.0	$0.0	$0.0
Total Benefit Estimates		**$175.8**	**$42.9**	**$90.2**

In addition to the monetized benefits and metrics presented in Table ES - 1, the Project would generate benefits that are difficult to monetize. A brief description of those benefits is provided below.

- ***Improved bridge resiliency and reliability***

  The Project will reconstruct the 3rd St NE Bridge and the rail bridge to strengthen their resiliency when facing extreme weather events. The Project allows both bridges to remain operational during a flooding event, which improves the reliability of the roadway bridge and rail services.

- ***Improved Economic Performance of Freight Shippers and Receivers***

  The Project helps improve on-time performance of freight rail services during a flood events. As a result, downstream freight receivers would be able to maintain operations without any disruptions and avoid any potential economic costs associated with delayed freight shipments.

- ***Improved Freight Rail Operating Flexibility***

  The Project will elevate both 3rd St NE Bridge and the rail bridge, which creates greater clearance between two bridges, and allows freight rail operators to have a better operating flexibility with respect to the type of trains operated in the future. For example, freight rail operators could have the option to operate double stack container trains.

2 Introduction

This document provides detailed technical information on the economic analyses conducted in support of the Grant Application for the 3rd Street NE Bridge and Rail Raise Project. The reminder of this document is organized as follows.

- Section 3 - Methodological Framework: Introduces the conceptual framework used in the BCA.
- Section 4 - Project Overview: Provides an overview of the project, including a brief description of existing conditions, description of the No Build/Base Case and Build/Alternative scenarios, a summary of cost estimates and schedule, and a description of the types of effects that the project is expected to generate.
- Section 5 – General Assumptions: Discusses the general assumptions used in the estimation of project costs and benefits.
- Section 6 – Demand Projections: Discusses estimation of travel demand facing the area under Build and No-Build scenarios.
- Section 7– Estimation of Economic Benefits / Merit Criteria Outcomes: Details the specific methodology and input assumptions used to estimate the benefits.
- Section 8 – Summary of Findings and Benefit-Cost Outcomes: Presents estimates the project's Net Present Value (NPV), its Benefit/Cost Ratio (BCR) and other project evaluation metrics.
- Section 9 – Benefit-Cost Sensitivity Analysis: Provides the outcomes of the sensitivity analysis for key input assumptions.

3 Methodological Framework

The specific methodology developed for this application was developed using the above BCA principles and is consistent with the USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs (December 2018). In particular, the methodology involves:

- Establishing existing and future conditions under the Base and Alternative scenarios;
- Assessing benefits with respect to each of the merit selection criteria identified in the Notice of Funding Opportunity (NOFO);
- Measuring benefits in dollar terms, whenever possible, and expressing benefits and costs in a common unit of measurement;
- Using USDOT guidance for the valuation of supply chain efficiency benefits, safety benefits, reductions in air emissions, pavement maintenance benefits and residual value of benefits while relying on industry best practice for the valuation of other effects; and
- Discounting future benefits and costs with the real discount rates recommended by USDOT (7 percent as the main evaluation scenario and 3 percent for sensitivity testing).

4 Project Overview

The 3rd Street NE bridge in the city of Minot, North Dakota, is one of two north-south corridors that cross the Mouse River from residential areas into the downtown area of Minot, providing access to the central business district area. The location also features a BNSF rail bridge and mainline tracks which are a part of BNSF's Northern Transcon route that runs between Chicago, IL, and Seattle, WA area. Altogether, the location serves an average of 40 trains and 9,000 vehicles per day.

The 3rd Street NE Bridge was originally constructed in 1936 and is considered to be functionally obsolete with a sufficiency rating of 62.20, according to NDDOT's Bridge Inventory. The 3rd Street NE Bridge does not meet current state guidelines for minimum clear width and also restricts the clearance of the BNSF Railway lines. Additionally, the alignment of the bridge includes a horizontal curve, the profile of the bridge has a steep grade, and the north approach to the bridge creates a skewed intersection. The combined crash rate for the intersections adjacent to this bridge is 4.45 per million vehicle miles traveled (MVMT), compared to North Dakota's most recent statewide crash rate of 1.54 per MVMT. In addition, the BNSF Railway has a restricted clearance at this location of 19'-0" versus BNSF's current standard of 23'-6".

The area is also susceptible to flooding from the Mouse River. During the 2011 flood event, the 3rd Street NE Bridge was closed for 15 days leaving open only two north-south corridors (with one restricted to emergency vehicles only). BNSF closed or delayed service in the area for about 22 days. The trains were rerouted to other BNSF tracks, causing longer travel times and related delays throughout the network. Similarly, the Amtrak Train that utilizes BNSF's rail tracks discontinued services on the Empire Builder Route for 45 days due to the flood and it was another 125 days before service was restored to Minot after repairs were completed to the Amtrak Station.

The proposed bridge replacement project will improve the specifications (such as the alignment and clearance) of the bridge to reduce crash rates. The project also intends to raise the elevation of the roadway bridge, the rail bridge and tracks to reduce their susceptibility to flooding, minimizing their downtime during flood events, disruptions, and repair costs.

Other benefits of raising the rail lines to increase their resiliency to natural disasters is the improvement of the overall efficiency and reliability of freight movements which supports the objectives of reducing the costs of doing business. This is a benefit of regional and national importance. Additionally, this project will reduce the environmental impacts experienced during flood events, such as pollutants entering the water stream, impacting the water quality and distributing pollutants to areas downstream.

4.1 Base Case and Alternative Case

<u>The Base Case</u>

The Base Case for the Project is defined as the No Build scenario. In the Base Case, the 3rd Street NE Bridge and the rail bridge are not reconstructed, and the railroad tracks are not raised. As a result, this infrastructure will remain vulnerable to flooding events such as those in 2011. If a flooding event does happen, both bridges and railroad tracks could be flooded and/or damaged by water flows and would be closed for safety reasons. Passenger and freight rail service going through Minot would be suspended. Rerouted highway vehicles and freight trains will need to take a detour, generating longer travel times, higher operating costs and emissions, and freight shipment delays. Some freight shippers and rail passengers could lose access to services altogether resulting in lost train services. The existing bridge structure will continue as is as an outdated structure and cause road safety concerns for vehicles passing through the bridge.

The Alternative Case

The Alternative Case is defined as the Build scenario. In the Alternative Case, the 3rd Street NE Bridge and the BNSF rail bridge are reconstructed as described above and rail tracks would be raised to improve their resiliency in flooding events and reduce the extend of disruptions such as bridge closures and suspension of freight and passenger rail services. The upgraded 3rd Street NE Bridge will also improve roadway safety for local residents.

4.2 Type of Impacts

Characteristics of the No Build and Build scenario indicate that the proposed project is expected to have the following impacts:

- Safety benefits, reduction in road accidents (due to better intersection geometry, greater road capacity, greater clearance and bridge alignment);
- State of good repair, renewal and upgrade of 3rd Street NE bridge to modern design standards with cost savings related to mitigation repairs;
- Travel time savings to passengers travelling along the corridor (due to alternative transportation mode choices for intercity travel and reduced congestion);
- Greater efficiency; reduced freight and passenger transport delays and out-of-service time due to flooding and weather events;
- Reduction in vehicle emissions (due to greater rail access);
- Greater safety to pedestrians and bicyclists and improved quality of walking and biking experience encouraging walk and bicycle use;
- Facilitation of economic development (commercial, retail, residential) around the corridor;
- Improved environmental protection by preventing water supply pollution during flooding events.

4.3 Project Cost and Schedule

The Project leverages funding to provide optimal Project cost delivery. Table 1 summarizes the Project's capital costs by year and component, with design work commencing in 2020 and Project completion in 2024. As a conservative measure for the purposes of the BCA, all benefits begin to accrue starting only in the first full year of operations (2025). Total capital expenditures for the project are estimated at $75.8 million in 2019 dollars, but were deflated to 2017 dollars using a GDP deflator. This resulted in an adjusted estimate of $73.5 million.

Table 1: Capital Cost Components, in Millions of 2017$

Component	2020	2021	2022	2023	2024	Total
3rd Street Bridge Reconstruction	$2.5	$16.9	-	-	$5.6	**$25.0**
Amtrak Platform Relocation	$0.1	-	$0.9	-	$0.3	**$1.3**
BNSF Civil Work (Non-Track)	$1.0	-	$4.4	$4.4	-	**$9.7**
BNSF Track Work	$3.7	-	$16.8	$16.8	-	**$37.4**
Total Project Costs	**$7.4**	**$16.9**	**$22.1**	**$21.2**	**$5.9**	**$73.5**

Operations and maintenance costs (O&M) related to the infrastructure that is being improved are not expected to change in a significant way. This is because the footprint of the infrastructure remains essentially the same. In the first few years after the project is completed, the O&M costs may actually go down somewhat as the extent of repairs on new infrastructure is likely to be much smaller than on old infrastructure.

4.4 Effects on Selection Criteria

The main benefit categories associated with the Project are mapped into the selection criteria outcomes set forth by the USDOT in the Notice of Funding Opportunity in the table below.

Table 2: Expected Effects on Selection Criteria Outcomes and Benefit Categories

Selection Criteria	Category of Benefits	Description	Monetized	Qualitative
Safety	Improved Safety of Road Traffic and Rail Movements	Reduced roadway accidents due to improved geometry of the upgraded bridge	Yes	
State of Good Repair	Improved Infrastructure Resiliency.	Reduced infrastructure repair costs following a flooding event, including repairs of rail bridge, rail tracks, and rail station buildings and platforms after a flooding event.	Yes	
	Residual Value of Assets	Residual value of the roadway bridge, the rail bridge, and improved rail tracks at the end of the benefit period.	Yes	
Economic Competitiveness	Reduced Freight Train Service Suspension During a Flooding Event.	Reduced train operating costs, freight inventory costs from freight train delays, as well as reduced lost freight deliveries from freight train cancellation.	Yes	
	Reduced Loss of Passenger Train Services During a Flooding Event.	Reduced Amtrak services suspensions through the entire Amtrak passenger rail network.	Yes	
		Reduced Amtrak services suspensions at the Amtrak station in Minot, North Dakota.	Yes	
	Operating Cost Savings During a Flooding Event.	Operating costs savings to automobile users from avoided bridge closure and detours.	Yes	
	Travel Time Savings During a Flooding Event.	Reduced travel times for passenger cars and trucks from an avoided longer detour route.	Yes	

Selection Criteria	Category of Benefits	Description	Monetized	Qualitative
	Improved bridge resiliency and reliability	The Project will reconstruct the 3rd Street NE Bridge and the rail bridge to strengthen their resiliency when facing extreme weather events. The Project allows both bridges to remain operational during a flooding event, which improves the reliability of the roadway bridge and rail services.		Yes
	Improved Reliability of Transportation Infrastructure.	Avoided economic costs of freight delays during flood events which disrupts operations of freight shippers and receivers.		Yes
	Improved Freight Rail Operating Flexibility.	Greater clearance between the roadway bridge and the rail bridge, which gives freight rail operators better operating flexibilities with respect to the type of trains operated in the future.		Yes
Environmental Sustainability	Reduced Emissions During a Flooding Event.	Reduced emissions from automobiles as a result of roadway bridge closure and detours.	Yes	

5 General Assumptions

The BCA measures the benefits against the costs throughout a period of analysis beginning at the start of construction and including 30 years of the post-construction period.

The methodology makes several important assumptions and seeks to avoid overestimation of benefits and underestimation of costs. Specifically:

- Input prices, or monetary input assumptions, are expressed in 2017 dollars;
- All benefits and costs are discounted to 2018;
- The period of analysis for the project begins in 2020 and ends in 2054. It includes project design and development phase (currently ongoing), project construction over (2020-2024), and 30 years of post-construction period (2025-2054);
- Demand impacts are fully realized in the first year of station closure (or avoided closure) without a ramp-up; and
- A constant 7 percent real discount rate is assumed throughout the period of analysis, and a 3 percent rate is used for sensitivity.

General assumptions used for the entire BCA analysis mentioned above for the Project are also provided in Table 3 below.

Table 3. General Assumptions Used in the Analysis

Variable Name	Unit	Value	Source
Real Discount Factor	%	7%	USDOT BCA Guidance
Base Year of Analysis	year	2018	Year to which all cash flows are discounted for the NPV
Project Development and Construction	year	2020 - 2024	According to Project Schedule

Variable Name	Unit	Value	Source
First Year of Benefits	year	2025	According to Project Schedule
Years of Benefits	years	30	Assume 30 years of benefits
End Year of Benefits	year	2054	Calculated Value
Grams per Short Ton	grams	907,185	Known
Feet per Mile	feet/mile	5,280	Known
Days per Year	days/year	365	
Hours per Day	hours/day	24	

6 Demand Projections

When quantifying the benefits of transportation infrastructure improvements, current and future traffic or travel demand using the infrastructure being improved needs to be analyzed and quantified.

In the case of this proposed project, the traffic and/or travel affected include the following:

- Autos and trucks passing through the 3rd Street NE Bridge;
- Freight trains travelling in the rail corridor (operated by BNSF) together with cargo they are carrying; and
- Passenger trains (Amtrak's Empire Builder service) and passengers boarding or detraining in North Dakota, Montana, Idaho, or passing through those states.

Assumptions regarding current traffic for each of these traffic components were made based on published data sources. Assumptions regarding future traffic were made either on the basis of existing published projections and/or analysis of recent trends. In cases where data for a current year and a future year (i.e. future projections) were available, values of traffic between those years were interpolated assuming the same growth trend throughout the analysis period. In situations when recent related trends did not support expectations of significant future growth, a zero growth or only modest growth rate was assumed.

It is noted that rail passenger traffic taking into account in this analysis includes passengers boarding and detraining in Minot as well as in other location in North Dakota and beyond the state. This is because a flood event near Minot resulting in service suspension and/or rerouting of trains will also affect other passengers along the route.

Table 4 below provides a summary of assumptions used in the quantification of demand and traffic on the infrastructure which is the subject of this analysis together with sources and comments pertaining to reasons behind key assumptions.

Table 4: Assumptions Used in the Estimation of Traffic Volumes

Variable Name	Unit	Value	Source
3rd St NE Bridge			
2017 Average Daily Traffic Counts Using 3rd St NE Bridge	ADT	9,000	National Bridge Inventory and NDDOT data.
2037 Average Daily Traffic Count Forecast Using 3rd St NE Bridge	ADT	9,500	National Bridge Inventory.

Variable Name	Unit	Value	Source
Truck Percent Share in the Traffic	%	1%	National Bridge Inventory and NDDOT data.
Bridge Length	feet	912	National Bridge Inventory provides structure length of the roadway bridge.
Vehicle Detour Length if Bridge Closed Due to Flooding - No Build	miles	3	NBI Inventory provides info on detour length in miles for the case when bridge is closed. It is assumed the detour length is the same in the case of a flooding event.
Vehicle Speed Over the Roadway Bridge	mph	25	Speed Limit for 3rd St NE Bridge
Vehicle Speed On the Detour Road	mph	30	Speed Limit for N Broadway Road
Rail Bridge			
Freight Rail Operating Days	days/year	365	Assumed
Rerouted Daily Train Counts During A Flood Event	trains/day	30	North Dakota DOT, 2040 North Dakota State Rail Plan, 2017. Calculated through, inbound, outbound and intra freight rail composition based on North Dakota rail traffic as follows: 48% through trains, 48% outbound trains, 8% inbound trains and 3% intra trains. Assumed through trains and 50% of the rest of the traffic will be rerouted, 50% of the rest of the traffic will be cancelled during a flooding event.
Cancelled Daily Train Counts During A Flood Event	trains/day	10	
Annual Freight Train Volume Growth	%	1%	ND State Rail Plan document retrieved data from FAF which supports this assumption.
Incremental Detour Length per Train Trip During a Flooding Event	miles	400	Assumed. Given the current network density, some train trips may require long detours with significant impact on total trip length and causing significant delays throughout the network.
Train Speed	mph	20	Assumed. Operating speeds on the remaining network may be reduced due to increased congestion.
Freight Tons per Carload	tons/car	50	2040 North Dakota State Rail Plan, BNSF Statistics. Adjusted for empty returning train hauls.
Carloads per Train	cars/train	100	Based on industry experience regarding trains operating in the area.
Amtrak Annual Operating Days	days/year	365	Assumed
Annual Growth of Passenger Volume	%	0%	Assumed no growth in passenger volumes
Passenger Volume Impacted During A Flooding Event; Network Impacts	passengers/annual equivalent	199,387	Based on news reports Amtrak cancelled services between St Paul and Spokane after the flooding event in 2011. Amtrak 2018 statistics show passengers boarding or detraining in ND of 103,200 and 88,599 who were boarding and detraining outside the state. In Montana there were some additional passengers increasing total number of passengers affected: 121,400 that were boarding/detraining in Montana and 77,987 that were boarding detraining in other states.
Passenger Volume Impacted During A Flooding Event; Minot Impacts	passengers/annual equivalent	29,531	Based on 2018 Amtrak ridership for Minot.

7 Estimation of Economic Benefits / Merit Criteria Outcomes

This section describes the measurement approach used for each quantifiable benefit or impact category listed in Table 2 and provides an overview of the associated methodology, assumptions, and benefit estimates. Certain benefits of the project are difficult to estimate in quantitative terms due to data limitations or lack of well-established measurement metrics. These benefits are addressed in qualitative terms.

The benefits of the proposed project as it relates to improved infrastructure resiliency in the event of flooding were estimated on the basis of disruptions and costs incurred by various infrastructure users during the historical flood of 2011 as reported in the news and corporate communications, as well as earlier flood events, and understanding how operations would be affected by floods of various magnitude. It is assumed that the proposed project would help reduce the disruptions in the event of flooding. The disruption cost avoided represents then the benefit of the proposed project. In particular, the following impacts of the 2011 flood event were identified:[1]

- Suspension of BNSF freight rail services. BNSF did not provide direct information about the length and extent of suspended services and incurred delays. Based on the news reports and BNSF service advisories, both main tracks were closed to traffic on June 24, 2011 and re-opened on July 6, 2011. However, traffic was slow due to soft track and some subdivisions were still closed. Delays continued for at least another week. During the flood, some traffic was rerouted but some customers did not have access to services at all.[2] For the purpose of this analysis, it was assumed that suspension of services lasted for 22 days.
- Suspension of Amtrak passenger rail services (the Empire Builder long distance train service). Amtrak did not provide directly information about the length and impact of suspension. Based on information gathered from news reports, Amtrak suspended operations of the Empire Builder between St. Paul, Minnesota, and Spokane, Washington, on June 1, 2011, and disruptions continued until mid-July 2011. In addition, Minot passengers could not be served until mid-November 2011 due to damage to platform and station building in Minot. For the purpose of this analysis, it was assumed that suspension of passenger rail services lasted for 45 days with an additional closure of services to Minot passenger for 120 days.[3]
- Infrastructure repair costs related to rail track restoration. In a 2011 fact sheet information, Amtrak reported that in that year it placed procurement contracts in Minot of about $4.8 million, and that restoration of segments of BNSF tracks after the 2011 flood event would cost about $20 million. For the purpose of this analysis, infrastructure repair costs were assumed at $24.8 million. This cost was inflated to 2017 dollars.

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[1] It is noted that certain information regarding the disrupted operations, length of disruptions, and costs incurred was not provided by the affected parties. In such instances, assumptions required for the quantification of benefits and impacts were made on the basis of news releases, published statistical data, related industry practice and previous project experience.

[2] For reference see https://domino.bnsf.com/website/updates.nsf/31ade8f1bd8ec8c786256b030057f790/1f11448f86234f95862578cc005d175d?OpenDocument (accessed July 2019).

[3] Amtrak Fact Sheet, Fiscal year 2011, State of North Dakota, http://miprc.org/Portals/7/pdfs/NORTHDAKOTA11.pdf (accessed July 2019).

- Closure of 3rd Street NE Bridge. The City of Minot provided information that during the 2011 flood the bridge was closed for 15 days. However, there were no significant repair costs to the bridge after waters receded. For the purpose of this analysis, bridge closure was assumed at 15 days with no flood-related repair costs.

The annual probability of another flood like that in 2011 is rather small. However, the project will also provide protection against less severe floods. These may have lower disruption costs but a greater probability of occurrence. The economic evaluation of flood mitigation projects has to take into account these benefits as well and aggregate them across all probability levels. Section 7.1 outlines the approach and key assumptions adopted to achieve this objective. Section 7.3 to 7.5 outline the methodology used in the evaluation of individual benefits that feed into this approach. Section 7.2 presents the methodology of estimation of safety benefits due to improved 3rd Street NE bridge. This benefit is not related to flooding events but, rather, to bridge design.

7.1 General Approach to Economic Analysis of Flood Events

To assess the repair cost savings as well as the economic competitiveness benefits of this project, impacts of flooding events on the condition of the infrastructure and impact on traffic using it have to be considered in-depth. In general, during a severe flood event, the 3rd Street NE Bridge can be expected to be closed and rail services (both passenger and freight) suspended. Some repairs to the infrastructure may then be required. Based on the experience during the 2011 floods, some freight trains may be rerouted, and some shippers may lose freight rail service altogether. Passenger trains may be cancelled altogether until the condition of the tracks improves and allows safe operations. The duration and thus the extent of these impacts will depend on the severity of flooding.

The US Geological Survey conducted studies of the hydrological conditions in the Minot area and developed estimates of annual exceedance probability of various levels of flooding – expressed in terms of cubic feet of water per second (cfs) – that are likely to persist for at least another 25 years.[4]

The project engineering team in consultation with BNSF established a flood level at which the railroad would suspend the operations which amounts to 10,000 cfs (or about 0.5 feet of water above rail tracks). Taking into account what happened in 2011 at the level of flooding of 26,900 cfs and the number of days that rail service was suspended and delayed (as outlined above in the introduction to Section 7), the engineering team assessed likely delays and service suspension at other levels of flooding for the conditions with the project and without the proposed project.

The other impacts of flood events such as suspension of passenger rail services and infrastructure repair costs were then extrapolated from the actual impact in 2011 in the same proportion as the impact on freight rail suspension. The results are shown in the table below. The column highlighted in yellow represents the level of flooding that actually occurred in 2011. As the table shows, with the project the flood-related disruptions and costs would be reduced.

[4] U.S. Department of the Interior, U.S. Geological Survey, "Stochastic Model for Simulating Souris River Basin Regulated Streamflow Upstream from Minot, North Dakota", Scientific Investigations Report 2018-5155, in particular Table 7, Condition A (Wet Equilibrium).

Table 5: Assumptions Regarding Disruptions and Infrastructure Repair Costs at Various Levels of Flooding, With Project and Without

Flow Rate	10,000	11,150	15,650	17,300	20,900	26,900	29,200
Annual Exceedance Probability	2.72%	2%	1%	0.74%	0.50%	0.26%	0.20%
IMPACTS - CONDITIONS WITHOUT PROJECT							
Outage Duration, Freight Rail (days)	0	1	7	10	14	22	25
Outage Duration, Passenger Rail (days)	0.0	2.0	14.3	20.5	28.6	45.0	45.0
Minot Passenger Rail Service Suspension	0.0	5.5	38.2	54.5	76.4	120.0	136.4
Closure of 3rd Street NE Bridge (days)	0	1	5	7	10	15	17
Repair Costs ($M)	$0.0	$1.2	$8.7	$12.4	$17.4	$27.3	$31.0
IMPACTS – CONDITIONS WITH PROPOSED PROJECT							
Outage Duration, Freight Rail (days)	0	0	0	0	4	12	15
Outage Duration, Passenger Rail (days)	0.0	0.0	0.0	0.0	8.2	24.5	27.0
Minot Passenger Rail Service Suspension	0.0	0.0	0.0	0.0	21.8	65.5	81.8
Closure of 3rd Street NE Bridge (days)	0	0	0	0	3	8	10
Repair Costs ($M)	$0.0	$0.0	$0.0	$0.0	$5.0	$14.9	$18.6

The next step in the methodology involved then estimation of the freight and service suspension impacts per 1 day which were then used to convert days of service suspension impacts into monetary costs so as to create a cost table of impacts at various levels of flooding. The approach and assumptions used in the estimation of these disruption costs per 1 day are presented in Section 7.4.

The hydro-economic model methodology was then used to calculate expected damages at various flood intervals of exceedance probability and derive the average annual damage cost without the project and with the project. The difference between the two is then the average annual damage prevented due to the project. Present value of this damage cost prevented aggregated over the analysis period is then the benefit of the project that can be evaluated against project costs.[5]

7.2 Safety Benefits

The proposed Project would contribute to promoting USDOT's safety merit outcome through (1) accident reductions as a result of 3rd Street NE Bridge upgrade and improvements in its geometry, (2) avoidance of additional vehicle miles of auto and truck travel during flood events, as well as by (3) making the 3rd Street NE Bridge, the rail bridge, and rail tracks more resilient, or robust, in flooding events.

This analysis focuses on the first component which is likely to be most significant and quantifiable impact. Historical crash data by severity type on the impacted road intersections with the bridge was retrieved from the City of Minot and converted to a crash rate under the No Build Scenario. A Crash Modification Factor was then applied to obtain the crash rate under the Build scenario. Crash rates are then applied to annual traffic volumes to calculate the number of accidents by type (injuries, and property damage only (PDO)

[5] The methodology adopted follows that presented in United States Army Corps of Engineers and Institute of Water Resources, "Flood Risk Management", IWR Report 2013-R-05, June 2013, Section 2.7.

accidents). Injuries and property damages are then monetized using the unit values of accident costs recommended by USDOT. The difference in total accident costs between No Build scenario and Build scenario represents the safety benefits of the project.

The assumptions used in the estimation of safety benefits are summarized in the table below.

Table 6: Assumptions used in the Estimation of Safety Outcomes

Variable Name	Unit	Value	Source
Injury Crashes per Year	crashes/year	0.60	2014 - 2019 crash data within impacted intersections retrieved from the City of Minot. Average taken to get number of crashes per year. Assume constant crash data over the study period
Property Damage Only (PDO) Crashes per year	crashes/year	3.00	
Crash Modification Factor	crash improvement	0.98	CMF Clearing House. CMF 9398: widen managed lane envelope.
Injury Rate	injuries/injury crash	1.50	Number of injuries involved divided by total injury crashes, 2014-2019 crash data retrieved from City of Minot
Property Damage Rate	vehicles/PDO crash	1.60	Number of cars involved divided by total PDO crashes, 2014-2019 crash data retrieved from City of Minot
Average Cost per Accident Injury	2017$/injury	$174,000	US DOT, BCA Guidance 2018. Based on MAIS Injury Severity Scale and KACBO-AIS Conversion if Injury Unknown. Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses (2016).
Average Cost per Vehicle for PDO Crashes	2017$/vehicle	$4,300	US DOT, BCA Guidance 2018. The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (revised May 2015), Page 12, Table 1-2, Summary of Unit Costs, 2000. Value inflated to 2017 dollars.

7.3 State of Good Repair

The state of good repair benefits are designed to capture benefits from maintaining infrastructure in good condition. This is captured through repair cost savings in case of a flood event and the residual value of assets at the end of the analysis period.

7.3.1 Repair Cost Savings

Transportation infrastructure may suffer significant damage in flood events and require costly repairs after flood waters recede. The proposed project will strengthen the infrastructure in question and make it more resilient, more likely to withstand future flood event without significant damage.

Based on information provided by the City of Minot, the 3rd St NE Bridge did not suffer any significant damage during the 2011 flood. However, Amtrak reported that it had to spend nearly $5 million for repairs to station building and platform in Minot and that it cost another $20 million to restore sections of BNSF track.[6]

[6] Amtrak Fact Sheet, Fiscal Year 2011, State of North Dakota, http://miprc.org/Portals/7/pdfs/NORTHDAKOTA11.pdf

Under the Build scenario, these repair costs would be avoided. The annual benefits of the Build scenario were thus estimated as the average annual damage avoided using the methodology outlined in Section 7.1.

7.3.2 Residual Value of Assets

Residual value of the infrastructure being improved in the Build scenario (3rd Street NE Bridge, the rail bridge and tracks) at the end of the study period was calculated using straight line depreciation methodology.

The assumptions used in the estimation of residual value of assets are summarized in the table below.

Table 7: Assumptions used in the Estimation of State of Good Repair Outcomes

Variable Name	Unit	Value	Source
Roadway Bridge Useful Life	years	50	Assumed
Rail Bridge Useful Life	years	50	Assumed
Rail Bridge Repair Cost After a Flooding Event	2017$	$27,337,710	Assumed value. Based on Amtrak Fact Sheet 2011 for North Dakota, the costs to restore segments of BNSF tracks amounted to $20 million. Amtrak spent about $4.9 million to restore station building and platform in Minot. Inflated to 2017 dollars.

7.4 Economic Competitiveness

Based on the BUILD NOFO, the economic competitiveness criterion captures impacts of the project on the movement of goods and people, including impacts on the efficiency or costs of these movements, freight connectivity to the national and global economy, and contribution to the functioning and growth of the economy. This project is well aligned with this criterion by helping avoid various disruptions in the movement of people and goods during flood events and resulting economic costs.

The benefits were categorized along the mode and type of impact that will be mitigated and follow categorization shown in Table 2.

7.4.1 Avoided Freight Train Delays

Freight trains will be impacted by the suspension of rail services (closure of the rail bridge and tracks) as a result of a flooding event. Freight trains to and/or from Minot, North Dakota, as well as trains passing through need to be rerouted in order to complete scheduled deliveries which causes delays.

BNSF did not provide information as to the length of detours, or trains affected. Examining the structure of the network, it seems that the detour would have to be fairly lengthy in the order of a few hundred miles. BNSF also reported around the time of the 2011 flood that many customers could expect delays of 12 to 20 hours.[7] These delays generate costs to both the railroad operating the trains and to the shippers and receivers of freight.

[7] BNSF Service Advisory, July 7, 2011, https://domino.bnsf.com/website/updates.nsf/65ec0c1801b3db3c86256b030057f78f/0d847f3ca13d6269862578c60050b6d4?OpenDocument (accessed July 2019)

The cost of train delays to the railroad are quantified on the basis of the assumed detour length, train speed, and train operating cost per hour. This is then multiplied by the number of affected/detoured trains per day to give the total cost of delays per day.[8]

The cost of freight delays to shippers and receivers is more challenging to quantify. It is well understood that delays in freight deliveries can lead to various disruptions throughout the logistics and production chain. However, there is a lack of a well-established methodology to capture these effects. At a minimum, the shipper will likely incur a delay in the payment for goods received. Therefore, for the purpose of this BCA, the costs of freight delays to shippers was estimated as an inventory cost, or the opportunity cost of delayed payment on the basis of the average value of freight per ton, interest rate for the delay period, and tonnage of freight carried by a typical train.

The specific assumptions used in the estimation of the above benefits are summarized in Table 8 below. It is noted that the "2040 North Dakota State Rail Plan" was used to help formulate some key assumptions regarding how many and which trains will be rerouted and how many would be cancelled (as specified in Table 4). The Federal Highway Administration Freight Analysis Framework database was used to establish the average value of goods shipped by rail in North Dakota.

The assumption used for the estimation of daily freight shipment delay outcomes are shown in Table 8.

Table 8: Assumptions used in the Estimation of Freight Shipment Delay Outcomes

Variable Name	Unit	Value	Source
Operating Cost of Freight Train Delay	2017$/hour	$592	Estimated cost of freight train delay by AAR. $175/hour for locomotives, $146 for freight cars and $284/hour for locomotive crew, based on Class I railroad average for 2018. Value de-escalated to 2017$.
Average Value of Freight	2017$/ton	$506	FAF shipment values for within, outbound and inbound U.S. states, 2017. Average of domestic, import and export shipment values within outbound and inbound of Minot, ND chosen.
Freight Inventory Cost of Train Delay	$/day per train	$693	Calculated as the daily opportunity cost of train payload value based on a 10% rate.
Incremental Detour Time per Train Trip	hours/trip	20	Calculated Value given assumed incremental detour length and travel speed.

7.4.2 Avoided Loss of Train Services

The methodology of quantification of the impacts of suspended train services differ somewhat depending whether they refer to freight trains or passenger trains. This is discussed in some detail below.

<u>Freight Trains</u>

Some freight trains going through Minot, in particular those with an origin or destination in the Minot area, may be cancelled during a flood event. The shippers and receivers of freight would lose access to services.

The economic cost of such event is challenging to quantify. For shippers, such stoppage of service may imply costly storage until service is available, more costly alternative transportation arrangements, or even

[8] It is noted that this is a conservative approach as it focuses only on the trains affected directly. Rerouted trains may also cause delays and costs throughout the network. These effects are not quantified for the purpose of this BCA.

loss of revenue if the goods are no longer needed after a certain time. For receivers of freight, such stoppage may imply additional costs related to finding alternative supplies, as well as a loss of own revenue. Although the significance of these effects is generally acknowledged, there is a lack of a well-established methodology to quantify them. For the purpose of this BCA, this cost is estimated on the basis of the average value of goods shipped ($/ton).

Passenger Trains

Based on the experience with the 2011 flood in Minot, it can be expected that Amtrak would suspend the operations of passenger trains passing through Minot, the Empire Builder route.

Passengers who lost service may respond in different ways, including to postpone the travel, cancel it altogether, or travel by some alternative mode. A guide for flood risk management and analysis suggests the latter option as the quantification of traffic disruptions costs caused by flooding. The increased costs and resources to access the alternative mode of transportation option provides then a measure of the disruption costs.[9] Given that the average trip length on the Empire Builder amounts to over 600 miles, the most realistic alternative mode of travel is air.[10] The difference between the average air fare and average train fare will then provide an estimate of the disruption cost per passenger. The cost per passenger multiplied by the number of passengers affected will then provide total disruption cost.

The assumptions used in the estimation of avoided lost train services are summarized in Table 9 below. As for the previous benefits quantification of avoided freight train delays, the “2040 North Dakota State Rail Plan” was used to help formulate some key assumptions regarding how many and which trains would be cancelled. The Federal Highway Administration Freight Analysis Framework database was used to establish the average value of goods shipped by rail in North Dakota. Average Amtrak train fare was determined based on published ridership statistics, average air fare was assumed based on a sample of destinations covered by the Empire Builder.[11]

The assumption used for the estimation of daily lost train service outcomes are shown in Table 9.

Table 9: Assumptions used in the Estimation of Lost Train Service Outcomes

Variable Name	Unit	Value	Source
Average Fare on Amtrak Empire Builder, 2018	$/passenger	$120.3	Amtrak Fact Sheet for Empire Builder Service, 2018. Adjusted to 2017 dollars.
Cost of Alternative Mode (Air)	$/passenger	$290.9	Assumption based on a sample of air fares to destinations covered by Amtrak Service (about $300 per trip). Adjusted to 2017 dollars.
Value of Lost Empire Builder Train Service	2017$	$171	Calculated value.

[9] United States Army Corps of Engineers and Institute of Water Resources, “Flood Risk Management”, IWR Report 2013-R-05, June 2013.

[10] Based on Amtrak fact sheets.

[11] Air fares may differ depending on many factors, including time of travel, direct or non-stop flight, time of booking, conditions of the fare, trip destination, etc. However, shorter destinations may not necessarily be significantly less expensive than longer routes. Also, air service may not be available directly to some destinations requiring travelers to incur additional costs such as car rentals, or taxi, to reach those destinations.

Variable Name	Unit	Value	Source
Distance to Next Closest Train Station from Minot (Stanley, ND)	miles	54	Based on Amtrak passenger train schedule.
Auto Travel Time from Minot to Stanley, ND	hours	1.00	Assumed based Google maps driving directions.
Vehicle Operating Costs - Passenger Car	2017$/VMT	$0.39	US DOT, 2018 BCA Guidance on recommended vehicle operating costs per mile for light duty vehicles.
Incremental Cost of Using Amtrak Services to Minot Passengers	$/passenger	$33	Calculated value.
Average Value of Freight	2017$/ton	$506	FAF shipment values for within, outbound and inbound U.S. states, 2017. Average of domestic, import and export shipment values within outbound and inbound of Minot, ND chosen.

7.4.3 Operating Cost Savings to Roadway Traffic

During a flood event in Minot, the 3rd Street NE Bridge may be closed for safety reasons. Traffic that usually uses the bridge will be rerouted resulting in a longer trip distance and thus vehicle operating costs.

Detour distances travelled by passenger cars and trucks were multiplied by respective operating unit costs ($/vehicle mile) and volume of vehicles to obtain total vehicle operating costs impact.

The assumptions used in the estimation of daily operating cost saving outcomes are summarized in Table 10.

Table 10: Assumptions used in the Estimation of Operating Cost Saving Outcomes

Variable Name	Unit	Value	Source
Vehicle Operating Costs - Passenger Car	2017$/VMT	$0.39	US DOT, 2018 BCA Guidance on recommended vehicle operating costs per mile for light duty vehicles.
Vehicle Operating Costs - Truck	2017$/VMT	$0.90	US DOT, 2018 BCA Guidance on recommended vehicle operating costs per mile for commercial trucks. American Transportation Research Institute, An Analysis of the Operational Costs of Trucking: 2017 Update.

7.4.4 Travel Time Savings to Roadway Traffic

During a flood event in Minot, the 3rd Street NE Bridge may be closed for safety reasons. Traffic that usually uses the bridge will be rerouted resulting in a longer trip distance and thus travel time.

Detour distances travelled by passenger cars and trucks were divided by average speed (assumed to be the speed limit) multiplied by value of travel time savings and volume of vehicles to obtain total travel time savings impact.

The assumptions used in the estimation of daily travel time saving outcomes are summarized in table below.

Table 11: Assumptions used in the Estimation of Travel Time Saving Outcomes

Variable Name	Unit	Value	Source
Auto Occupancy	persons/vehicle	1.68	US DOT, 2018 BCA Guidance and Federal Highway Administration Highway Statistics 2016, Table VM1.
Truck Occupancy	persons/vehicle	1.00	
Value of Time for Automobile Driver and Passenger	2017$/h	$16.10	US DOT, 2018 BCA Guidance on recommended hourly value of travel time savings, based on Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis.
Value of Time for Truck Driver	2017$/h	$28.60	

7.4.5 Other Benefits

Other benefits of this project which are difficult to quantify due to data gaps and a lack of well-established metrics and methodologies include the following:

- Improved bridge resiliency and reliability

The Project will reconstruct the 3rd Street NE Bridge and the rail bridge to strengthen their resiliency when facing extreme weather events. The Project allows both bridges to remain operational during a flooding event, which improves the reliability of the roadway bridge and rail services.

- Improved economic performance of freight receivers

The Project ensures on-time freight deliveries by rail during flood events. As a result, freight shippers and receivers will be able to maintain operations without any disruptions and avoid any potential economic costs associated with delayed freight shipments.

- Improved freight rail operating flexibility

The Project will elevate the 3rd Street NE Bridge which will increase the clearance between this bridge and the BNSF rail bridge. This may give freight rail operators greater operating flexibility with respect to the type of trains operated in the future, including trains that require a certain height clearance. This will then improve the operating efficiency of freight rail in the region.

7.5 Environmental Sustainability

The Project generates a net reduction in carbon dioxide and criteria air contaminants as a result of avoided automobile detour route.

The automobile travel distances for No Build and Build Cases are used to estimate the total emissions released. The vehicle miles are multiplied by the appropriate emission factors for tons of nitrogen oxides (NOx), volatile organic compounds (VOC), particulate matter (PM), sulfur dioxide (SO2) and carbon dioxide (CO2) emitted per year. Emission factors are based on average vehicle movements across the US. Each pollutant, measured in tons, is then multiplied by its monetary value to get the total emission costs, which is then adjusted to reflect the likelihood of a flooding event. The change in total emission cost between No Build and Build Cases indicates the total avoided emission benefits.

The assumptions used in the estimation of daily environmental sustainability outcomes are summarized in Table 12 to Table 15 below.

Table 12: Passenger Car Emission Factors

Passenger Car Emissions (grams/mile)					
Year	NO_X	VOC	PM2.5	SO_2	CO_2
2020	0.1984	0.0419	0.0044	0.0052	337
2021	0.1726	0.0365	0.0042	0.0047	328
2022	0.1467	0.0310	0.0039	0.0041	319
2023	0.1209	0.0256	0.0036	0.0036	310
2024	0.0951	0.0201	0.0033	0.0030	300
2025	0.0434	0.0092	0.0027	0.0019	282
2026	0.0407	0.0087	0.0027	0.0018	276
2027	0.0379	0.0083	0.0026	0.0018	270
2028	0.0351	0.0078	0.0025	0.0018	264
2029	0.0324	0.0073	0.0024	0.0017	258
2030	0.0296	0.0068	0.0023	0.0017	252
2031	0.0268	0.0063	0.0022	0.0016	246
2032	0.0241	0.0058	0.0021	0.0016	241
2033	0.0213	0.0053	0.0020	0.0016	235
2034	0.0186	0.0048	0.0020	0.0015	229
2035	0.0130	0.0039	0.0018	0.0015	217
2036	0.0126	0.0038	0.0018	0.0014	216
2037	0.0122	0.0037	0.0017	0.0014	215
2038	0.0118	0.0036	0.0017	0.0014	214
2039	0.0114	0.0035	0.0017	0.0014	214
2040	0.0111	0.0035	0.0017	0.0014	213
2041	0.0107	0.0034	0.0017	0.0014	212
2042	0.0103	0.0033	0.0017	0.0014	211
2043	0.0099	0.0032	0.0017	0.0014	210
2044	0.0095	0.0032	0.0016	0.0014	209
2045	0.0087	0.0030	0.0016	0.0014	208
2046	0.0087	0.0030	0.0016	0.0014	208
2047	0.0087	0.0030	0.0016	0.0014	208
2048	0.0087	0.0030	0.0016	0.0014	208
2049	0.0087	0.0030	0.0016	0.0014	208
2050	0.0087	0.0030	0.0016	0.0014	208
2051	0.0087	0.0030	0.0016	0.0014	208
2052	0.0087	0.0030	0.0016	0.0014	208
2053	0.0087	0.0030	0.0016	0.0014	208
2054	0.0087	0.0030	0.0016	0.0014	208
Source/Comment					
Based on MOVES average annual emissions factors for passenger cars assuming speed of 25 mph. MOVES model run in June 2018.					

Table 13: Truck Emission Factors

Truck Emissions (grams/mile)					
Year	NO_X	VOC	PM2.5	SO_2	CO_2
2020	4.5677	0.3514	0.2413	0.0143	1,682
2021	4.1682	0.3161	0.2155	0.0142	1,672
2022	3.7686	0.2808	0.1897	0.0140	1,663
2023	3.3691	0.2455	0.1639	0.0139	1,653
2024	2.9695	0.2101	0.1382	0.0138	1,643
2025	2.1705	0.1395	0.0866	0.0136	1,623
2026	2.0906	0.1329	0.0816	0.0136	1,620
2027	2.0108	0.1263	0.0766	0.0135	1,617
2028	1.9309	0.1197	0.0716	0.0135	1,614
2029	1.8511	0.1131	0.0665	0.0135	1,612
2030	1.7712	0.1065	0.0615	0.0134	1,609
2031	1.6914	0.0999	0.0565	0.0134	1,606
2032	1.6115	0.0933	0.0515	0.0134	1,603
2033	1.5317	0.0867	0.0464	0.0134	1,600
2034	1.4518	0.0801	0.0414	0.0133	1,597
2035	1.2921	0.0669	0.0314	0.0133	1,591
2036	1.2878	0.0666	0.0312	0.0133	1,591
2037	1.2835	0.0664	0.0310	0.0133	1,591
2038	1.2793	0.0662	0.0308	0.0133	1,590
2039	1.2750	0.0660	0.0306	0.0133	1,590
2040	1.2707	0.0657	0.0305	0.0133	1,589
2041	1.2664	0.0655	0.0303	0.0132	1,589
2042	1.2621	0.0653	0.0301	0.0132	1,589
2043	1.2578	0.0651	0.0299	0.0132	1,588
2044	1.2535	0.0648	0.0297	0.0132	1,588
2045	1.2449	0.0644	0.0294	0.0132	1,587
2046	1.2449	0.0644	0.0294	0.0132	1,587
2047	1.2449	0.0644	0.0294	0.0132	1,587
2048	1.2449	0.0644	0.0294	0.0132	1,587
2049	1.2449	0.0644	0.0294	0.0132	1,587
2050	1.2449	0.0644	0.0294	0.0132	1,587
2051	1.2449	0.0644	0.0294	0.0132	1,587
2052	1.2449	0.0644	0.0294	0.0132	1,587
2053	1.2449	0.0644	0.0294	0.0132	1,587
2054	1.2449	0.0644	0.0294	0.0132	1,587
Source/Comment					
Based on MOVES average annual emissions factors for trucks assuming speed of 25 mph. MOVES model run in June 2018.					

Table 14: Environmental Damage Costs for Green House Gas (GHG) Emissions

Year	Value
2020	$0.91
2021	$0.91
2022	$0.91
2023	$0.91
2024	$0.91
2025	$0.91
2026	$0.91
2027	$0.91
2028	$0.91
2029	$0.91
2030	$0.91
2031	$1.09
2032	$1.27
2033	$1.45
2034	$1.63
2035	$1.81
2036	$1.81
2037	$1.81
2038	$1.81
2039	$1.81
2040	$1.81
2041	$1.81
2042	$1.81
2043	$1.81
2044	$1.81
2045	$1.81
2046	$1.81
2047	$1.81
2048	$1.81
2049	$1.81
2050	$1.81
2051	$1.81
2052	$1.81
2053	$1.81
2054	$1.81
Source/Comment	
US DOT, BCA Guidance December 2018; The Safer Affordable Fuel-Efficient Vehicles Rule for MY2021-MY2026 Passenger Cars and Light Trucks Preliminary Regulatory Impact Analysis (October 2018)	

Table 15: Environmental Damage Costs for Criteria Air Contaminate (CAC) Emissions

Pollutant	Value (2020-2054)
Nitrogen oxides (NOx)	$8,300
Volatile Organic Compounds (VOCs)	$2,000
Particulate matter (PM)	$377,800
Sulfur dioxide (SO_2)	$48,900
Source/Comment	
US DOT, BCA Guidance December 2018; The Safer Affordable Fuel-Efficient Vehicles Rule for MY2021-MY2026 Passenger Cars and Light Trucks Preliminary Regulatory Impact Analysis (October 2018)".	

8 Summary of Findings and Benefit-Cost Outcomes

The Benefit Cost Analysis (BCA) was conducted for this project by assessing damage costs that could occur at flood events of various extent (with the project and without) and estimating the average annual damage cost. Reduced average annual damage cost with the project constitutes then a benefit of the project. The damage costs analyzed include the following:

- Suspension and disruptions to freight train services with resulting freight train operating delay costs, delay costs to shippers and receivers of freight, and loss of access to transportation services to some shippers and receivers of freight;
- Suspension and disruptions of passenger train services and loss of access to passenger rail transportation;
- Repair costs to rail bridge, tracks, and rail station; and
- Closure of 3rd Street NE Bridge forcing bridge users to use a detour, and resulting in additional travel time costs, operating costs, and emission costs.

Other evaluated benefits include safety benefits due to upgraded bridge design and the residual value of project assets.

Table 16 summarizes the BCA findings. Annual costs and benefits are computed over the lifecycle of the project over the years 2020-2054 which include five years of construction and 30 years of post-construction period. Benefits accrue after the project is completed over the years 2025-2054.

Table 16: Overall Results of the Benefit Cost Analysis, in Millions of 2017$*

Project Evaluation Metric	Undiscounted	Discounted at 7%	Discounted at 3%
Total Benefits	$175.8	$42.9	$90.2
Total Costs	$73.5	$56.1	$65.3
Net Present Value	**$102.3**	**-$13.2**	**$25.0**
Benefit / Cost Ratio	**2.39**	**0.76**	**1.38**
Internal Rate of Return (%)	5.1%		
Payback Period (years)	14.1	>30 yrs	21.1

** Unless Specified Otherwise*

Considering all monetized benefits and costs, the estimated internal rate of return of the project is 5.1 percent. The $73.5 million investment (in constant 2017 undiscounted dollars) would result in $42.9 million in total benefits discounted at a 7 percent real discount rate, and a Benefit/Cost ratio of approximately 0.76. With a 3 percent discount rate, the investment would result in $90.2 million in total benefits, $25 million net present value, and a benefit-cost ratio of 1.38.

Table 17 shows the BCA outcomes for the rail bridge and tracks only (i.e. excluding the 3rd Street NE Bridge component of this project). The table shows that the $48.5 million investment (in constant 2017 undiscounted dollars) would result in $42 million in total benefits, $5.6 million net present value – all discounted at a 7 percent discount rate – and a benefit-cost ratio of 1.15.

Table 17: Results of the Benefit Cost Analysis, in Millions of 2017$* - Rail Bridge Only

Project Evaluation Metric	Undiscounted	Discounted at 7%	Discounted at 3%
Total Benefits	$165.6	$42.0	$86.7
Total Costs	$48.5	$36.4	$42.8
Net Present Value	**$117.1**	**$5.6**	**$43.9**
Benefit / Cost Ratio	**3.42**	**1.15**	**2.03**
Internal Rate of Return (%)	8.2%		
Payback Period (years)	8.9	17.3	11.8

** Unless Specified Otherwise*

Table 18 shows the BCA outcomes for the 3rd Street NE Bridge only. The table shows that the $25 million investment (in constant 2017 undiscounted dollars) would result in $0.9 million in total benefits, -$18.8 million net present value – all discounted at a 7 percent discount rate – and a benefit-cost ratio of 0.05.

Table 18: Results of the Benefit Cost Analysis, in Millions of 2017$* - 3rd St NE Bridge

Project Evaluation Metric	Undiscounted	Discounted at 7%	Discounted at 3%
Total Benefits	$10.2	$0.9	$3.6
Total Costs	$25.0	$19.7	$22.5
Net Present Value	**-$14.8**	**-$18.8**	**-$18.9**
Benefit / Cost Ratio	**0.41**	**0.05**	**0.16**
Internal Rate of Return (%)	-2.7%		
Payback Period (years)	>30 yrs	>30 yrs	>30 yrs

** Unless Specified Otherwise*

Table 19 presents project benefits quantified and monetized by category. The table demonstrates that the vast majority of project benefits (nearly 90 percent of total benefits) are accounted for by avoided disruptions to freight train services. Residual value of assets accounts for about 6 percent of total benefits while savings in infrastructure repair costs account for about 3.3 percent of total benefits. Other benefits evaluated in this BCA are relatively small in magnitude ($0.1 million each or less).

Table 19: Estimates of Monetized Benefits by Merit Criteria Outcomes, in Millions of 2017$

Merit Criteria	Benefit Category	Over the Project Study Period		
		Constant 2017$	Discounted at 7%	Discounted at 3%
Safety	Improved Safety of Road Traffic.	$0.11	$0.03	$0.06
State of Good Repair	Improved Infrastructure Resiliency.	$5.21	$1.44	$2.85
	Residual Value of Assets	$29.38	$2.57	$10.14
Economic Competitiveness	Reduced Freight Train Service Suspension During a Flooding Event.	$139.69	$38.50	$76.44
	Reduced Loss of Passenger Train Services During a Flooding Event - Amtrak Network	$0.92	$0.25	$0.50
	Reduced Loss of Passenger Train Services During a Flooding Event - Amtrak in Minot	$0.35	$0.10	$0.19
	Operating Cost Savings During a Flooding Event.	$0.03	$0.01	$0.02
	Reduced Travel Time During a Flooding Event.	$0.07	$0.02	$0.04
Environmental Sustainability	Reduced Emissions During a Flooding Event.	$0.00	$0.00	$0.00
Total Benefit Estimates		**$175.77**	**$42.92**	**$90.23**

In addition to the above quantified and monetized benefits, the project is expected to generate a range of benefits that are difficult to quantify and monetize due to data limitations and/or lack of well-established metrics for capturing such benefits in a benefit-cost analysis framework. These benefits include the following:

- Greater safety to pedestrians and bicyclists and improved quality of walking and biking experience around the 3rd Street NE Bridge encouraging walk and bicycle use;
- Facilitation of economic development (commercial, retail, residential) around the corridor;
- Providing greater operational flexibility to railroad operators due to greater clearance between the roadway bridge and the railroad bridge, and
- Improved environmental protection by preventing water supply pollution during flooding events.

9 Sensitivity Analysis

The quantitative BCA outcomes presented in the previous section rely on a large number of assumptions and long-term projections; both of which are subject to uncertainty.

The primary purpose of the sensitivity analysis is to help identify the variables and model parameters whose variations have the greatest impact on the BCA outcomes (the "critical variables") and to

- Evaluate the impact of changes in individual critical variables – how much the final results would vary with reasonable departures from the "preferred" or most likely value for the variable; and
- Assess the robustness of the BCA and evaluate, in particular, whether the conclusions reached under the "preferred" set of input values are significantly altered by reasonable departures from those values.

The outcomes of the sensitivity analysis for the Project are summarized in the table below. The table provides the percentage changes in project NPV associated with variations in variables or parameters. Overall, results are primarily driven by impacts on freight train service suspensions. As such, several sensitivity scenarios have been conducted focusing on factors impacting the freight train service suspensions. Specifically, a 25% change in in train suspension time results in a NPV range of -$11.1 million to -$15.1 million and a BCR of 0.7 to 0.8. Moreover, a 2% annual growth of freight train volumes represents a 72.7% change in NPV and a BCR of 0.9.

Changes in upfront capital cost estimates are always a significant driver of BCA results. A 10% change in capital cost estimates results in a 42.5% change in NPV, and a BCR range of 0.7 to 0.8.

Table 20: Assessment of BCA Sensitivity, Summary, in Millions of 2017$*

Original NPV (Discounted at 7%)	Original BCR (Discounted at 7%)	Parameters	Change in Parameter Value	Net Present Value	Change in NPV	New BCR
-$13.2	**0.8**	Capital Costs	10% Reduction in Capital Costs	-$7.6	42.5%	0.8
			10% Increase in Capital Costs	-$18.8	-42.5%	0.7
		Train Service Suspension Days	25% Increase in Suspension Days	-$11.1	15.7%	0.8
			25% Reduction in Suspension Days	-$15.1	-14.5%	0.7
		Annual Freight Train Growth Rate	2% Annual Growth of Freight Train Volumes	-$3.6	72.7%	0.9

** Unless Specified Otherwise*