APPENDIX B: Benefit-Cost Analysis

Benefit-Cost Analysis Supplementary Documentation

TIGER Discretionary Grant Program

ODOT TIGER Grant 2016

Oklahoma Department of Transportation

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Benefit-Cost Analysis Supplementary Documentation

1 Executive Summary

In Oklahoma, railroad crossing safety is a high priority. This is demonstrated by the Oklahoma Department of Transportation's (ODOT) efforts since 2014 to improve railroad/highway grade crossing safety. Since 2014, fifty four (54) crossings have been improved. In support of Federal Railroad Administrator Feinberg's efforts to improve railroad/highway grade crossing safety, ODOT is applying for $6,705,000 in 2016 TIGER Grant funding to improve twenty seven (27) rural railroad crossings to increase safety for its citizens and to promote continued efficient movements of freight along the railroads. The requested 2016 TIGER funds will be matched by ODOT and private railroad funds to result in a benefit cost ratio of nearly $4 in public benefits for every $1 spent. A table summarizing the changes expected from the project (and the associated 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	Type of Impacts	County and Population Affected by Impacts	Benefits	Summary of Results Discounted at 7% (millions of $2015)
Crossing 330389F has passive warning device (Crossbucks)	Signal & Surface Improvements on the KCS at Twin Falls Road north of Watts.	Addition of gates will reduce the number of accidents	Adair County 22,004	Monetized reduction in accident costs	**$1,130,774**
Crossing 330616J has passive warning device (Crossbucks)	Signal & Surface Improvements on the KCS at Adair Co Rd E0755 near Baron.	Addition of gates will reduce the number of accidents	Adair County 22,004	Monetized reduction in accident costs	**$1,121,346**
Crossing 330619E has passive warning device (Crossbucks)	Signal & Surface Improvements on the KCS at Adair Co Rd E0772 north of Maryetta.	Addition of gates will reduce the number of accidents	Adair County 22,004	Monetized reduction in accident costs	**$1,266,377**
Crossing 330620Y has passive warning device (Crossbucks)	Signal & Surface Improvements on the KCS at Adair Co Rd E0778 north of Maryetta.	Addition of gates will reduce the number of accidents	Adair County 22,004	Monetized reduction in accident costs	**$2,183,047**
Crossing 008485A has mast flasher warning device	Signal Improvements on the SKOL at Frank Phillips Avenue in Bartlesville.	Addition of gates will reduce the number of accidents	Washington County 51,937	Monetized reduction in accident costs	**$1,669,050**
Crossing 008495F has cantilever flashing lights warning system	Signal Improvements to add Gates to the existing Cantilevered Signals at the SKOL on 14th Street in Bartlesville.	Addition of gates will reduce the number of accidents	Washington County 51,937	Monetized reduction in accident costs	**$1,489,539**

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

Current Status or Baseline & Problems to be Addressed	Changes to Baseline / Alternative	Type of Impacts	County and Population Affected by Impacts	Benefits	Summary of Results Discounted at 7% (millions of $2015)
Crossing 008509L has passive warning device (Crossbucks)	Signal Improvements at the SKOL on Washington Co Rd E2600 north of Ochelata.	Addition of gates will reduce the number of accidents	Washington County 51,937	Monetized reduction in accident costs	**$534,961**
Crossing 434122E has passive warning device (Crossbucks)	Signal & Surface Improvements on the UP at Fargo Street in Muldrow.	Addition of gates will reduce the number of accidents	Sequoyah County 41,358	Monetized reduction in accident costs	**$1,284,516**
Crossing 434179F has passive warning device (Crossbucks)	Signal & Surface Improvements on the UP at Craig Avenue in Braggs.	Addition of gates will reduce the number of accidents	Muskogee County 69,699	Monetized reduction in accident costs	**$1,261,779**
Crossing 845767Y has mast flasher warning device	Signal & Surface Improvements on the Muskogee Power Plant lead operated by UP at Three Forks Road near Muskogee.	Addition of gates will reduce the number of accidents	Muskogee County 69,699	Monetized reduction in accident costs	**$1,010,748**
Crossing 018116F has cantilever flashing lights warning system	Signal & Surface Improvements on the FMRC at Modelle Street in Clinton.	Addition of gates will reduce the number of accidents	Custer County 29,500	Monetized reduction in accident costs	**$1,238,013**
Crossing 020710S has mast flasher warning device	Signal & Surface Improvements on the BNSF at NE 3rd Avenue in Ardmore.	Addition of gates will reduce the number of accidents	Carter County 48,821	Monetized reduction in accident costs	**$683,314**
Crossing 672020R has passive warning device (Crossbucks)	Signal & Surface Improvements on the BNSF at Pontotoc Co Rd E0016/6th Street in Roff.	Addition of gates will reduce the number of accidents	Pontotoc County 38,005	Monetized reduction in accident costs	**$2,462,623**
Crossing 673060S has passive warning device (Crossbucks)	Signal Improvements on the BNSF at Cobb Road near Ravia.	Addition of gates will reduce the number of accidents	Johnston County 11,103	Monetized reduction in accident costs	**$752,705**
Crossing 600221J has mast flasher warning device	Signal & Surface Improvements on the AOK at 2nd Street in McAlester.	Addition of gates will reduce the number of accidents	Pittsburg County 44,626	Monetized reduction in accident costs	**$1,339,204**
Crossing 600223X has mast flasher warning device	Signal & Surface Improvements on the AOK at 3rd Street in McAlester.	Addition of gates will reduce the number of accidents	Pittsburg County 44,626	Monetized reduction in accident costs	**$1,312,442**
Crossing 600224E has cantilever flashing lights warning system	Signal & Surface Improvements on the AOK at 5th Street in McAlester.	Addition of gates will reduce the number of accidents	Pittsburg County 44,626	Monetized reduction in accident costs	**$1,091,509**
Crossing 600227A has cantilever flashing lights warning system	Signal & Surface Improvements on the AOK at Strong Avenue in McAlester.	Addition of gates will reduce the number of accidents	Pittsburg County 44,626	Monetized reduction in accident costs	**$1,547,329**

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

Current Status or Baseline & Problems to be Addressed	Changes to Baseline / Alternative	Type of Impacts	County and Population Affected by Impacts	Benefits	Summary of Results Discounted at 7% (millions of $2015)
Crossing 600287J has passive warning device (Crossbucks)	Signal & Surface Improvements on the AOK at Panola Road near Panola High School.	Addition of gates will reduce the number of accidents	Latimer County 10,693	Monetized reduction in accident costs	**$326,798**
Crossing 330744S has mast flasher warning device	Signal Improvements on the KCS at Le Flore Co Rd E1440/Forest Hill Road near Howe.	Addition of gates will reduce the number of accidents	Le Flore County 49,761	Monetized reduction in accident costs	**$1,009,719**
Crossing 413699G has passive warning device (Crossbucks)	Signal Improvements on the UP at Choctaw Avenue in Savanna.	Addition of gates will reduce the number of accidents	Pittsburg County 44,626	Monetized reduction in accident costs	**$1,459,594**
Crossing 413702M has passive warning device (Crossbucks)	Signal Improvements on the UP at Pittsburg Co Rd E1540 south of Savanna.	Addition of gates will reduce the number of accidents	Pittsburg County 44,626	Monetized reduction in accident costs	**$300,385**
Crossing 670441V has mast flasher warning device	Signal & Surface Improvements on the BNSF at US-69B/ Main Street in Miami.	Addition of gates will reduce the number of accidents	Ottawa County 32,105	Monetized reduction in accident costs	**$1,432,943**
Crossing 674008R has passive warning device (Crossbucks)	Signal & Surface Improvements on the BNSF at York Street in Muskogee.	Addition of gates will reduce the number of accidents	Muskogee County 69,699	Monetized reduction in accident costs	**$595,223**
Crossing 668761V has passive warning device (Crossbucks)	Signal & Surface Improvements on the SLWC at Creek Co Rd N3370 northeast of Bristow.	Addition of gates will reduce the number of accidents	Creek County 70,892	Monetized reduction in accident costs	**$398,070**
Crossing has 670401X has mast flasher warning device	Signal Improvements on the BNSF at NE 3rd Avenue in Miami.	Addition of gates will reduce the number of accidents	Ottawa County 32,105	Monetized reduction in accident costs	**$2,110,805**
Crossing has 597430K has mast flasher warning device	Signal & Surface Improvements on the FMRC at N2274 Rd.	Addition of gates will reduce the number of accidents	Custer County 29,500	Monetized reduction in accident costs	**$644,549**

The period of analysis used in the estimation of benefits and costs corresponds to 21 years, including 1 year of construction and 20 years of operation. The total project costs are $8,940,000 million and are expected to be financed by Federal, State, and private funds according to the distribution shown in Table ES-2.

Table ES-2: Summary of Project Costs and Anticipated Funding Sources, in Millions of Dollars of 2015

Funding Source	Capital Funds (Thousands $2016)	Percent of Total Cost Financed by Source
State - ODOT	$1,788,000	20.0%
Private - Railroads	$447,000	5.0%
Federal - TIGER VIII	$6,705,000	75.0%
TOTAL	**$8,940,000**	**100.0%**

A summary of the relevant data and calculations used to derive the benefits and costs of the project are shown in Table ES-3 (in dollars of 2015). Based on the analysis presented in the rest of this document, the project is expected to generate $31,657,362 in discounted benefits and $8,355,140 in discounted costs, using a 7 percent real discount rate. Therefore, the project is expected to generate a Net Present Value of $23,302,222 million and a Benefit/Cost Ratio of 3.79.

Table ES-3: Summary of Pertinent Data, Quantifiable Benefits and Costs

Calendar Year	Project Year	Total Direct Beneficiaries	Total Benefits ($2015)	Initial Costs ($2015)	Undiscounted Net Benefits ($2015)	Discounted Net Benefits at 7%	Discounted Net Benefits at 3%
2017	1	Vehicle operators and local residents	$0	$8,940,000	-$8,940,000	-$8,355,140	-$8,679,612
2018	2	Vehicle operators and local residents	$2,890,869	$0	$2,890,869	$2,524,997	$2,724,921
2019	3	Vehicle operators and local residents	$2,929,862	$0	$2,929,862	$2,391,640	$2,681,238
2020	4	Vehicle operators and local residents	$2,969,380	$0	$2,969,380	$2,265,326	$2,638,256
2021	5	Vehicle operators and local residents	$3,009,431	$0	$3,009,431	$2,145,683	$2,595,962
2022	6	Vehicle operators and local residents	$3,050,023	$0	$3,050,023	$2,032,359	$2,554,346
2023	7	Vehicle operators and local residents	$3,091,162	$0	$3,091,162	$1,925,020	$2,513,398
2024	8	Vehicle operators and local residents	$3,132,856	$0	$3,132,856	$1,823,351	$2,473,106
2025	9	Vehicle operators and local residents	$3,175,113	$0	$3,175,113	$1,727,051	$2,433,459
2026	10	Vehicle operators and local residents	$3,217,939	$0	$3,217,939	$1,635,837	$2,394,449

Table ES-3: Summary of Pertinent Data, Quantifiable Benefits and Costs

Calendar Year	Project Year	Total Direct Beneficiaries	Total Benefits ($2015)	Initial Costs ($2015)	Undiscounted Net Benefits ($2015)	Discounted Net Benefits at 7%	Discounted Net Benefits at 3%
2027	11	Vehicle operators and local residents	$3,261,343	$0	$3,261,343	$1,549,441	$2,356,063
2028	12	Vehicle operators and local residents	$3,305,332	$0	$3,305,332	$1,467,607	$2,318,294
2029	13	Vehicle operators and local residents	$3,349,915	$0	$3,349,915	$1,390,096	$2,281,129
2030	14	Vehicle operators and local residents	$3,395,099	$0	$3,395,099	$1,316,678	$2,244,561
2031	15	Vehicle operators and local residents	$3,440,893	$0	$3,440,893	$1,247,138	$2,208,578
2032	16	Vehicle operators and local residents	$3,487,304	$0	$3,487,304	$1,181,271	$2,173,173
2033	17	Vehicle operators and local residents	$3,534,341	$0	$3,534,341	$1,118,882	$2,138,335
2034	18	Vehicle operators and local residents	$3,582,013	$0	$3,582,013	$1,059,788	$2,104,055
2035	19	Vehicle operators and local residents	$3,630,328	$0	$3,630,328	$1,003,816	$2,070,325
2036	20	Vehicle operators and local residents	$3,679,294	$0	$3,679,294	$950,799	$2,037,136
2037	21	Vehicle operators and local residents	$3,728,921	$0	$3,728,921	$900,583	$2,004,479
Total			**$65,861,418**	**$8,940,000**	**$56,921,418**	**$23,302,222**	**$38,265,650**

In addition to the monetized benefits presented in Table ES-3, the project would generate benefits that are difficult to quantify. A brief description of those benefits is provided below.

State of Good Repair

Improving the crossings identified in this project will improve the state of repair for existing infrastructure that is handling growing volumes of freight shipments via rail. The surface improvements at the crossings will increase the overall quality of the existing infrastructure, which is expected to result in fewer critical repairs in the future. It is assumed that the increase in maintenance costs for the proposed improvements to the warning devices will be fully offset by the need for fewer critical repairs.

Economic Competitiveness

The increased mobility represented by the crossing improvements described in this application will result in an increased economic competitiveness for local businesses. With the crossing

improvements implemented, local consumers will also have better access to vital services and goods, and safe infrastructure will provide a stronger foundation for local businesses to grow.

Quality of Life

The traveling public and individuals living near the crossings will notice benefits to their quality of life from these crossing improvements through increased safety and connectivity. These qualitative benefits are achieved as opportunities for potential increases in use of the crossings due to improved safety.

In rural areas, travelers rely heavily on highway access. There are 13 crossings with proposed improvements, such as Crossing #23 that provide direct highway access to vehicular traffic. These improvements will increase connectivity of the traveling public in addition to safety.

Eighteen of the crossings lie within city limits with railroad tracks in some manner splitting the town. These improvements will promote safer travel within the city.,. In Ardmore at Crossing #12, this means improving the 5-track crossing near an Amtrak Station. In Clinton at Crossing #11, this means improved connectivity for a secondary route for those needing to get to the health facilities and Integris Clinton Regional Hospital on the west side of town from the east.

Environmental Sustainability

The crossing improvements described in this application are neutral with respect to environmental sustainability.

Safety

In addition to the monetized safety benefits, there are also benefits to safety which are difficult to quantify but important to note. There are five (5) crossings with sidewalks that connect people to residences or commercial areas of towns. The improvements to the crossing surface and addition of gates will improve the conditions of the pedestrian crossing, making the crossing more desirable for pedestrians to use. In the city of Bartlesville, there are two (2) crossing with proposed improvements which have sidewalks**.** One of these crossings is located in the commercial area of town while the other is located in the residential area of town. Both, with their proposed improvements, will be safer for the community to be connected on either side of the crossings whether by foot, bike, or vehicle.

There are three (3) crossings that are used by school bus traffic. The proposed improvements at these crossings will enhance safety for students and also improve the flow of traffic at these crossings.

2 Introduction

This document provides detailed technical information on the economic analyses conducted in support of the Grant Application for the Oklahoma Tribal Rural Railroad Crossing Safety Improvement project.

Section 3, Methodological Framework, introduces the conceptual framework used in the Benefit-Cost Analysis (BCA). Section 4, Project Overview, provides an overview of the project, including a brief description of existing conditions and proposed alternatives; a summary of cost estimates and schedule; and a description of the types of effects that the Oklahoma Tribal Rural Railroad Crossing Safety Improvement project is expected to generate. Section 5, General Assumptions, discusses the general assumptions used in the estimation of project costs and benefits, while estimates of travel demand and traffic growth can be found in Section 6, Demand Projections. Specific data elements and assumptions pertaining to the long-term outcome selection criteria are presented in Section 7, Benefits Measurement, Data and Assumptions, along with associated benefit estimates. Estimates of the project's Net Present Value (NPV), its Benefit/Cost ratio (BCR) and other project evaluation metrics are introduced in Section 8, Summary of Findings and BCA Outcomes. Next, Section 9, BCA Sensitivity Analysis, provides the outcomes of the sensitivity analysis. Additional data tables are provided in Section 10, Supplementary Data Tables, including annual estimates of benefits and costs, as well as intermediate values to assist DOT in its review of the application.

3 Methodological Framework

Benefit-Cost Analysis (BCA) is a conceptual framework that quantifies in monetary terms as many of the costs and benefits of a project as possible. Benefits are broadly defined. They represent the extent to which people impacted by the project are made better-off, as measured by their own willingness-to-pay. In other words, central to BCA is the idea that people are best able to judge what is "good" for them, what improves their well-being or welfare.

BCA also adopts the view that a net increase in welfare (as measured by the summation of individual welfare changes) is a good thing, even if some groups within society are made worse-off. A project or proposal would be rated positively if the benefits to some are large enough to compensate for the losses of others.

Finally, BCA is typically a forward-looking exercise, seeking to anticipate the welfare impacts of a project or proposal over its entire life-cycle. Future welfare changes are weighted against today's changes through discounting, which is meant to reflect society's general preference for the present, as well as broader inter-generational concerns.

The specific methodology developed for this application was developed using the above BCA principles and is consistent with the TIGER guidelines. In particular, the methodology involves:

- Establishing existing and future conditions under the build and no-build scenarios;
- Assessing benefits with respect to each of the five long-term outcomes 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 DOT guidance for the valuation of travel time savings, safety benefits and reductions in air emissions, while relying on industry best practice for the valuation of other effects;
- Discounting future benefits and costs with the real discount rates recommended by the DOT (7 percent, and 3 percent for sensitivity analysis); and
- Conducting a sensitivity analysis to assess the impacts of changes in key estimating assumptions.

4 Project Overview

The State of Oklahoma, through the Oklahoma Department of Transportation (ODOT), plans to address the increased potential hazards associated with increased train/motor vehicle interaction and improve community connectivity through improvements at twenty seven (27) rural railroad crossings in Oklahoma. On a crossing by crossing basis, these upgrades will include:

- Upgrading crossing warning devices such as signals, pavement markings, and signage
- Improving crossing surfaces
- Improving roadway crossing geometry within existing right-of-way, as warranted
- Addressing sight distance issues, where feasible

The crossings included in this project have either experienced growing volumes of freight traffic, or intersect with key street and highway routes that serve tribal facilities such as medical centers, community centers, schools, and business activities.

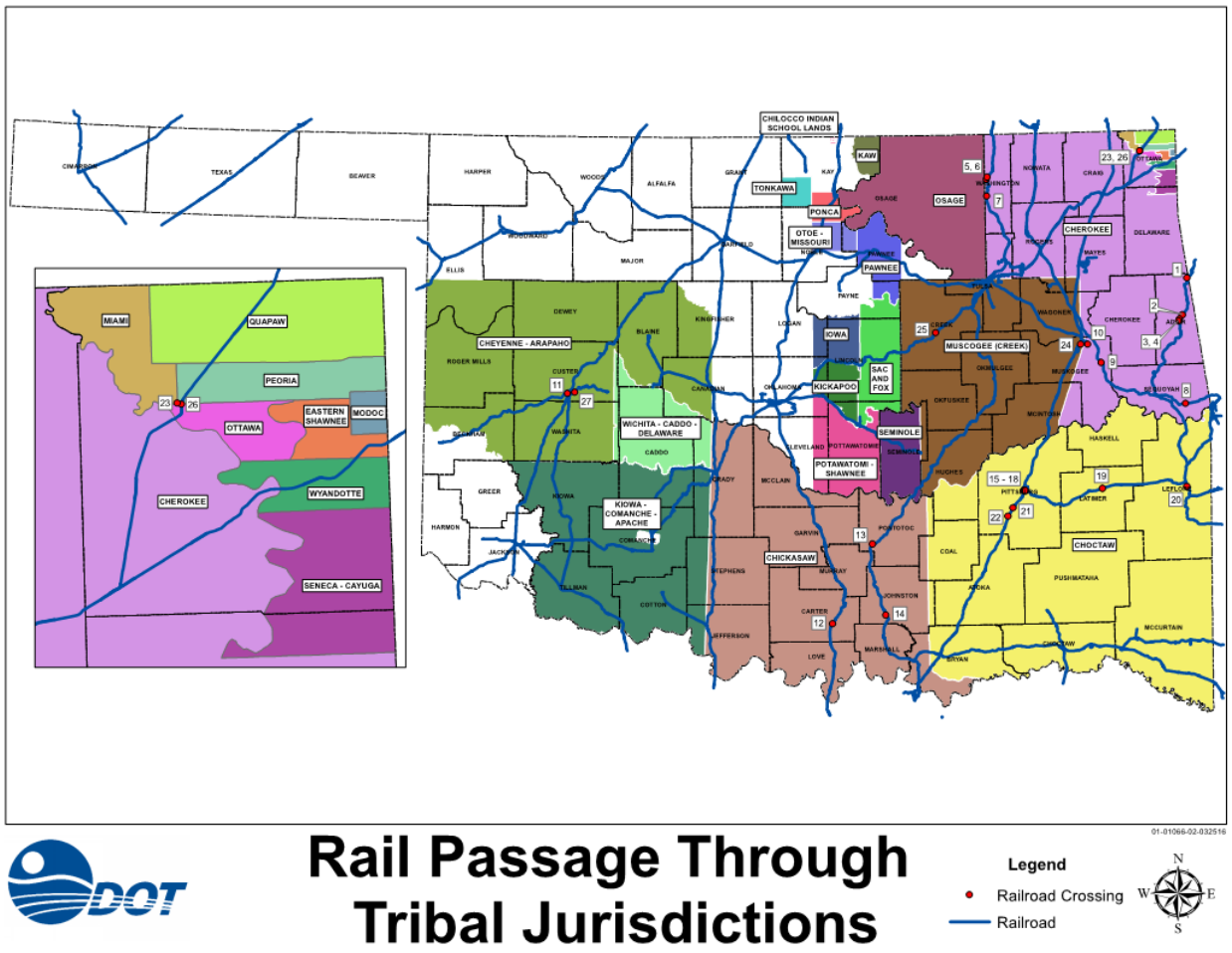
Oklahoma’s freight traffic on the railroads has increased over the years transporting crude oil, agricultural products, and intermodal freight throughout the country. A majority of the increased oil production in recent years is shipped by rail, originating from North Dakota shale oil fields to refineries in Texas, often through Oklahoma. Unit car lengths are increasing as well in order to help the railroads optimize operating efficiencies. The railroads have taken numerous steps to improve operations while the federal government is currently in the process of increasing safety requirements. These rural crossing improvements will further improve safety in Oklahoma by assisting with keeping the traveling public away from trains.

Many of Oklahoma's tribal citizens have taken advantage of changing federal policy to assert their sovereignty and assume responsibility for their own welfare. Constitutions have been written and tribal governments established to provide social services for the people including health, housing and jobs. Culture and language preservation continue to be a priority amongst the nations. Many of these endeavors are funded through tribal enterprises. One example of a tribal-federal partnership is the Choctaw Promise Zone, established by President Obama in 2014 to build and strengthen partnerships at all levels to promote and advocate investment in the people, land, and economy of the Choctaw Nation. Improving public safety and creating economic opportunity are goals of the Promise Zone initiative that will be facilitated with these crossing improvements.

Currently, there are thirty nine (39) tribal governments of which thirty eight (38) are federally recognized tribes and tribal towns in Oklahoma. Oklahoma's thirty eight (38) federally recognized Indian tribes produce an estimated $10.8 billion impact on Oklahoma's economic output. As Oklahoma's tribal partners exercise their economic growth through commercial, industrial, infrastructure and community resource development, ODOT is collaborating with them to make sure the railroad/highway grade crossings in their respective jurisdictions have enhanced safety features. These proposed rural crossing improvements will ensure safer travel and connectivity of the tribal citizens within the community.

The twenty seven (27) rural crossing upgrades described in our 2016 TIGER Grant application will help railroads operate more efficiently and safely as well as allow Oklahoma's citizens to move safely across these crossings in pursuit of personal and business activities. The figure below shows the location of each crossing.

Figure 1: Accidents Costs due to Crossing Category Change



4.1 Base Case and Alternatives

The base case is defined as not pursuing the installation of the crossing gates or the surface and roadway improvements. The alternate case is defined as pursuing the road surface improvements and installation of gates at each crossing.

4.2 Types of Impacts and Affected Population

ODOT is submitting this Oklahoma Rural Tribal Railroad Crossing Safety Improvement Project application for 2016 TIGER Grant funding to achieve three key benefits: to reduce accidents, to achieve a state of good repair of these crossings, and to enhance the quality of life of the traveling public through improved community connectivity. These needed improvements will assist the railroads in operating more efficiently and safely as well as allow Oklahoma's citizens, including tribal community members, to move safely across these crossings in pursuit of personal and business activities.

As ODOT's tribal partners exercise their economic growth through commercial, industrial, infrastructure and community resource development, ODOT is working with them to make sure the railroad/highway grade crossings in their tribal jurisdictions having improved or enhanced safety features. The 27 rural crossing upgrades described in our 2016 TIGER Grant application specifically will enhance safety and improve access along key routes to tribal medical centers, community centers, schools, and business activities.

4.3 Project Cost and Schedule[1]

ODOT, along with partners at the local public agencies, and the railroad operators, are ready to proceed with design/construction upon notice of award. All the crossings are anticipated to be constructed in FY2017, at a cost of $8.94 million.

4.4 Disruptions Due to Construction

Each of the proposed crossing locations lies within existing railroad or state right-of-way and will not require additional property acquisition. Work for these crossings is not planned to be outside of railroad or state right-of-way.

4.5 Effects on Long-Term Outcomes

The main benefit categories associated with the project are mapped into the five long-term outcome criteria set forth by the DOT in the table below.

Table 4: Expected Effects on Long-Term Outcomes and Benefit Categories

Long-Term Outcomes	Benefit or Impact Categories	Description	Quantified	Qualitative
State of Good Repair	Repairs as a result of improvements	Assumed that increased maintenance costs for improvements is offset by fewer critical repairs		√

[1] All cost estimates in this section are in millions of dollars of 2015, discounted to 2016 using a 7 percent real discount rate.

Table 4: Expected Effects on Long-Term Outcomes and Benefit Categories

Long-Term Outcomes	Benefit or Impact Categories	Description	Quantified	Qualitative
Economic Competitiveness	Increased mobility	Increased mobility allows consumers better access to vital services and goods		√
Quality of Life	Increased Quality of Life for surrounding residents	Increased connectivity due to sidewalk and roadway improvements		√
Environmental Sustainability	Environmental savings	No significant environmental improvements		√
Safety	Reduce accident costs due to signal improvements	Reduction in accident rates at each intersection due to improved signalization	√	

5 General Assumptions

The BCA measures benefits against costs throughout a period of analysis beginning at the start of construction and including 20 years of operations.

The monetized benefits and costs are estimated in 2015 dollars with future dollars discounted in compliance with TIGER requirements using a 7 percent real rate, and sensitivity testing at 3 percent.

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

- Input prices are expressed in 2015 dollars;
- The period of analysis begins in 2017 and ends in 2037. It includes project development and construction years (2016 - 2017) and 20 years of operations (2018 - 2037);
- A constant 7 percent real discount rate is assumed throughout the period of analysis. A 3 percent real discount rate is used for sensitivity analysis;
- Opening year demand is an input to the BCA and is assumed to be fully realized in Year 1 (no ramp-up); and
- Unless specified otherwise, the results shown in this document correspond to the effects of the Full Build alternative.

6 Demand Projections

Accurate demand projections are important to ensure reasonable BCA output results. The magnitude of the long-term benefits accruing due to the project over the study period is a function of the number of existing and projected Average Daily Traffic (ADT) and train counts.

6.1 Methodology

The existing ADT information for each crossing was provided by the Oklahoma Department of Transportation. Traffic is expected to grow at approximately 0.35% per year (See Table 4) based on the population growth for non metropolitan areas in Oklahoma. The growth rate was applied to ADT counts for all crossings to derive projections for 2016-2037

The freight train volume was provided by the Oklahoma Department of Transportation.

6.2 Assumptions

The assumptions used in the estimation of demand inputs are detailed in Table 2.

Table 5: Assumptions Used in the Estimation of Average Daily Traffic Counts

Variable Name	Unit	Value	Data Year	Source
AADT at Crossing 330389F	vehicles/day	160	2015	ODOT for Value and Year
AADT at Crossing 330616J	vehicles/day	150	1980	ODOT for Value, FRA for Year
AADT at Crossing 330619E	vehicles/day	250	1980	ODOT for Value, FRA for Year
AADT at Crossing 330620Y	vehicles/day	200	1980	ODOT for Value, FRA for Year
AADT at Crossing 008485A	vehicles/day	12000	1988	ODOT for Value, FRA for Year
AADT at Crossing 008495F	vehicles/day	3404	1988	ODOT for Value, FRA for Year
AADT at Crossing 008509L	vehicles/day	131	2015	ODOT for Value and Year
AADT at Crossing 434122E	vehicles/day	150	1988	ODOT for Value, FRA for Year
AADT at Crossing 434179F	vehicles/day	150	1988	ODOT for Value, FRA for Year
AADT at Crossing 845767Y	vehicles/day	11400	2007	ODOT for Value and Year
AADT at Crossing 018116F	vehicles/day	6750	2007	ODOT for Value and Year
AADT at Crossing 020710S	vehicles/day	1000	1987	ODOT for Value, FRA for Year
AADT at Crossing 672020R	vehicles/day	420	2015	ODOT for Value and Year
AADT at Crossing 673060S	vehicles/day	54	2015	ODOT for Value and Year
AADT at Crossing 600221J	vehicles/day	4500	1986	ODOT for Value, FRA for Year
AADT at Crossing 600223X	vehicles/day	4000	2007	ODOT for Value and Year
AADT at Crossing 600224E	vehicles/day	4500	1986	ODOT for Value, FRA for Year
AADT at Crossing 600227A	vehicles/day	4800	2007	ODOT for Value and Year
AADT at Crossing 600287J	vehicles/day	250	1987	ODOT for Value, FRA for Year
AADT at Crossing 330744S	vehicles/day	150	1980	ODOT for Value, FRA for Year
AADT at Crossing 413699G	vehicles/day	364	2015	ODOT for Value and Year
AADT at Crossing 413702M	vehicles/day	87	2015	ODOT for Value and Year
AADT at Crossing 670441V	vehicles/day	16100	1988	ODOT for Value, FRA for Year
AADT at Crossing 674008R	vehicles/day	14000	2007	ODOT for Value and Year
AADT at Crossing 668761V	vehicles/day	250	1988	ODOT for Value, FRA for Year
AADT at Crossing 670401X	vehicles/day	1100	2015	ODOT for Value, FRA for Year

6.3 Demand Projections

The resulting projections for the Average Daily Traffic and Trains per Day are presented in the tables below.

Table 6: AADT Demand Projections

Category	In Project Opening Year 2016	2018	2025	2030	2037
AADT at Crossing 330389F	161	162	166	168	173
AADT at Crossing 330616J	170	171	175	178	183
AADT at Crossing 330619E	283	285	292	297	304
AADT at Crossing 330620Y	226	228	234	238	243
AADT at Crossing 008485A	13,216	13,308	13,633	13,870	14,209
AADT at Crossing 008495F	3,749	3,775	3,867	3,934	4,030
AADT at Crossing 008509L	131	132	136	138	141
AADT at Crossing 434122E	165	166	170	173	178
AADT at Crossing 434179F	165	166	170	173	178
AADT at Crossing 845767Y	11,759	11,841	12,130	12,341	12,642
AADT at Crossing 018116F	6,963	7,011	7,182	7,307	7,486
AADT at Crossing 020710S	1,105	1,113	1,140	1,160	1,188
AADT at Crossing 672020R	421	424	435	442	453
AADT at Crossing 673060S	54	55	56	57	58
AADT at Crossing 600221J	4,990	5,025	5,148	5,237	5,365
AADT at Crossing 600223X	4,126	4,155	4,256	4,330	4,436
AADT at Crossing 600224E	4,990	5,025	5,148	5,237	5,365
AADT at Crossing 600227A	4,951	4,986	5,107	5,196	5,323
AADT at Crossing 600287J	276	278	285	290	297
AADT at Crossing 330744S	170	171	175	178	183
AADT at Crossing 413699G	365	368	377	383	393
AADT at Crossing 413702M	87	88	90	92	94
AADT at Crossing 670441V	17,732	17,854	18,291	18,609	19,063
AADT at Crossing 674008R	14,441	14,541	14,896	15,155	15,526
AADT at Crossing 668761V	275	277	284	289	296
AADT at Crossing 670401X	2,974	2,994	3,067	3,121	3,197
AADT at Crossing 597430K	1,104	1,111	1,139	1,158	1,187

Table 7: Trains per Day Demand Projections

Category	In Project Opening Year 2016	2018	2025	2030	2037
Trains per Day at Crossing 330389F	22.0	22.2	22.7	23.1	23.7
Trains per Day at Crossing 330616J	22.0	22.2	22.7	23.1	23.7
Trains per Day at Crossing 330619E	22.0	22.2	22.7	23.1	23.7
Trains per Day at Crossing 330620Y	22.0	22.2	22.7	23.1	23.7
Trains per Day at Crossing 008485A	7.0	7.0	7.2	7.3	7.5
Trains per Day at Crossing 008495F	3.0	3.0	3.1	3.1	3.2
Trains per Day at Crossing 008509L	3.0	3.0	3.1	3.1	3.2
Trains per Day at Crossing 434122E	23.0	23.2	23.7	24.1	24.7
Trains per Day at Crossing 434179F	23.0	23.2	23.7	24.1	24.7
Trains per Day at Crossing 845767Y	5.0	5.0	5.2	5.2	5.4
Trains per Day at Crossing 018116F	1.0	1.0	1.0	1.0	1.1
Trains per Day at Crossing 020710S	32.0	32.2	33.0	33.6	34.4
Trains per Day at Crossing 672020R	11.0	11.1	11.3	11.5	11.8
Trains per Day at Crossing 673060S	11.0	11.1	11.3	11.5	11.8
Trains per Day at Crossing 600221J	5.0	5.0	5.2	5.2	5.4
Trains per Day at Crossing 600223X	5.0	5.0	5.2	5.2	5.4
Trains per Day at Crossing 600224E	5.0	5.0	5.2	5.2	5.4
Trains per Day at Crossing 600227A	5.0	5.0	5.2	5.2	5.4
Trains per Day at Crossing 600287J	1.0	1.0	1.0	1.0	1.1
Trains per Day at Crossing 330744S	34.0	34.2	35.1	35.7	36.6
Trains per Day at Crossing 413699G	22.0	22.2	22.7	23.1	23.7
Trains per Day at Crossing 413702M	17.0	17.1	17.5	17.8	18.3
Trains per Day at Crossing 670441V	4.0	4.0	4.1	4.2	4.3
Trains per Day at Crossing 674008R	1.0	1.0	1.0	1.0	1.1
Trains per Day at Crossing 668761V	6.0	6.0	6.2	6.3	6.5
Trains per Day at Crossing 670401X	8.0	8.1	8.3	8.4	8.6
Trains per Day at Crossing 597460K	1.0	1.0	1.0	1.0	1.1

7 Benefits Measurement, Data and Assumptions

This section describes the measurement approach used for each benefit or impact category identified in Table 1 (Expected Effects on Long Term Outcomes and Benefit Categories) and provides an overview of the associated methodology, assumptions, and estimates. The benefit categories include State of Good Repair, Economic Competitiveness, Quality of Life, Environmental Sustainability and Safety.

7.1 State of Good Repair

The State of Good Repair benefits for this application were qualitatively assessed. Improving the state of repair for existing infrastructure will increase the overall quality of the surface; thus fewer critical repairs should be required in the future.

7.2 Economic Competitiveness

The proposed project would contribute to enhancing the economic competitiveness of the Nation through improvements in the mobility of people and goods within and across the study area. This benefit was qualitatively assessed.

7.3 Quality of Life

The impact to the Quality of Life was qualitatively assessed. Individuals living near to and using the crossings will notice benefits to their quality of life through increased safety and connectivity.

7.4 Environmental Sustainability

The proposed project would contribute to the environmental sustainability through a reduction in amount of time vehicles are idling as a result of accidents. This benefit is qualitatively assessed.

7.5 Safety

The project will improve the safety of the rail and highway system primarily through upgrading the crossing protection at twenty-seven (27) rural crossings. Fourteen (14) of these crossings only have a passive warning device (crossbucks), and thirteen (13) of these crossings have lights (cantilever or mastflashers). These upgrades will greatly increase safety by implementing a barrier between vehicle and train traffic.

7.5.1 Methodology

The proposed project would contribute to promoting safety long-term through the reduction of accident exposure risk at each grade crossing. Currently the combined accident rate at the twenty seven (27) crossings is 2.34 accidents per year. This value was calculated using principles consistent with DOT Accident Prediction Model[2]. In particular, the methodology involves two independent calculations to produce a collision prediction value:

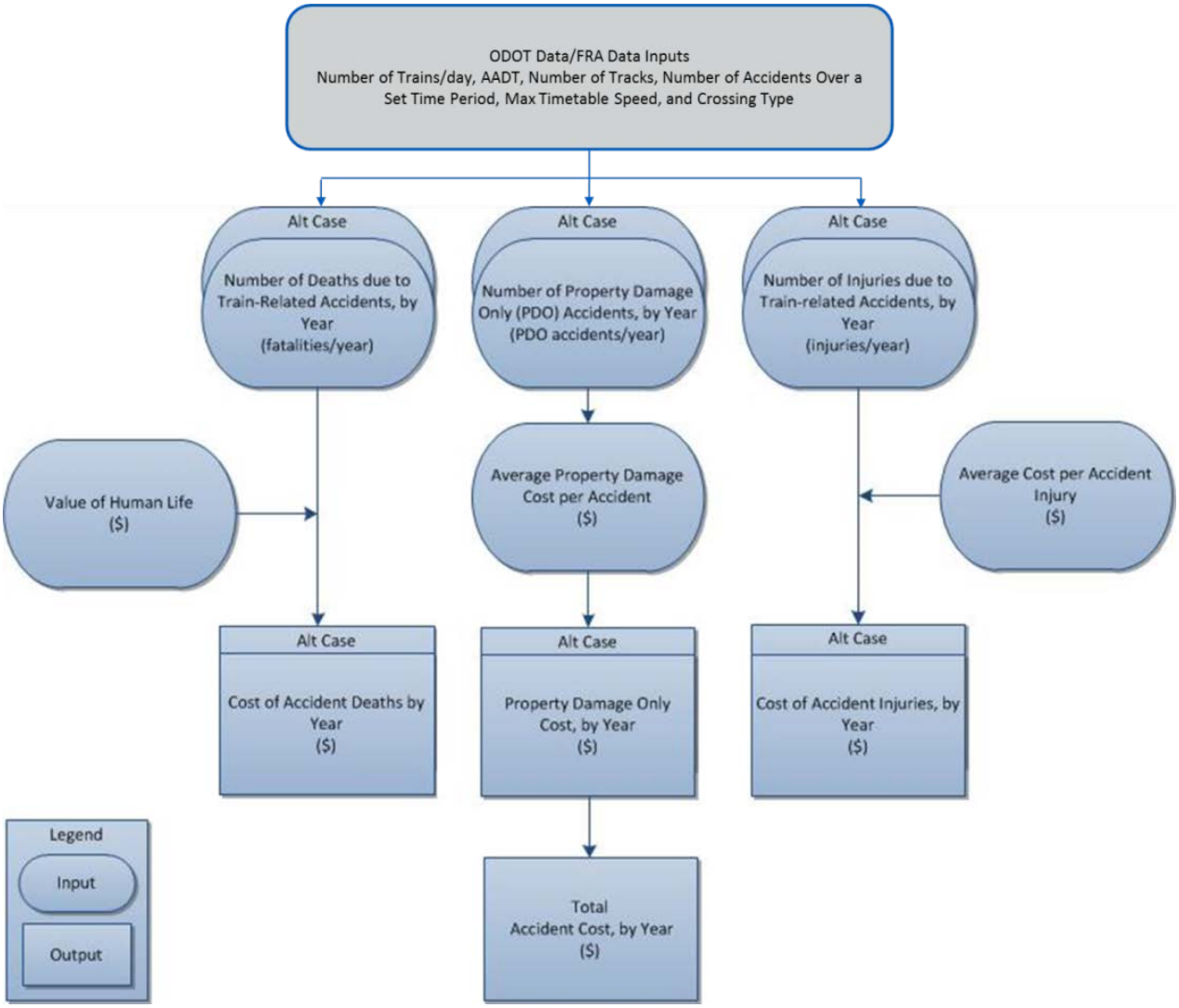
- The basic formula provides an initial hazard ranking based on a crossing's characteristics. The crossing characteristics were taken from the ODOT Crossing Inventory and FRA Accident/Incident Reports; and,
- The second calculation utilizes the actual collision history at a crossing over a five (5) year period to produce a collision prediction value – taken from the FRA Accident/Incident Reports. This procedure assumes that future collisions per year at a crossing will be the same as the average historical collision rate over the time period used in the calculation.

[2] USDOT. Accident Prediction Model. http://safety.fhwa.dot.gov/xings/com_roaduser/07010/sec03.htm

The calculations are first performed for the base (no build) case to establish the current number of collisions per year at each crossing. The calculations are then performed again using the same historical collision data, but accounting for the crossing improvements to determine the expected collision reduction per year at each crossing.

Under the Alternative Case the crossing category changes from passive to gates, or from flashing lights to gates depending on the crossing. Accidents are further delineated by the numbers of fatalities and injuries. The monetary value of a life, as well as that of an injury is well documented in the DOT BCA Resource Guide.[3] A diagram below outlines the calculations.

Figure 2: Accidents Costs due to Crossing Category Change



[3] US DOT. TIGER Benefit-Cost Analysis (BCA) Resource Guide. 2014.

7.5.2 Assumptions

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

Table 8: Assumptions Used in the Estimation of Safety Benefits

Variable Name	Unit	Value	Source
Traffic annual growth rate	%	0.35%	Based on population growth rate for non metropolitan areas - Regional Economical Analysis Project (REAP) for Oklahoma https://oklahoma.reaproject.org/analysis/comparative-indicators/year_vs_year/population/tools/2000/2014/400115/
Value of a Statistical Life	2015$	$ 9,600,000	US DOT, Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses. 2015
Average Cost per Accident Injury	2015$	$ 174,029	USDOT, Based on MAIS Injury Severity Scale and KACBO-AIS Conversion if Severity of Injury is Unknown. Department of Transportation Analyses. 2015.
Cost of a Property Damage Only (PDO) Accident	2015$	$ 4,198	USDOT, TIGER BCA Resource Guide, based on The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (April 2015)
Growth of the Cost of Accidents	%	1.00%	USDOT TIGER VIII BCA Resource Guide (2016)
Rail Grade Crossing Expected Accident Rate per Year - Base Case	accidents/year	Calculated for each intersection	HDR Calculated based on USDOT Accident Prediction Model (APM) and FRA Highway-Rail Grade Crossing Accident/Incident Reports

7.5.3 Benefit Estimates

The table below shows the benefit estimates of increased safety and reduction of accidents due to the installation of gates at each of the crossings. With a 7 percent discount rate applied to the accident cost reduction benefit, the estimate present value over the project period is $31.7 million dollars.

Table 9: Estimates of Safety Benefits, Millions of 2015 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	**Discounted at 7 Percent**
Installation of Gates at all Crossings	$2.9	$65.9	$31.7

8 Summary of Findings and BCA Outcomes

The tables below summarize the BCA findings. Annual costs and benefits are computed over the lifecycle of the project (20 years). As stated earlier, construction is expected to be completed by the end of 2017. Benefits accrue during the full operation of the project.

Table 10: Overall Results of the Benefit Cost Analysis, Millions of 2015 Dollars*

Project Evaluation Metric	7% Discount Rate	3% Discount Rate
Total Discounted Benefits	$31.7	$46.9
Total Discounted Costs	$8.4	$8.7
Net Present Value	$23.3	$38.3
Benefit / Cost Ratio	3.79	5.41
Internal Rate of Return (%)	33.6%	
Payback Period (years)	3.55	

** Unless Specified Otherwise*

Considering all monetized benefits and costs, the estimated internal rate of return of the project is 33.6 percent. With a 7 percent real discount rate, the $8.4 million investment would result in $31.7 million in total benefits and a Benefit/Cost ratio of approximately 3.79.

With a 3 percent real discount rate, the Net Present Value of the project would increase to $38.3 million, for a Benefit/Cost ratio of 5.41.

9 BCA Sensitivity Analysis

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

The sensitivity analysis can also be used 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 quantitative analysis using a 7 percent discount rate are summarized in the table below. The table provides the percentage changes in project NPV associated with variations in variables or parameters (listed in row), as indicated in the column headers.

For example, using the lower bound recommendation for the value of a statistical life the Net Present Value decreases by 61.9%. The table below shows similar results for other sensitivity tests.

Table 11: Quantitative Assessment of Sensitivity, Summary

Parameters	Change in Parameter Value	New NPV (7% discounted)	Change in NPV	New B/C Ratio (7% discounted)
Value of Statistical Life	Lower Bound Range Recommended by USDOT ($5.2 Million)	$8,875,621	-61.9%	2.06
	Upper Bound Range Recommended by USDOT ($12.9 Million)	$34,122,173	46.4%	5.08
Capital Cost Estimate	25% Reduction in Capital Cost	$25,391,007	9.0%	5.05