Nogales Line Bypass

Benefit-Cost Analysis Supplementary Documentation

Pima County

September 17th 2018

Contents

Tables

Figures

1 Executive Summary

With growth in both freight train and vehicle traffic in Tucson, the Nogales Line is generating significant delays for local motorists, and negatively impacting residents. These delays not only generate travel time uncertainty in Tucson, but it also results in inefficient emergency service access and potential pressure on the local government to plan and execute multiple costly grade separation projects for several key crossings.

Beyond this, there are significant safety concerns along the corridor, especially given the expected growth in freight rail traffic. While there are standard concerns for potential incidents at grade crossings, another major safety concern pertains to safety along the Nogales Line tracks and the prevention of pedestrians from trespassing onto the tracks. The lack of barriers and the current alignment of the Nogales Line tracks increases the likelihood of incidents along the track from illegal pedestrian crossings.

A related concern is the safety of the students who cross the tracks via bus or bicycle, or as pedestrians. There are two elementary schools located adjacent to the Nogales Line that are served by 73 school buses, where 70 of them cross the tracks 3 – 4 times daily. Other concerns include the increase risks from hazardous materials being transported through residential areas and school zones.

As presented in Figure 1, the Nogales Line Bypass Project creates a new grade-separated line that connects the Nogales Line to the Sunset Line. The new line, highlighted in blue, will be constructed in a largely undeveloped area along Old Vail Connection Road. This bypass will significantly reduce vehicle congestion at the existing 19 at-grade crossings, where 3 crossings are currently estimated to experience 40 vehicle-hours of daily delay due to rail traffic. Rerouting rail traffic would eliminate potential train/vehicle incidents at the 19 crossings and would reroute hazardous materials such that they are no longer transported through residential areas and school zones.

Finally, the location of the bypass will also promote future economic development through efficient rail access to largely undeveloped industrial lands. The new alignment will connect thousands of acres of vacant and rail-serviceable land available for industrial and logistic uses.

Figure 1: Nogales Line Bypass Project

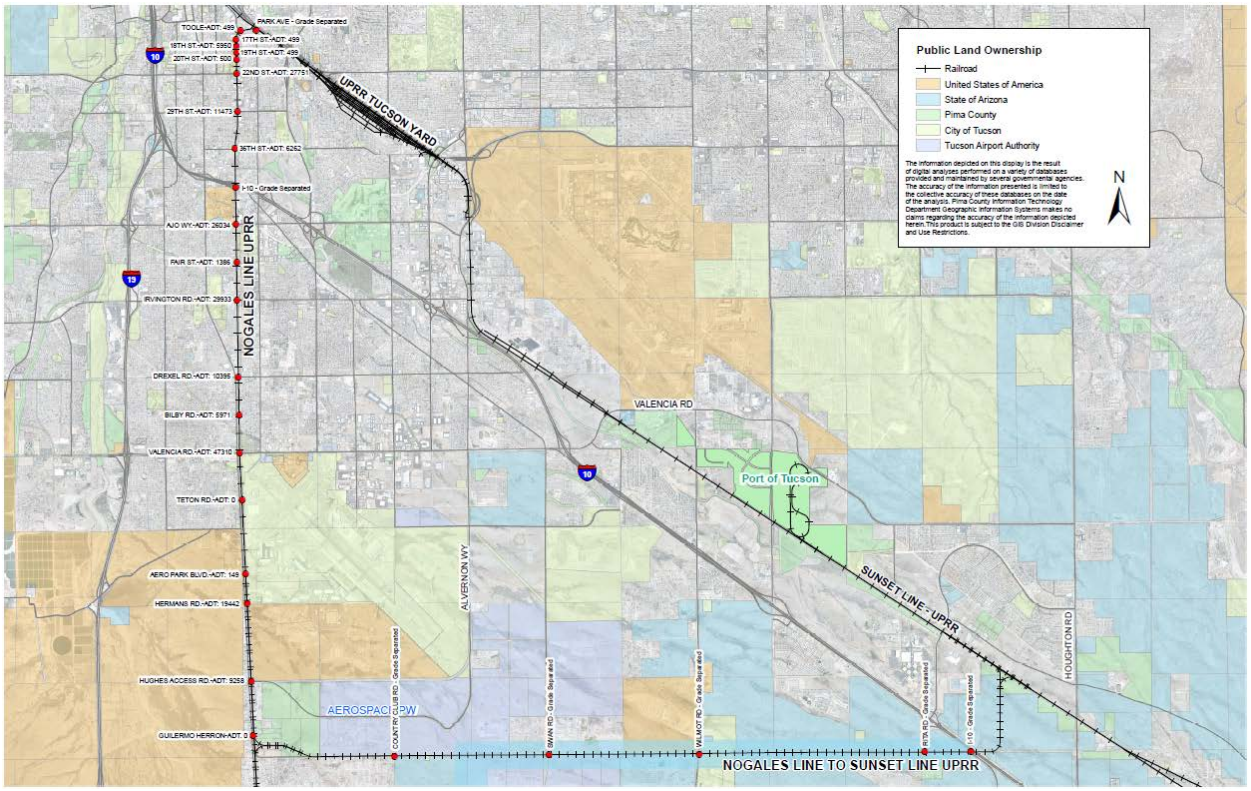

Table ES - 1 summarizes the impacts and associated monetary benefits expected from the project.

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	Population Affected by Impacts	Economic Benefits	Summary of Results ($2017)
While the Nogales Line is a major link for transporting goods between Arizona and Mexico, it is also a source of significant delays for local motorists and a potential safety concern for local residents. These delays are expected to worsen as freight rail and vehicle traffic grows resulting in increasing travel time delay, unreliability, safety concerns, and environmental damage due to idling vehicles.	This project will create a new rail line along Old Vail Connection Road, a largely undeveloped area south of Tucson. The bypass will connect the Nogales Line to the Sunset Line and bypass 19 current at-grade crossings. The bypass will eliminate vehicle delays while crossings are occupied thereby improving the mobility of motorists. The construction of the bypass is expected to improve safety by reducing the number of vehicle/pedestrian – train encounters. Further, thousands of acres of vacant land serviceable by the new alignment will become available for those industries reliant on low cost, efficient rail service. The bypass will also improve rail fluidity in the region and help avoid the need for costly future grade separation projects at multiple crossings.	Reduced travel time costs from vehicle idling and delay at 19 at-grade crossings.	Motorists, shippers, local businesses and residents	Reduced Travel Time Costs	**$156,711,913**
		Improved safety and avoided accident costs from bypassing the Nogales Line and the 19 road grade crossings.	Motorists, shippers, local businesses and residents	Improved Safety and Avoided Accident Costs	**$84,281,863**
		Avoided emission costs from vehicle idling and delay along the existing Nogales Line	Local residents and residents across the country	Avoided Emissions Costs	**$242,979**
		Reduced vehicle operating costs from vehicle idling and delay along the existing Nogales Line.	Motorists, shippers, local businesses and residents	Reduced Vehicle Operating Costs	**$7,879,856**
		Bypassing the grade crossing would reduce the amount spent maintaining the 19 at-grade crossings.	Local/state/federal government, and shippers,	Maintenance Cost Savings	**$7,650,000**
		Bypassing the road grade crossings will improve travel time reliability as there will be significantly lower probability for drivers to be delayed.	Motorists, shippers, local businesses, and residents	Improved Travel Time Reliability	**n/a**
		The new rail alignment will open up thousands of acres of vacant land currently zoned for industrial use serviceable by freight rail.	Motorists, shippers, local businesses and residents, local/state/federal governments	Improved Access to Future Development Potential	**n/a**

Current Status or Baseline & Problems to be Addressed	Changes to Baseline / Alternative	Type of Impacts	Population Affected by Impacts	Economic Benefits	Summary of Results ($2017)
		Reducing rail congestion by allowing higher speeds along new alignment will increase switching volumes and improve the current operational efficiency and capacity for economic growth.	Motorists, shippers, local businesses and residents, local/state/federal governments	Efficient Rail Operations	**n/a**
		Fewer rail crossing blockages will improve travel time and reliability for emergency responders that may otherwise be delayed or be forced to take a longer route.	Local residents	Improved Emergency Vehicle Access	**n/a**
		Reducing the number of trains travelling through Tucson limits potential hazardous cargo from passing through various neighborhoods, including two adjacent elementary schools.	Residents	Eliminate Transportation of Hazardous Materials through Residential Neighborhoods	**n/a**

The period of analysis used in the estimation of benefits and costs is 36 years, including 6 years of construction and project development, as well as 30 years of operation. The total project costs include $176.8 million dollars in future capital costs.

Table ES - 2, Table ES - 3 and Table ES - 4 provide various summaries of the relevant data and calculations used to derive the benefits and costs of the project. Based on the analysis presented in this document, the project is expected to generate $68.0 million in discounted benefits and $130.5 million in discounted costs, using a 7 percent real discount rate. Therefore, the project is expected to generate a Benefit/Cost Ratio of 0.52.

An additional scenario analysis was completed based on the need for various individual crossings that require grade crossing separation, following the criteria for highway-rail grade crossing separation presented in the *Railroad-Highway Grade Crossing Handbook* created by the USDOT FHWA.[1] Following the requirements, 3 crossings (22nd Street, Irvington Road, and Ajo Way crossings) would require grade separation and this would generate an additional $100.9 million in discounted benefits as the project would eliminate this need. Therefore, considering the individual at-grade separations, the project is expected to generate a Benefit/Cost Ratio of 1.29.

[1] Ogden, Brent D. and Korve Engineering. *Railroad-Highway Grade Crossing Handbook – Revised Second Edition 2007*. Prepared for: Federal Highway Administration, Office of Safety Design. Washington, D.C.

Table ES - 2: Summary of Total Project Benefits and Costs, (2017$)

Calendar Year	Project Year	Direct Beneficiaries	Total Economic Benefits	Total Costs	Undiscounted Net Benefits	Discounted Total Benefits at 7%	Discounted Total Costs at 7%	Discounted Net Benefits at 7%
2018	1	Workers otherwise unemployed (shadow wage benefit); not quantified	$0	$0	$0	$0	$0	$0
2019	2		$0	$0	$0	$0	$0	$0
2020	3		$0	$0	$0	$0	$0	$0
2021	4		$0	$0	$0	$0	$0	$0
2022	5		$0	$88,416,971	-$88,416,971	$0	$67,452,884	-$67,452,884
2023	6		$0	$88,416,971	-$88,416,971	$0	$63,040,078	-$63,040,078
2024	7	Federal and State governments, pedestrians, cyclists, motorists, local residents and businesses, trucking companies, property owners along the project corridor, and other residents across the country.	$6,072,267	$0	$6,072,267	$4,046,208	$0	$4,046,208
2025	8		$6,210,322	$0	$6,210,322	$3,867,476	$0	$3,867,476
2026	9		$6,351,167	$0	$6,351,167	$3,696,437	$0	$3,696,437
2027	10		$6,496,113	$0	$6,496,113	$3,533,455	$0	$3,533,455
2028	11		$6,644,182	$0	$6,644,182	$3,377,565	$0	$3,377,565
2029	12		$6,795,038	$0	$6,795,038	$3,228,274	$0	$3,228,274
2030	13		$6,948,641	$0	$6,948,641	$3,085,280	$0	$3,085,280
2031	14		$7,107,011	$0	$7,107,011	$2,949,157	$0	$2,949,157
2032	15		$7,266,904	$0	$7,266,904	$2,818,231	$0	$2,818,231
2033	16		$7,430,611	$0	$7,430,611	$2,693,195	$0	$2,693,195
2034	17		$7,598,256	$0	$7,598,256	$2,573,792	$0	$2,573,792
2035	18		$7,768,774	$0	$7,768,774	$2,459,395	$0	$2,459,395
2036	19		$7,942,748	$0	$7,942,748	$2,349,972	$0	$2,349,972
2037	20		$8,122,558	$0	$8,122,558	$2,245,955	$0	$2,245,955
2038	21		$8,304,576	$0	$8,304,576	$2,146,060	$0	$2,146,060
2039	22		$8,491,073	$0	$8,491,073	$2,050,705	$0	$2,050,705
2040	23		$8,681,487	$0	$8,681,487	$1,959,526	$0	$1,959,526
2041	24		$8,876,418	$0	$8,876,418	$1,872,453	$0	$1,872,453
2042	25		$9,075,736	$0	$9,075,736	$1,789,251	$0	$1,789,251
2043	26		$9,279,686	$0	$9,279,686	$1,709,775	$0	$1,709,775
2044	27		$9,489,219	$0	$9,489,219	$1,634,001	$0	$1,634,001
2045	28		$9,704,381	$0	$9,704,381	$1,561,730	$0	$1,561,730
2046	29		$9,924,064	$0	$9,924,064	$1,492,601	$0	$1,492,601
2047	30		$10,151,345	$0	$10,151,345	$1,426,902	$0	$1,426,902
2048	31		$10,385,264	$0	$10,385,264	$1,364,282	$0	$1,364,282
2049	32		$10,624,557	$0	$10,624,557	$1,304,409	$0	$1,304,409
2050	33		$10,871,404	$0	$10,871,404	$1,247,397	$0	$1,247,397
2051	34		$11,123,221	$0	$11,123,221	$1,192,795	$0	$1,192,795
2052	35		$11,381,912	$0	$11,381,912	$1,140,688	$0	$1,140,688
2053	36		$11,647,675	$0	$11,647,675	$1,090,955	$0	$1,090,955
Total			**$256,766,611**	**$176,833,941**	**$79,932,670**	**$67,907,922**	**$130,492,962**	**-$62,585,040**

Table ES - 3: Summary of Project Benefits by Benefit Type

Calendar Year	Project Year	Reduced Travel Time Costs	Improved Safety and Avoided Accident Costs	Avoided Emissions Costs	Reduced Vehicle Operating Costs	O&M Savings
2018	1	$0	$0	$0	$0	$0
2019	2	$0	$0	$0	$0	$0
2020	3	$0	$0	$0	$0	$0
2021	4	$0	$0	$0	$0	$0
2022	5	$0	$0	$0	$0	$0
2023	6	$0	$0	$0	$0	$0
2024	7	$3,254,747	$2,406,287	$5,961	$150,273	$255,000
2025	8	$3,360,019	$2,434,301	$6,060	$154,941	$255,000
2026	9	$3,467,981	$2,462,248	$6,158	$159,780	$255,000
2027	10	$3,578,672	$2,490,117	$6,256	$166,069	$255,000
2028	11	$3,692,119	$2,517,889	$6,351	$172,823	$255,000
2029	12	$3,808,472	$2,545,613	$6,446	$179,507	$255,000
2030	13	$3,927,863	$2,573,321	$6,539	$185,919	$255,000
2031	14	$4,050,472	$2,601,066	$6,631	$193,842	$255,000
2032	15	$4,176,073	$2,628,702	$6,720	$200,409	$255,000
2033	16	$4,304,790	$2,656,258	$6,808	$207,755	$255,000
2034	17	$4,436,777	$2,683,774	$6,894	$215,811	$255,000
2035	18	$4,572,114	$2,711,252	$6,978	$223,431	$255,000
2036	19	$4,710,909	$2,738,707	$7,059	$231,072	$255,000
2037	20	$4,853,238	$2,766,139	$7,274	$240,907	$255,000
2038	21	$4,999,181	$2,793,545	$7,494	$249,357	$255,000
2039	22	$5,148,843	$2,820,936	$7,719	$258,575	$255,000
2040	23	$5,302,345	$2,848,326	$7,950	$267,867	$255,000
2041	24	$5,459,977	$2,875,796	$8,188	$277,458	$255,000
2042	25	$5,621,966	$2,903,394	$8,432	$286,944	$255,000
2043	26	$5,788,498	$2,931,148	$8,683	$296,357	$255,000
2044	27	$5,959,843	$2,959,115	$8,941	$306,319	$255,000
2045	28	$6,136,134	$2,987,295	$9,207	$316,746	$255,000
2046	29	$6,317,580	$3,015,714	$9,481	$326,290	$255,000
2047	30	$6,504,461	$3,044,422	$9,762	$337,700	$255,000
2048	31	$6,696,979	$3,073,434	$10,053	$349,799	$255,000
2049	32	$6,895,316	$3,102,756	$10,352	$361,132	$255,000
2050	33	$7,099,685	$3,132,403	$10,660	$373,656	$255,000
2051	34	$7,310,122	$3,162,331	$10,977	$384,791	$255,000
2052	35	$7,526,809	$3,192,541	$11,304	$396,258	$255,000
2053	36	$7,749,931	$3,223,036	$11,641	$408,067	$255,000
Total		**$156,711,913**	**$84,281,863**	**$242,979**	**$7,879,856**	**$7,650,000**

Table ES - 4: Summary of Pertinent Quantifiable Data

Calendar Year	Project Year	Avoided Person Hours of Delay at Crossing	Avoided Gasoline Consumption (Gallons)	Avoided Diesel Consumption (Gallons)	Avoided Motor Oil Consumption (Quarts)	Fatalities Avoided - At Grade Crossing	Injuries Avoided - At Grade Crossing	PDO-Accidents Avoided	Fatalities Avoided - Trespasser Incidents	Injuries Avoided - Trespasser Incidents
2018	1	0	0	0	0	0.00	0.00	0.00	0.00	0.00
2019	2	0	0	0	0	0.00	0.00	0.00	0.00	0.00
2020	3	0	0	0	0	0.00	0.00	0.00	0.00	0.00
2021	4	0	0	0	0	0.00	0.00	0.00	0.00	0.00
2022	5	0	0	0	0	0.00	0.00	0.00	0.00	0.00
2023	6	0	0	0	0	0.00	0.00	0.00	0.00	0.00
2024	7	186,075	30,578	17,746	4,202	0.08	0.48	1.84	0.14	0.86
2025	8	192,089	31,576	18,323	4,339	0.08	0.48	1.86	0.14	0.87
2026	9	198,255	32,600	18,915	4,479	0.09	0.49	1.88	0.15	0.88
2027	10	204,578	33,650	19,522	4,623	0.09	0.49	1.90	0.15	0.89
2028	11	211,058	34,725	20,144	4,771	0.09	0.50	1.92	0.15	0.90
2029	12	217,704	35,829	20,782	4,922	0.09	0.50	1.94	0.15	0.91
2030	13	224,524	36,961	21,437	5,078	0.09	0.51	1.96	0.15	0.92
2031	14	231,527	38,124	22,109	5,237	0.09	0.51	1.98	0.15	0.93
2032	15	238,701	39,316	22,798	5,401	0.09	0.52	1.99	0.16	0.94
2033	16	246,053	40,537	23,504	5,568	0.09	0.52	2.01	0.16	0.95
2034	17	253,592	41,789	24,228	5,740	0.09	0.53	2.03	0.16	0.96
2035	18	261,322	43,074	24,971	5,917	0.09	0.53	2.05	0.16	0.97
2036	19	269,249	44,391	25,732	6,097	0.09	0.54	2.07	0.16	0.98
2037	20	277,378	45,741	26,513	6,283	0.10	0.54	2.09	0.16	0.99
2038	21	285,714	47,126	27,313	6,473	0.10	0.55	2.11	0.17	1.00
2039	22	294,262	48,547	28,134	6,668	0.10	0.55	2.13	0.17	1.01
2040	23	303,029	50,004	28,977	6,868	0.10	0.56	2.15	0.17	1.02
2041	24	312,032	51,500	29,841	7,073	0.10	0.56	2.17	0.17	1.03
2042	25	321,284	53,038	30,730	7,284	0.10	0.57	2.19	0.17	1.04
2043	26	330,795	54,619	31,644	7,501	0.10	0.57	2.21	0.17	1.05
2044	27	340,581	56,247	32,584	7,724	0.10	0.58	2.23	0.18	1.06
2045	28	350,650	57,921	33,552	7,954	0.10	0.58	2.25	0.18	1.07
2046	29	361,012	59,644	34,548	8,190	0.10	0.59	2.27	0.18	1.08
2047	30	371,685	61,419	35,574	8,434	0.10	0.59	2.29	0.18	1.09
2048	31	382,680	63,249	36,630	8,685	0.11	0.60	2.31	0.18	1.10
2049	32	394,007	65,133	37,719	8,943	0.11	0.60	2.33	0.18	1.11
2050	33	405,678	67,075	38,841	9,210	0.11	0.61	2.36	0.19	1.12
2051	34	417,696	69,075	39,997	9,484	0.11	0.62	2.38	0.19	1.13
2052	35	430,070	71,135	41,187	9,767	0.11	0.62	2.40	0.19	1.14
2053	36	442,812	73,256	42,412	10,058	0.11	0.63	2.42	0.19	1.15
Total		**8,956,092**	**1,477,882**	**856,410**	**202,972**	**2.90**	**16.50**	**63.75**	**5.01**	**30.15**

In addition to the monetized benefits presented in Table ES - 2 to Table ES - 3, the project would generate benefits that are difficult to monetize. A brief description of those benefits is provided below.

- ***Improved Travel Time Reliability***

  Travel time reliability reflects the variability of travel conditions and indicates how consistent or dependable daily travel times are. Generally, variability will arise either unpredictable demand, such as congestion and driver interactions, or unpredictable supply, such as traffic incidents, maintenance, as well as natural events. While it is obvious this would heavily be driven by train crossing delays in the study region, however other factors such as incidents both at crossings and along crossing could generate notable blockages. Such unpredictably and variability in travel times forces roadway users to either plan additional time beyond the expected time or alternatively deal with the consequences of being late. Moreover this would generate frustrating and stress inducing travel conditions.[2]

- ***Improved Access to Future Development Potential***

  The proposed Nogales Line Bypass will be located in a largely undeveloped area along Old Vail Connection Road. This will allow thousands of acres of vacant land currently zoned for industrial use to achieve its best use by allowing efficient freight rail service to service these lots.

- ***Efficient Freight Rail Operations***

  The bypass is also expect to significantly improve rail operations in Tucson, by allowing for higher speeds which will reduce rail congestion in the Sun Corridor region. This will result in increased switching volumes and thus improving the current operational efficiency and capacity for economic growth. As well, given the close proximity of the line to the Port of Tucson, the region's only intermodal facility, the bypass will promote continued freight growth through direct delivery and origination of international containers.

- ***Improved Emergency Vehicle Access***

  With key emergency services (fire, police, and EMS) located west of the rail crossings, the delays experienced at the crossings may impact the efficiency of these services. Eliminating the 19 at-grade crossing blockages will improve travel time and travel time reliability for emergency responders that may otherwise not be able to pass.

- ***Eliminate Transportation of Hazardous Materials through Residential Neighborhoods***

  The new bypass would limit the freight traffic traveling through various populated residential neighborhoods. The Federal Railroad Administration (FRA) Office of Safety reported that over 90 railcars carrying hazmat cargo were transported within Pima County between 2009 and 2017, which is approximately 10 hazmat railcars per year.[3] This project would eliminate hazardous cargo passing through these neighborhoods, which includes two elementary schools adjacent to the current Nogales Line.

[2] HDR. California Life-Cycle Benefit/Cost Analysis Model Reliability Enhancement – Technical Documentation. Prepared for California Department of Transportation. March 2018.

[3] Based on data from FRA Office of Safety, Table 1.12 Ten Year Accident/Incident Overview. Accessed May 10th, 2018.

2 Introduction

This document provides detailed technical information on the economic analyses conducted in support of the Grant Application for the Nogales Line Bypass project.

- Section 1 – Executive Summary
- Section 2 – Introduction: Outlines the BCA document layout and structure to assist USDOT reviewer.
- 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 Nogales Line Bypass 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: Estimates of travel demand and traffic volumes.
- Section 7 – Estimation of Economic Benefits: Details the specific data elements and assumptions used to address the goals of the project and to comply with program requirements.
- Section 8 –Summary of Findings and Benefit-Cost Outcome: 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 that evaluates the different assumptions made by Pima County and the impact that the variability of those assumptions may have on the overall project.
- Section 10 - Supplementary Data Tables: Includes a breakdown of all benefits associated with the outcomes for the project, including annual estimates of benefits and costs, as well as intermediate values to assist DOT in its review of the application.

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 Applications (June 2018). In particular, the methodology involves:

- Establishing existing and future conditions under the Build and No Build scenarios;
- Assessing benefits with respect to the merit criteria outcomes identified in the Notice of Funding Opportunity;
- 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

Pima County proposes construction of a grade-separated rail line in the rural and undeveloped area along Old Vail Connection Road connecting Nogales Line and Sunset Line outside downtown Tucson, bypassing 19 at-grade crossings in and around the downtown Tucson area. Currently, the Nogales Line generates significant east-west vehicle congestions, and with limited alternative route options, the congestion creates notable variability in travel time as well as crossing hazards for motorists and local residents. By rerouting rail traffic, the project will alleviate local traffic congestions and other problems which would otherwise worsen given the expected grown in rail traffic.

Beyond this, there are significant safety concerns along the corridor, especially given the expected growth in freight rail traffic. While there are standard concerns for potential incidents at grade crossings, another major safety concern pertains to safety along the Nogales Line tracks and the prevention of pedestrians from trespassing onto the tracks. The lack of barriers and the current alignment of the Nogales Line tracks increases the likelihood of incidents along the track from illegal pedestrian crossings.

A related concerns is the safety of the students who cross the tracks via bus or bicycle, or as pedestrians. There are two elementary schools located adjacent to the Nogales Line that are served by 73 school buses, where 70 of them cross the tracks 3 – 4 times daily. Other concerns include the increase risks from hazardous materials being transported through residential areas and school zones.

As presented in Figure 1, the Nogales Line Bypass Project creates a new grade-separated line that connects the Nogales Line to the Sunset Line. The new line, highlighted in blue, will be constructed in a largely undeveloped area along Old Vail Connection Road. This bypass will significantly reduce vehicle congestion at the existing 19 at-grade crossings, where 3 crossings are currently estimated to experience 40 vehicle-hours of daily delay due to rail traffic. Rerouting rail traffic would eliminate potential train/vehicle incidents at the 19 crossings and would reroute hazardous materials such that they are no longer transported through residential areas and school zones.

The project is also expected to support economic development in Tucson as the bypass is in alignment with Arizona's goal of supporting economic growth and enhancing the State's global competitive position through strategic rail initiatives. The bypass would not only open up thousands of acres of vacant land for industrial and logistics uses, which would be served by the new route, but it would also reduce rail congestion along the Sun Corridor.

The project will improve the current conditions in the area and in nearby neighborhoods by:

- ***Reducing*** wait times and prolonged queuing both at the crossings and along the project corridor.
- ***Enhancing*** public safety around the various residential areas and the two elementary schools adjacent to the Nogales Line by eliminating rail traffic at 19 at-grade crossings.
- ***Improving*** travel time reliability through the elimination of rail crossing blockages, allowing for greater predictability and less variability in travel times.
- ***Eliminating*** significant future capital costs of multiple grade crossing separation projects.
- ***Promoting*** future economic development along the new rail alignment.
- ***Supporting*** the economic growth of Arizona in line with the Arizona State Rail Plan.

4.1 Base Case and Alternative Case

4.1.1 Base Case

The Base Case for the Nogales Line Bypass project is defined as the No Build scenario. In the Base Case, trains still travel along the Nogales Line and continue train growth (both freight and passenger

train) continues to delay road users. Vehicles queuing along the various at-grade crossings continue to pose severe safety concerns.

The key assumptions used to define the Base Case (No Build Scenario) are as follows:

- Average Annual Daily Traffic (AADT) on all crossings are expected to grow at a rate correlated to the population growth projected to Pima County.[4]
- AADT is broken down between passenger vehicles and trucks based on the Federal Railroad Administration's (FRA) Highway-Rail Crossing Inventory database.
- **6** daily freight trains (2017) growing at a rate of **2.0** percent per year, which follows the average estimated US freight rail growth.
- **2** daily local trains (2017) growing at a rate of **2.0** percent per year.
- Average train length of **7,000** feet.
- Average train speed for each crossing uses the average of the minimum track speed and the maximum timetable speed using data obtained from the FRA.
- Average lead and lag time for gate closure of **0.5** minutes.

4.1.2 Alternative Case

The Alternative Case is defined as the Build scenario. In the Alternative Case, a new bypass route for rail will be constructed south of downtown Tucson in a largely undeveloped area along Old Vail Connection Road. The bypass will connect the Nogales Line and the Sunset Line outside of the downtown core and reroute train traffic to avoid the at-grade crossings. Traffic congestion and relative safety concerns are eliminated due to the rerouted train traffic. Specifically, the new infrastructure and improved process described in the project overview section above will result in the following changes to some key inputs and assumptions:

- Average Annual Daily Traffic (AADT) on all crossings are expected to grow at a rate correlated to the population growth projected to Pima County. (Same as Base Case)
- AADT is broken down between passenger vehicles and trucks based on the Federal Railroad Administration's (FRA) Highway-Rail Crossing Inventory database.
- **6** daily freight trains (2017) growing at a rate of **2.0** percent per year (same as Base Case)
- **2** daily local trains (2017) growing at a rate of **2.0** percent per year (same as Base Case)
- Average train length of **7,000** feet. (Same as Base Case).
- Average train speed for each crossing uses the average of the minimum track speed and the maximum timetable speed using data obtained from the FRA (Same as Base Case)
- Average lead and lag time for gate closure of **0.5** minutes (Same as Base Case)

4.2 Project Cost and Schedule

Table 1 summarizes the project's capital expenditure components, with construction beginning in 2022 and project delivery estimated for 2024.

[4] Population projection for Pima County based on 2013 - 2050 Incorporated Place Population Projects in Pima County from the Arizona Department of Economic Security.

Table 1: Cost Summary Table, 2017 Dollars

Capital Expenditures	2017 Dollars
2022	$88,416,971
2023	$88,416,971
Total	**$176,833,941**

Table 2: Capital Cost Component, 2017 Dollars

Capital Expenditures	2017 Dollars
Construction Costs	$113,449,632
Design Engineering	$3,743,838
Construction Engineering	$7,487,676
Mobilization	$11,344,963
Contingency	$40,807,833
Total Project Cost	**$176,833,941**

4.3 Benefit Outcomes

The main benefit categories associated with the project are summarized in the table below.

Table 3: Expected Effects on Benefit Categories

Impact Categories	Description	Monetized	Qualitative
Reduced Travel Time Costs	Reduced travel time costs from vehicle idling and delay at 19 at-grade crossings.	Yes	-
Improved Safety and Avoided Accident Costs	Improved safety and avoided accident costs from bypassing the Nogales Line and the 19 road grade crossings.	Yes	-
Avoided Emissions Costs	Avoided emission costs from vehicle idling and delay along the existing Nogales Line	Yes	-
Reduced Vehicle Operating Costs	Reduced vehicle operating costs from vehicle idling and delay along the existing Nogales Line.	Yes	-
O&M Cost Savings	Bypassing the grade crossing would reduce the amount spent maintaining the 19 at-grade crossings.	Yes	-
Improved Travel Time Reliability	Bypassing the road grade crossings will improve travel time reliability as there will be significantly lower probability for drivers to be delayed.	-	Yes
Improved Access to Future Development Potential	The new rail alignment will open up thousands of acres of vacant land currently zoned for industrial use serviceable by freight rail.	-	Yes
Efficient Rail Operations	Reducing rail congestion by allowing higher speeds along new alignment will increase switching volumes and improve the current operational efficiency and capacity for economic growth.	-	Yes
Improved Emergency Vehicle Access	Fewer rail crossing blockages will improve travel time and reliability for emergency responders that may otherwise be delayed or be forced to take a longer route.	-	Yes
Eliminate Transportation of Hazardous Materials through Residential Neighborhoods	Reducing the number of trains travelling through Tucson limits potential hazardous cargo from passing through various neighborhoods, including two adjacent elementary schools.	-	Yes

5 General Assumptions

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

The monetized benefits and costs are estimated in 2017 dollars with future dollars discounted 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 2017 dollars;
- The period of analysis begins in 2018 and ends in 2053. It includes project development and construction years (6) and full years of operations (30).
- 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.

6 Demand Projections

Accurate demand projections are important to ensure the reasonable BCA output results. The magnitudes of the long-term benefits accruing over the Nogales Line Bypass project study period are a function of vehicle traffic at the various 19 at-grade crossings, vehicle traffic growth, and train growth.

6.1 Methodology

Population projections from 2015 – 2050 for Pima County developed by the office of Economic Opportunity were used to provide annual growth rates. For years after 2050, the growth rates are assumed to be constant based on the 2050 growth rates. Meanwhile, all train traffic will be rerouted along the proposed bypass, and thus there will be no rail traffic along the Nogales Line in the Alternative case.

6.2 Assumptions

General assumptions used for the entire corridor in the estimation of demand inputs for the Nogales Line Bypass project are provided in Table 4. Crossing specific assumptions, such as AADT and bus counts, used in the analysis can be found in Section 10.2 – 10.4.

Table 4: Assumptions used in the Estimation of Demand

Variable Name	Unit	Date	Value	Source
Freight Trains at Crossing	trains/day	2017	6	Pima County. Based on FRA Data, rail expert opinion. Growth rates for train traffic growth are based FRA long term national freight growth.
Local Trains at Crossing	trains/day	2017	2	
Avg. Freight Train Length	feet	2017	7000	
Avg. Local Train Length	feet	2017	7000	
Freight Train Traffic Growth	%	2018-2053	2%	
Local Train Traffic Growth	%	2018-2053	2%	
Lead and Lag Time	minutes	2018-2053	0.5	
AADT Growth Rate (2010 - 2017)	%	2010-2017	0.61%	HDR calculation based on United States Census Bureau population estimates for Pima County between 2010 and 2017.
AADT Growth Rate	%	2018	1.55%	HDR calculated based on 2013 - 2050 Incorporated Place Population Projects in
		2019	1.43%	

Variable Name	Unit	Date	Value	Source
		2020	1.36%	Pima County from the Arizona Department of Economic Security.
		2021	1.33%	
		2022	1.31%	
		2023	1.28%	
		2024	1.26%	
		2025	1.24%	
		2026	1.22%	
		2027	1.20%	
		2028	1.17%	
		2029	1.15%	
		2030	1.14%	
		2031	1.12%	
		2032	1.10%	
		2033	1.08%	
		2034	1.07%	
		2035	1.05%	
		2036	1.04%	
		2037	1.02%	
		2038	1.01%	
		2039	0.99%	
		2040	0.98%	
		2041	0.97%	
		2042	0.97%	
		2043	0.96%	
		2044	0.96%	
		2045	0.96%	
		2046	0.96%	
		2047	0.96%	
		2048	0.96%	
		2049	0.96%	
		2050	0.96%	
		2051	0.96%	
		2052	0.96%	
		2053	0.96%	

6.3 Demand Projections

The resulting projections for annual train and vehicle traffic volumes are presented in the table below. As well, the table also presents the total expected hours of delay in the corridor given demand projections. Demand forecasts by grade crossing can be found in Sections 10.5 and 10.6, while detailed corridor traffic projections can be found in Section 10.7.

Table 5: Demand Projections – Corridor

Category	2018	2023	2033	2043	2053
Total Annual Traffic for Corridor	222,901	238,209	267,451	295,518	325,045
Annual Freight Trains	2,190	2,418	2,947	3,593	4,380
Annual Local Trains	730	806	982	1,198	1,460
Total Vehicle Hours Delay for Corridor	99,779	117,750	161,200	217,169	291,232
Total Person Hours Delay for Corridor	152,965	180,213	246,053	330,795	442,812

7 Estimation of Economic Benefits

This section describes the measurement approach used for each benefit or impact category identified in Table ES - 1 and provides an overview of the associated methodology, assumptions, and estimates.

7.1 Travel Time Costs

7.1.1 Methodology

Travel time savings will be generated for motorists (automobiles, trucks, transit and school buses) along the at-grade crossings. Reduced crossing blockage times will lead to decreased vehicle travel time costs which are monetized using DOT guidance for value of time of automobile drivers and passengers, transit bus passengers, as well as heavy vehicle truck drivers and bus drivers. It should be noted that while school buses were included, only the benefits of the bus driver were monetized given the passengers of focus are elementary school students and lack an appropriate value of time.

Travel time savings in hours between the Base and the Alternative Cases were estimated based on AADT forecasts derived on Pima County's historical traffic counts, population projection for Pima County, and the Federal Rail Administration (FRA) database regarding daily train counts, speeds, and lengths. The expected crossing time delay was then derived by applying the probability of delay which is a function of train frequency, speed, length, and lead and lag time.

Value of time by vehicle type, as well as occupancy assumptions for both automobiles and trucks are available in the Benefit-Cost Analysis Guidance for TIGER and INFRA Applications published by US DOT. The average transit bus occupancy was derived from Sun Tran data and consultation with Pima County. The estimate for travel time savings is simply the product of hours of delay, vehicle occupancy, and respective value of time.

7.1.2 Assumptions

The assumptions used in the estimation of economic outcomes and benefits are summarized in the table below.

Table 6: Assumptions used in the Estimation of Travel Time Costs

Variable Name	Unit	Date	Value	Source
Average Passenger Vehicle Occupancy	persons	2018-2053	1.70	FHWA: Average Vehicle Occupancy Factors for Computing Travel Time Reliability Measures and Total Peak Hour Excessive Delay Metrics. (April 2018)
Average Truck Occupancy	persons	2018-2053	1.00	
Average Transit Bus Occupancy - 22nd Street Crossing	persons	2018-2053	24.5	HDR Calculated based on Sun Tran Monthly Reports for 2017 and Sun Tran Route Maps and Schedules.
Average Transit Bus Occupancy - Ajo Way Crossing	persons	2018-2053	27.5	
Average Transit Bus Occupancy - Irvington Road Crossing	persons	2018-2053	18.9	
Average Transit Bus Occupancy - Vamori Road Crossing	persons	2018-2053	8.0	
Average Transit Bus Occupancy - Hermans Road Crossing	persons	2018-2053	8.0	

Variable Name	Unit	Date	Value	Source
Average Transit Bus Occupancy - Hughes Access Road Crossing	persons	2018-2053	8.0	
Average Transit Bus Occupancy - Others	persons	2018-2053	0.0	
Value of Time for Automobile Driver and Passenger	2017$/hour	2018-2053	$14.8	USDOT BCA Guidance, 2018
Value of Time for Truck Driver	2017$/hour	2018-2053	$28.6	
Value of Time for Bus Driver	2017$/hour	2018-2053	$30.0	
Value of Time for Bus Passenger	2017$/hour	2018-2053	$14.8	

7.1.3 Benefit Estimates

The complete set of economic outcomes is shown in the table below. With a 7 percent discount rate, the estimated present value of benefits over the project life cycle is approximately $39.9 million. These benefits accrue to many users including motorists, local residents and businesses, and shippers. See Section 10.8 and 10.9 for additional information.

Table 7: Estimates of Travel Time Costs, 2017 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Reduced Travel Time Costs	$3,254,747	$156,711,913	$39,945,245
Total	**$3,254,747**	**$156,711,913**	**$39,945,245**

7.2 Vehicle Operating Costs

7.2.1 Methodology

The elimination of vehicle idling time along the at-grade crossings will translate into lower net vehicle operating costs from reduced fuel and motor oil consumption. The change in vehicle delay time (by vehicle type and by year) is multiplied by the associated vehicle fuel consumption rate to obtain annual estimates of fuel consumption from idling. This multiplied by the cost per unit of fuel provides an estimate of the change in fuel costs. The same methodology is applied to track the change in motor oil consumption and costs. The sum of the two costs produces an estimate for the overall vehicle operating cost impacts due to vehicle delay time at the crossing.

7.2.2 Assumptions

The assumptions used in the estimation of vehicle operating costs are summarized in the table below.

Table 8: Assumptions used in the Estimation of Vehicle Operating Costs

Variable Name	Unit	Date	Value	Source
Vehicle Fuel Burned at Idle - Automobile	gal/hr	2018-2053	0.36	US DOE: Alternative Fuels Data Center and Argonne National Laboratory, "Idle Reduction Savings Worksheet" (2014) - Average of gasoline passenger vehicles
Vehicle Diesel Burned at Idle - Truck	gal/hr	2018-2053	0.49	US DOE: Alternative Fuels Data Center and Argonne National Laboratory, "Idle Reduction Savings Worksheet" (2014) - Combination Trucks
Vehicle Diesel Burned at Idle - Bus	gal/hr	2018-2053	0.97	US DOE: Alternative Fuels Data Center and Argonne National Laboratory, "Idle Reduction Savings Worksheet" (2014) - Transit Bus

Variable Name	Unit	Date	Value	Source
Average Consumption of Motor Oil per Hour	quarts/hr	2018-2053	0.03	Based on US DOT: HERS-ST Highway Economic Requirements System (2002) oil consumption of 1.38qt/1000miles and assuming that "One hour of idle time is equal to approximately 25 miles of driving" (Ford Motor Company, 2011)
Cost of Motor Oil - Automobile	2017$/hour	2018-2053	$10.16	Average oil price sourced from HERS model and inflated to 2017$ by Motor Oil CPI (BLS CUUR0000SS47021)
Cost of Motor Oil - Truck	2017$/hour	2018-2053	$4.06	
Cost of Motor Oil - Bus	2017$/hour	2018-2053	$4.06	
Gasoline Retail Price	2017$/gallon	2018	$1.97	Gasoline and Diesel Source: US EIA Annual Energy Outlook 2018, net of Federal & State Taxes
		2019	$2.03	
		2020	$2.39	
		2021	$2.56	
		2022	$2.64	
		2023	$2.70	
		2024	$2.77	
		2025	$2.77	
		2026	$2.77	
		2027	$2.79	
		2028	$2.82	
		2029	$2.86	
		2030	$2.88	
		2031	$2.92	
		2032	$2.94	
		2033	$2.96	
		2034	$2.99	
		2035	$3.01	
		2036	$3.02	
		2037	$3.07	
		2038	$3.09	
		2039	$3.11	
		2040	$3.14	
		2041	$3.16	
		2042	$3.18	
		2043	$3.19	
		2044	$3.20	
		2045	$3.21	
		2046	$3.20	
		2047	$3.22	
		2048	$3.24	
		2049	$3.25	
		2050	$3.26	
		2051	$3.26	
		2052	$3.26	
		2053	$3.26	
Diesel Retail Price	2017$/gallon	2018	$1.42	Gasoline and Diesel Source: US EIA Annual Energy Outlook 2018, net of Federal & State Taxes
		2019	$1.47	
		2020	$1.54	
		2021	$1.62	
		2022	$1.64	
		2023	$1.72	
		2024	$1.72	
		2025	$1.71	
		2026	$1.70	
		2027	$1.71	
		2028	$1.73	
		2029	$1.73	
		2030	$1.73	
		2031	$1.75	
		2032	$1.74	
		2033	$1.76	

Variable Name	Unit	Date	Value	Source
		2034	$1.77	
		2035	$1.78	
		2036	$1.80	
		2037	$1.81	
		2038	$1.82	
		2039	$1.84	
		2040	$1.85	
		2041	$1.87	
		2042	$1.88	
		2043	$1.89	
		2044	$1.90	
		2045	$1.92	
		2046	$1.94	
		2047	$1.95	
		2048	$1.97	
		2049	$1.98	
		2050	$2.00	
		2051	$2.00	
		2052	$2.00	
		2053	$2.00	

7.2.3 Benefit Estimates

The table below shows the benefit estimates of reduced vehicle operating costs. With a 7 percent discount rate applied to the benefits, the estimated present value is $1.96 million. See Section 10.10 and 10.11 for more information.

Table 9: Estimates of Vehicle Operating Costs, 2017 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Reduced Vehicle Operating Costs	$150,273	$7,879,856	$1,957,582
Total	**$150,273**	**$7,879,856**	**$1,957,582**

7.3 Safety Outcomes

The proposed project would contribute to promoting DOT's safety merit outcome through accident reductions due to significant decreases in the likelihood of train/vehicle encounters, if any, along all at-grade crossing along the Nogales line.

The bypass would also improve the safety of the students who cross the tracks as vehicle passengers, cyclist, or pedestrians to reach school. While there are many schools along the various districts impacted by the current line, two particular elementary schools are located adjacent to the line and would benefit the most by the project, relative to the other schools. In particular, it would eliminate the potential for train/vehicle encounters between train and school buses, as well as the accidents related to those who walk or cycle to school. Currently, the two elementary schools combined have 73 daily bus routes, where majority of the buses cross the tracks 3 – 4 times per day.

Trespasser incidents are not concerns limited to students, as it is a concern to all pedestrians and residents. This is driven mainly due to ease in which pedestrians can illegally cross the current Nogales Line as it is not fenced off nor is it separated. Since there is no preventative measures to limit pedestrians from trespassing and crossing the tracks, there have been several trespasser incidents that have led to both injuries and fatalities in the past.

7.3.1 Methodology

Accident costs, and impacts on life, limb and property, are a significant component of road user costs. Road safety is a key economic factor in the planning of roads, as well as an important indicator of transportation efficiency, while outside of the economic context, highway safety is often the object of public concern and a leading social issue. Estimating safety benefits requires data on the characteristics of the grade crossings; in addition, the costs of injuries and fatalities must be monetized. Expected accidents at the various at-grade crossings were derived using the FRA's collision prediction formulae.

Trespasser incident projections are derived using the 10 year historical average for trespasser incidents by incident type. This data is collected from the FRA's Office of Safety Report 4.12, *Causalities by State/Railroad,* isolating for Pima County. Only incidents which occurred along the study region based on the reported longitude and latitude in the individual incident reports. For incidents without locational data (i.e. longitude and latitude), the respective share of incident counts, by accident type, in the study area is used to derive the expected incident count.

7.3.2 Assumptions

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

Table 10: Assumptions used in the Estimation of Safety Benefits

Variable Name	Unit	Value	Source
Value of a Statistical Life	2017$/fatality	$9,600,000	US DOT, BCA Guidance 2018. Guidance on Treatment of the Economic Value of a Statistical Life in U.S. Department of Transportation Analyses. 2016.
Average Cost per Accident Injury	2017$/fatality	$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 PDO Accident	2017 $/pdo accident	$4,327	US DOT, BCA Guidance 2018 and The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (revised May 2015), Page 12, Table 1-2, Summary of Unit Costs, 2000"
Historic 10 Year Average Trespasser Incidents - Fatalities	fatalities/year	0.131	HDR Calculated based on 11 year (2007 - 2017) historical trespasser incidents along the Study Area. Data obtained from FRA Office of Safety Report 4.12
Historic 10 Year Average Trespasser Incidents - Injuries	injuries/year	0.791	
2018 Expected Accident Rate - Grade Crossing - Grade Crossing	accidents/year	1.73	HDR Calculations using FRA Collision Prediction Formulae
2023 Expected Accident Rate - Grade Crossing	accidents/year	1.83	
2033 Expected Accident Rate - Grade Crossing	accidents/year	2.01	
2043 Expected Accident Rate - Grade Crossing	accidents/year	2.21	
2053 Expected Accident Rate - Grade Crossing	accidents/year	2.42	

7.3.3 Benefit Estimates

The table below shows the benefit estimates of significantly reduced train/vehicle encounters and trespasser incidents. With a 7 percent discount rate applied to the benefits, the estimated present value is $23.7 million. See Section 10.12 and 10.13 for additional information.

Table 11: Estimates of Safety Benefits, 2017 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Improved Safety and Avoided Accident Costs	$2,406,287	$84,281,863	$23,684,973
Total	**$2,406,287**	**$84,281,863**	**$23,684,973**

7.4 Environmental Sustainability Outcomes

The proposed project would contribute to environmental sustainability benefits through a net reduction in emissions due to reduced vehicle delay time along the 19 at-grade crossings. Environmental costs are increasingly considered as an important component in the evaluation of transportation projects and the main environmental impacts of vehicle use and exhaust emissions can impose wide-ranging social costs on people, material, and vegetation. The negative effects of pollution depend not only on the quantity of pollution produced, but also on the types of pollutants emitted and the conditions into which the pollution is released.

7.4.1 Methodology

The change in vehicle delay time at all the crossing is used to estimate the total fuel consumption while idling by vehicle type. The total estimated vehicle delay times are multiplied by the appropriate emission factors for tons of for CO_2, NO_x VOC, PM, and SO_2 per hour of vehicle idling. Each pollutant is then multiplied by its monetary value to get the total emission cost impact due to vehicle delay time.

7.4.2 Assumptions

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

Table 12: Assumptions used in the Estimation of Environmental Sustainability Benefits

Variable	Unit	Year	Value	Source
Auto Emissions Inputs				
NOx per Gallon of Fuel Burned - Autos (Idling)	grams/hour	2018	0.32	HDR Calculations based on Auto Emissions reported in California Air Resources Board, EMFAC 2014
		2019	0.31	
		2020	0.29	
		2021	0.28	
		2022	0.26	
		2023	0.25	
		2024	0.24	
		2025	0.22	
		2026	0.21	
		2027	0.19	
		2028	0.18	
		2029	0.17	
		2030	0.15	
		2031	0.14	
		2032	0.13	
		2033	0.11	
		2034	0.10	
		2035	0.08	
		2036	0.07	
		2037	0.07	
		2038	0.07	
		2039	0.07	
		2040	0.07	

Variable	Unit	Year	Value	Source
		2041	0.07	
		2042	0.07	
		2043	0.07	
		2044	0.07	
		2045	0.07	
		2046	0.07	
		2047	0.07	
		2048	0.07	
		2049	0.07	
		2050	0.07	
		2051	0.07	
		2052	0.07	
		2053	0.07	
VOC per Gallon of Fuel Burned - Autos (Idling)	grams/hour	2018	0.01	HDR Calculations based on Auto Emissions reported in California Air Resources Board, EMFAC 2014
		2019	0.01	
		2020	0.01	
		2021	0.01	
		2022	0.01	
		2023	0.01	
		2024	0.01	
		2025	0.01	
		2026	0.01	
		2027	0.01	
		2028	0.01	
		2029	0.01	
		2030	0.01	
		2031	0.01	
		2032	0.01	
		2033	0.01	
		2034	0.01	
		2035	0.01	
		2036	0.01	
		2037	0.01	
		2038	0.01	
		2039	0.01	
		2040	0.01	
		2041	0.01	
		2042	0.01	
		2043	0.01	
		2044	0.01	
		2045	0.01	
		2046	0.01	
		2047	0.01	
		2048	0.01	
		2049	0.01	
		2050	0.01	
		2051	0.01	
		2052	0.01	
		2053	0.01	
PM per Gallon of Fuel Burned - Autos (Idling)	grams/hour	2018	0.01	HDR Calculations based on Auto Emissions reported in California Air Resources Board, EMFAC 2014
		2019	0.01	
		2020	0.01	
		2021	0.01	
		2022	0.01	
		2023	0.01	
		2024	0.01	
		2025	0.01	
		2026	0.01	
		2027	0.01	
		2028	0.01	
		2029	0.01	
		2030	0.01	
		2031	0.01	

Variable	Unit	Year	Value	Source
		2032	0.01	
		2033	0.01	
		2034	0.01	
		2035	0.01	
		2036	0.01	
		2037	0.01	
		2038	0.01	
		2039	0.01	
		2040	0.01	
		2041	0.01	
		2042	0.01	
		2043	0.01	
		2044	0.01	
		2045	0.01	
		2046	0.01	
		2047	0.01	
		2048	0.01	
		2049	0.01	
		2050	0.01	
		2051	0.01	
		2052	0.01	
		2053	0.01	
SO_2 per Gallon of Fuel Burned - Autos (Idling)	grams/hour	2018	0.32	HDR Calculations based on Auto Emissions reported in California Air Resources Board, EMFAC 2014
		2019	0.31	
		2020	0.29	
		2021	0.28	
		2022	0.27	
		2023	0.26	
		2024	0.25	
		2025	0.24	
		2026	0.23	
		2027	0.22	
		2028	0.21	
		2029	0.19	
		2030	0.18	
		2031	0.17	
		2032	0.16	
		2033	0.15	
		2034	0.14	
		2035	0.13	
		2036	0.12	
		2037	0.12	
		2038	0.12	
		2039	0.12	
		2040	0.12	
		2041	0.12	
		2042	0.12	
		2043	0.12	
		2044	0.12	
		2045	0.12	
		2046	0.12	
		2047	0.12	
		2048	0.12	
		2049	0.12	
		2050	0.12	
		2051	0.12	
		2052	0.12	
		2053	0.12	
Truck Emissions Inputs				
NOx per Gallon of Fuel Burned - Trucks (Idling)	grams/hour	2018	8.19	HDR Calculations based on Truck Emissions reported in California Air Resources Board, EMFAC 2014
		2019	8.30	
		2020	8.41	
		2021	8.52	

Variable	Unit	Year	Value	Source
		2022	8.63	
		2023	8.73	
		2024	8.84	
		2025	8.95	
		2026	9.06	
		2027	9.17	
		2028	9.28	
		2029	9.39	
		2030	9.49	
		2031	9.60	
		2032	9.71	
		2033	9.82	
		2034	9.93	
		2035	10.04	
		2036	10.14	
		2037	10.14	
		2038	10.14	
		2039	10.14	
		2040	10.14	
		2041	10.14	
		2042	10.14	
		2043	10.14	
		2044	10.14	
		2045	10.14	
		2046	10.14	
		2047	10.14	
		2048	10.14	
		2049	10.14	
		2050	10.14	
		2051	10.14	
		2052	10.14	
		2053	10.14	
VOC per Gallon of Fuel Burned - Trucks (Idling)	grams/hour	2018	0.10	HDR Calculations based on Truck Emissions reported in California Air Resources Board, EMFAC 2014
		2019	0.09	
		2020	0.09	
		2021	0.08	
		2022	0.08	
		2023	0.07	
		2024	0.07	
		2025	0.07	
		2026	0.06	
		2027	0.06	
		2028	0.05	
		2029	0.05	
		2030	0.04	
		2031	0.04	
		2032	0.03	
		2033	0.03	
		2034	0.02	
		2035	0.02	
		2036	0.01	
		2037	0.01	
		2038	0.01	
		2039	0.01	
		2040	0.01	
		2041	0.01	
		2042	0.01	
		2043	0.01	
		2044	0.01	
		2045	0.01	
		2046	0.01	
		2047	0.01	
		2048	0.01	

Variable	Unit	Year	Value	Source
		2049	0.01	
		2050	0.01	
		2051	0.01	
		2052	0.01	
		2053	0.01	
PM per Gallon of Fuel Burned - Trucks (Idling)	grams/hour	2018	0.02	HDR Calculations based on Truck Emissions reported in California Air Resources Board, EMFAC 2014
		2019	0.02	
		2020	0.02	
		2021	0.02	
		2022	0.02	
		2023	0.02	
		2024	0.02	
		2025	0.02	
		2026	0.02	
		2027	0.02	
		2028	0.02	
		2029	0.02	
		2030	0.02	
		2031	0.02	
		2032	0.02	
		2033	0.02	
		2034	0.02	
		2035	0.02	
		2036	0.02	
		2037	0.02	
		2038	0.02	
		2039	0.02	
		2040	0.02	
		2041	0.02	
		2042	0.02	
		2043	0.02	
		2044	0.02	
		2045	0.02	
		2046	0.02	
		2047	0.02	
		2048	0.02	
		2049	0.02	
		2050	0.02	
		2051	0.02	
		2052	0.02	
		2053	0.02	
SO_2 per Gallon of Fuel Burned - Trucks (Idling)	grams/hour	2018	0.99	HDR Calculations based on Truck Emissions reported in California Air Resources Board, EMFAC 2014
		2019	0.96	
		2020	0.93	
		2021	0.90	
		2022	0.87	
		2023	0.84	
		2024	0.81	
		2025	0.78	
		2026	0.75	
		2027	0.72	
		2028	0.69	
		2029	0.66	
		2030	0.63	
		2031	0.60	
		2032	0.57	
		2033	0.53	
		2034	0.50	
		2035	0.47	
		2036	0.44	
		2037	0.44	
		2038	0.44	
		2039	0.44	

Variable	Unit	Year	Value	Source
		2040	0.44	
		2041	0.44	
		2042	0.44	
		2043	0.44	
		2044	0.44	
		2045	0.44	
		2046	0.44	
		2047	0.44	
		2048	0.44	
		2049	0.44	
		2050	0.44	
		2051	0.44	
		2052	0.44	
		2053	0.44	
Bus Emissions Inputs				
NOx per Gallon of Fuel Burned - Buses (Idling)	grams/hour	2018	20.41	HDR Calculations based on Bus Emissions reported in California Air Resources Board, EMFAC 2014
		2019	19.57	
		2020	18.73	
		2021	17.89	
		2022	17.05	
		2023	16.21	
		2024	15.37	
		2025	14.53	
		2026	13.69	
		2027	12.85	
		2028	12.01	
		2029	11.17	
		2030	10.33	
		2031	9.49	
		2032	8.65	
		2033	7.81	
		2034	6.97	
		2035	6.13	
		2036	5.29	
		2037	5.29	
		2038	5.29	
		2039	5.29	
		2040	5.29	
		2041	5.29	
		2042	5.29	
		2043	5.29	
		2044	5.29	
		2045	5.29	
		2046	5.29	
		2047	5.29	
		2048	5.29	
		2049	5.29	
		2050	5.29	
		2051	5.29	
		2052	5.29	
		2053	5.29	
VOC per Gallon of Fuel Burned - Buses (Idling)	grams/hour	2018	0.36	HDR Calculations based on Bus Emissions reported in California Air Resources Board, EMFAC 2014
		2019	0.34	
		2020	0.33	
		2021	0.31	
		2022	0.29	
		2023	0.27	
		2024	0.25	
		2025	0.23	
		2026	0.22	
		2027	0.20	
		2028	0.18	
		2029	0.16	

Variable	Unit	Year	Value	Source
		2030	0.14	
		2031	0.13	
		2032	0.11	
		2033	0.09	
		2034	0.07	
		2035	0.05	
		2036	0.04	
		2037	0.04	
		2038	0.04	
		2039	0.04	
		2040	0.04	
		2041	0.04	
		2042	0.04	
		2043	0.04	
		2044	0.04	
		2045	0.04	
		2046	0.04	
		2047	0.04	
		2048	0.04	
		2049	0.04	
		2050	0.04	
		2051	0.04	
		2052	0.04	
		2053	0.04	
PM per Gallon of Fuel Burned - Buses (Idling)	grams/hour	2018	0.03	HDR Calculations based on Bus Emissions reported in California Air Resources Board, EMFAC 2014
		2019	0.03	
		2020	0.03	
		2021	0.03	
		2022	0.03	
		2023	0.03	
		2024	0.03	
		2025	0.03	
		2026	0.03	
		2027	0.03	
		2028	0.03	
		2029	0.03	
		2030	0.02	
		2031	0.02	
		2032	0.02	
		2033	0.02	
		2034	0.02	
		2035	0.02	
		2036	0.02	
		2037	0.02	
		2038	0.02	
		2039	0.02	
		2040	0.02	
		2041	0.02	
		2042	0.02	
		2043	0.02	
		2044	0.02	
		2045	0.02	
		2046	0.02	
		2047	0.02	
		2048	0.02	
		2049	0.02	
		2050	0.02	
		2051	0.02	
		2052	0.02	
		2053	0.02	
SO_2 per Gallon of Fuel Burned - Buses (Idling)	grams/hour	2018	2.84	HDR Calculations based on Bus Emissions reported in California Air Resources Board, EMFAC 2014
		2019	2.70	
		2020	2.57	

Variable	Unit	Year	Value	Source
		2021	2.43	
		2022	2.29	
		2023	2.16	
		2024	2.02	
		2025	1.89	
		2026	1.75	
		2027	1.61	
		2028	1.48	
		2029	1.34	
		2030	1.20	
		2031	1.07	
		2032	0.93	
		2033	0.80	
		2034	0.66	
		2035	0.52	
		2036	0.39	
		2037	0.39	
		2038	0.39	
		2039	0.39	
		2040	0.39	
		2041	0.39	
		2042	0.39	
		2043	0.39	
		2044	0.39	
		2045	0.39	
		2046	0.39	
		2047	0.39	
		2048	0.39	
		2049	0.39	
		2050	0.39	
		2051	0.39	
		2052	0.39	
		2053	0.39	
Emission Value Inputs				
NOx cost per short ton	2017$/short ton	2017-2053	$7,508	US DOT, BCA Guidance 2018 and Corporate Average Fuel Economy for MY2017-MY2025 Passenger Cars and Light Trucks (August 2012), page 922, Table VIII-16, "Economic Values Used for Benefits Computations (2010 dollars)".
VOC cost per short ton	2017$/short ton	2017-2053	$1,905	
PM cost per short ton	2017$/short ton	2017-2053	$343,442	
SO_2 cost per short ton	2017$/short ton	2017-2053	$44,373	

7.4.3 Benefit Estimates

The table below shows the benefit estimates of reducing vehicle delay times. With a 7 percent discount rate, the estimated present value of benefits over the project life cycle is $64,015 dollars. See Sections 10.14 and 10.15 for additional information.

Table 13: Estimates of Community and Environmental Benefits, 2017 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Avoided Emissions Costs	$5,961	$242,979	$64,015
Total	**$5,961**	**$242,979**	**$64,015**

7.5 Maintenance Cost Savings

7.5.1 Methodology

The proposed project would contribute to overall state of good repair by bypassing the 19 at-grade crossings, thus reducing the ongoing costs to maintain the various crossings.

7.5.2 Assumptions

The assumptions used in the estimation of maintenance cost savings are summarized in the table below.

Table 14: Assumptions used in the Estimation of Maintenance Cost Savings

Variable Name	Unit	Date	Value	Source
Surface Cost per Crossing	2017$	2018-2053	$3,500	Pima County. Based on opinion from rail expert.
Signal Cost - Toole Ave.	2017$	2018-2053	$14,000	
Signal Cost - 17th St.	2017$	2018-2053	$9,500	
Signal Cost - 18th St.	2017$	2018-2053	$9,500	
Signal Cost - 19th St.	2017$	2018-2053	$9,500	
Signal Cost - 20th St.	2017$	2018-2053	$9,500	
Signal Cost - 22nd St.	2017$	2018-2053	$14,000	
Signal Cost - 29th St.	2017$	2018-2053	$9,500	
Signal Cost - 36th St.	2017$	2018-2053	$9,500	
Signal Cost - Ajo Way	2017$	2018-2053	$14,000	
Signal Cost - Fair St.	2017$	2018-2053	$9,500	
Signal Cost - Irvington Rd.	2017$	2018-2053	$14,000	
Signal Cost - Drexel Rd.	2017$	2018-2053	$9,500	
Signal Cost - Bilby Rd.	2017$	2018-2053	$9,500	
Signal Cost - Valencia Rd.	2017$	2018-2053	$14,000	
Signal Cost - Vamori Rd.	2017$	2018-2053	$14,000	
Signal Cost - Hermans Rd.	2017$	2018-2053	$9,500	
Signal Cost - Hughes Access Rd.	2017$	2018-2053	$9,500	

7.5.3 Benefit Estimates

The table below shows the estimated maintenance cost savings by bypassing the Nogales Line. With a 7 percent discount rate, the estimated present value is $2.26 million. Additional information can be found in Section 10.16.

Table 15: Estimates of Maintenance Cost Savings, 2017 Dollars

	In Project Opening Year	Over the Project Lifecycle	
		In Constant Dollars	Discounted at 7 Percent
Maintenance Cost Savings	$255,000	$7,650,000	$2,256,106
Total	**$255,000**	**$7,650,000**	**$2,256,106**

7.6 Qualitative Benefits

7.6.1 Improved Travel Time Reliability

Travel time reliability reflects the variability of travel conditions and indicates how consistent or dependable daily travel times are. Generally, variability will arise either unpredictable demand, such as congestion and driver interactions, or unpredictable supply, such as traffic incidents, maintenance, as well

as natural events. While it is obvious this would heavily be driven by train crossing delays in the study region, however other factors such as incidents both at crossings and along crossing could generate notable blockages. Such unpredictably and variability in travel times forces roadway users to either plan additional time beyond the expected time or alternatively deal with the consequences of being late. Moreover this would generate frustrating and stress inducing travel conditions.[5]

7.6.2 Improved Access to Future Development Potential

The proposed Nogales Line Bypass will be located in a largely undeveloped area along Old Vail Connection Road. This will allow thousands of acres of vacant land currently zoned for industrial use to achieve its best use by allowing efficient freight rail service to service these lots.

7.6.3 Efficient Rail Operations

The bypass is also expect to significantly improve rail operations in Tucson, by allowing for higher speeds which will reduce rail congestion in the Sun Corridor region. This will result in increased switching volumes and thus improving the current operational efficiency and capacity for economic growth. As well, given the close proximity of the line to the Port of Tucson, the region's only intermodal facility, the bypass will promote continued freight growth through direct delivery and origination of international containers.

7.6.4 Improved Emergency Vehicle Access

With key emergency services (fire, police, and EMS) located west of the rail crossings, the delays experienced at the crossings may impact the efficiency of these services. Eliminating the 19 at-grade crossing blockages will improve travel time and travel time reliability for emergency responders that may otherwise not be able to pass.

7.6.5 Eliminate Transportation of Hazardous Materials through Residential Neighborhoods

The new bypass would limit the freight traffic traveling through various populated residential neighborhoods. The Federal Railroad Administration (FRA) Office of Safety reported that over 90 railcars carrying hazmat cargo were transported within Pima County between 2009 and 2017, which is approximately 10 hazmat railcars per year.[6] This project would eliminate hazardous cargo passing through these neighborhoods, which includes two elementary schools adjacent to the current Nogales Line.

8 Summary of Findings and Benefit-Cost Outcome

The tables below summarizes the BCA findings. Annual costs and benefits are computed over the lifecycle of the project (30 years). As stated earlier, construction is expected to be completed by 2023 with 2024 being the project opening year. Benefits accrue during the full operation of the project.

[5] HDR. California Life-Cycle Benefit/Cost Analysis Model Reliability Enhancement – Technical Documentation. Prepared for California Department of Transportation. March 2018.

[6] Based on data from FRA Office of Safety, Table 1.12 Ten Year Accident/Incident Overview. Accessed May 10th, 2018.

Table 16: Overall Results of the Benefit-Cost Analysis, 2017 Dollars*

Project Evaluation Metric	7% Discount Rate	3% Discount Rate
Total Discounted Benefits	$68.0	$137.9
Total Discounted Costs	$130.5	$154.8
Net Present Value	-$62.5	-$16.9
Benefit / Cost Ratio	0.52	0.89
Internal Rate of Return (%)	2.2%	
Payback Period (years)	22.60	

**Values in 2017 dollars unless specified otherwise*

Considering all monetized benefits and costs, the estimated internal rate of return of the project is 2.2 percent. With a 7 percent real discount rate, the $130.5 million investment would result in $68.0 million in total benefits for a Net Present Value of -$62.5 million and a Benefit/Cost ratio of approximately 0.52.

With a 3 percent real discount rate, the Net Present Value of the project would increase to -$16.9 million, for a Benefit/Cost ratio of 0.89.

Table 17: Benefit Estimates for the Full Build Alternative

Impact Categories	7% Discount Rate	3% Discount Rate
Reduced Travel Time Costs	$39,945,245	$82,726,549
Improved Safety and Avoided Accident Costs	$23,684,973	$46,469,123
Avoided Emissions Costs	$64,015	$129,989
Reduced Vehicle Operating Costs	$1,957,582	$4,114,044
O&M Cost Savings	$2,256,106	$4,311,416
Improved Travel Time Reliability	n/a	n/a
Improved Access to Future Development Potential	n/a	n/a
Improved Emergency Vehicle Access	n/a	n/a
Eliminate Transportation of Hazardous Materials through Residential Neighborhoods	n/a	n/a
Total Benefit Estimates	**$67,907,922**	**$137,751,120**

9 Benefit-Cost Sensitivity Analysis

9.1 Variation in Benefit-Cost Analysis

The primary purpose of the sensitivity analysis is to help identify potential variations that have large implications on the BCA outcomes. The particular sensitivity analysis conducted considers the potential of additional benefits generated by the Nogales Line Bypass.

Following the *Railroad-Highway Grade Crossing Handbook*, created by the USDOT FHWA, it highlights various conditions and criteria for highway-rail grade crossing separation, where if one or more of the conditions are met, then "*grade crossing should be considered for grade separation or otherwise eliminated across the railroad right of way*".[7] One of the notable criteria is if the grade crossing experiences daily vehicle delays of at least 40 vehicle-hours. Using this criteria, each of the relevant grade crossings in the study area are assessed to determine their qualifications and potential first year construction. Section 10.17 presents the total daily vehicle delays by crossing and indicates the following crossings projected to exceed the 40 hours of daily vehicle delay within the study period: 22nd Street, Irvington Road, Ajo Way, 18th Street, Valencia, 29th Street, and 36th Street.

[7] Ogden, Brent D. and Korve Engineering. *Railroad-Highway Grade Crossing Handbook – Revised Second Edition 2007*. Prepared for: Federal Highway Administration, Office of Safety Design. Washington, D.C.

Of the crossings expected the surpass the 40 vehicle-hours of daily delay threshold, only 22nd Street, Irvington Road, and Ajo Way crossings will be considered. This is because the considered crossings are expected to already exceed the threshold in the study period, with current daily delays estimated at 52.6 hours, 49.9 hours, and 43.1 hours for the 3 respective crossings. Meanwhile, the remainder will surpass 40 hours of delay later in the study period, with 2 crossings exceeding the threshold in the last year of the study period, and thus more uncertainty regarding the likelihood of this occurring.

The assumptions outcomes of the qualitative analysis for the Nogales Line Bypass project using a 7 percent discount rate are summarized in the tables below (Table 18 and Table 19 respectively). Table 19 presents an updated net present value, percentage change in net present value, and the new benefit-cost ratio based on the grade crossings to be separated.

Table 18: Assumptions used in the Sensitivity Analysis

Variable Name	Unit	Value	Source
Grade Crossing Separation Construction Cost	2017$	$60,000,000	Pima County
Grade Crossing Separation Construction Period	year	2	Pima County
Grade Crossing Separation Construction Period - 22nd Street	year	2022-2023	HDR Calculated based on USDOT FHWA Railroad-Highway Grade Crossing Handbook requirement of 40 vehicle-hours of daily vehicle delay.
Grade Crossing Separation Construction Period -Irvington Road	year	2023-2024	
Grade Crossing Separation Construction Period - Ajo Way	year	2024-2025	

Table 19: Quantitative Assessment of Sensitivity, Summary (Discounted at 7%)[8]

Original NPV (discounted at 7%)	Grade Crossings Separated	New NPV	Change in NPV	New B/C Ratio
-$62.5 M	22nd Street, Irvington Road, and Ajo Way	$38.4 M	$100.9 M	1.29

As evident in the table above, if all 3 recommended at-grade crossings are considered for grade separation, it is expected to generate approximately an additional $100.9 million in discounted benefits. This scenario is very likely to occur as all 3 crossings experience significant vehicular delays. Not only would the delays be exacerbated as the freight volumes increase, but safety concerns would also elevate. Thus with the additional benefits, investing in the Nogales Line Bypass would produce significant benefits generating a discounted net present value of $38.4 million and a benefit-cost ratio of 1.29.

[8] In the sensitivity analysis, benefits are not considered for crossings after the individual grade separation projects are completed.

10 Supplementary Data Tables

This section reports on all economic benefits associated with the Nogales Line Bypass project. Results are reported by year and benefit type. Supplementary data tables are also provided for some specific benefit categories.

10.1 Annual Estimates of Total Project Benefits and Costs

Calendar Year	Project Year	Total Benefits ($2017)	Total Costs ($2017)	Undiscounted Net Benefits ($2017)	Discounted Net Benefits at 7%	Discounted Net Benefits at 3%
2018	1	$0	$0	$0	$0	$0
2019	2	$0	$0	$0	$0	$0
2020	3	$0	$0	$0	$0	$0
2021	4	$0	$0	$0	$0	$0
2022	5	$0	$88,416,971	-$88,416,971	-$67,452,884	-$78,557,333
2023	6	$0	$88,416,971	-$88,416,971	-$63,040,078	-$76,269,256
2024	7	$6,072,267	$0	$6,072,267	$4,046,208	$5,085,428
2025	8	$6,210,322	$0	$6,210,322	$3,867,476	$5,049,560
2026	9	$6,351,167	$0	$6,351,167	$3,696,437	$5,013,670
2027	10	$6,496,113	$0	$6,496,113	$3,533,455	$4,978,730
2028	11	$6,644,182	$0	$6,644,182	$3,377,565	$4,943,895
2029	12	$6,795,038	$0	$6,795,038	$3,228,274	$4,908,880
2030	13	$6,948,641	$0	$6,948,641	$3,085,280	$4,873,637
2031	14	$7,107,011	$0	$7,107,011	$2,949,157	$4,839,528
2032	15	$7,266,904	$0	$7,266,904	$2,818,231	$4,804,280
2033	16	$7,430,611	$0	$7,430,611	$2,693,195	$4,769,426
2034	17	$7,598,256	$0	$7,598,256	$2,573,792	$4,734,982
2035	18	$7,768,774	$0	$7,768,774	$2,459,395	$4,700,236
2036	19	$7,942,748	$0	$7,942,748	$2,349,972	$4,665,527
2037	20	$8,122,558	$0	$8,122,558	$2,245,955	$4,632,181
2038	21	$8,304,576	$0	$8,304,576	$2,146,060	$4,598,043
2039	22	$8,491,073	$0	$8,491,073	$2,050,705	$4,564,370
2040	23	$8,681,487	$0	$8,681,487	$1,959,526	$4,530,803
2041	24	$8,876,418	$0	$8,876,418	$1,872,453	$4,497,608
2042	25	$9,075,736	$0	$9,075,736	$1,789,251	$4,464,661
2043	26	$9,279,686	$0	$9,279,686	$1,709,775	$4,432,030
2044	27	$9,489,219	$0	$9,489,219	$1,634,001	$4,400,101
2045	28	$9,704,381	$0	$9,704,381	$1,561,730	$4,368,806
2046	29	$9,924,064	$0	$9,924,064	$1,492,601	$4,337,578
2047	30	$10,151,345	$0	$10,151,345	$1,426,902	$4,307,686
2048	31	$10,385,264	$0	$10,385,264	$1,364,282	$4,278,591

Calendar Year	Project Year	Total Benefits ($2017)	Total Costs ($2017)	Undiscounted Net Benefits ($2017)	Discounted Net Benefits at 7%	Discounted Net Benefits at 3%
2049	32	$10,624,557	$0	$10,624,557	$1,304,409	$4,249,686
2050	33	$10,871,404	$0	$10,871,404	$1,247,397	$4,221,769
2051	34	$11,123,221	$0	$11,123,221	$1,192,795	$4,193,746
2052	35	$11,381,912	$0	$11,381,912	$1,140,688	$4,166,291
2053	36	$11,647,675	$0	$11,647,675	$1,090,955	$4,139,390
Total		**$256,766,611**	**$176,833,941**	**$79,932,670**	**-$62,585,040**	**-$17,075,469**

10.2 Annual Demand Assumptions by Grade Crossing (1)

Variable Name	Unit	Sources	Toole Ave.	17th St.	18th St.	19th St.	20th St.	22nd St.	29th St.
AADT – Bus Excluded	vehicles/day	Data from FRA and Pima Association of Governments, provided by Pima County	521	521	6,208	521	522	33,069	11,472
Passenger Vehicles	%	FRA Highway-Rail Crossing Inventory Database. Some School Bus data is provided by Pima County.	50%	50%	50%	60%	65%	75%	75%
Trucks	%		50%	50%	50%	40%	35%	25%	25%
School Bus	school bus/day		0	0	0	0	0	1	1
Transit Bus	transit bus/day	Sun Trans Bus Schedule	0	0	0	0	0	88	0
Average Freight Train Speed	miles/hour	HDR calculated using the average between the minimum track speed and the maximum timetable speed. Data from the FRA Highway-Rail Crossing Inventory database	7.5	7.5	7.5	7.5	15.0	15.0	15.0
Average Local Train Speed	miles/hour		7.5	7.5	7.5	7.5	15.0	15.0	15.0

10.3 Annual Demand Assumptions by Grade Crossing (2)

Variable Name	Unit	Sources	36th St.	Ajo Way	Fair St.	Irvington Rd.	Fletcher Ave.	Drexel Rd.
AADT - Bus Excluded	vehicles/day	Data from FRA and Pima Association of Governments, provided by Pima County	8,924	27,105	1,393	30,954	521	10,585
Passenger Vehicles	%	FRA Highway-Rail Crossing Inventory Database. Some School Bus data is provided by Pima County.	75%	75%	75%	75%	75%	75%
Trucks	%		25%	25%	25%	25%	25%	25%
School Bus	school bus/day		1	1	1	99	0	250
Transit Bus	transit bus/day	Sun Trans Bus Schedule	0	55	0	167	0	0
Average Freight Train Speed	miles/hour	HDR calculated using the average between the minimum track speed and the maximum timetable speed. Data from the FRA Highway-Rail Crossing Inventory database	15.0	15.0	15.0	15.0	7.5	30.0
Average Local Train Speed	miles/hour		15.0	15.0	15.0	15.0	7.5	30.0

10.4 Annual Demand Assumptions by Grade Crossing (3)

Variable Name	Unit	Sources	Bilby Rd.	Valencia Rd.	Teton Rd.	Vamori Rd.	Hermans Rd.	Hughes Access Road
AADT – Bus Excluded	vehicles/day	Data from FRA and Pima Association of Governments, provided by Pima County.	6,127	49,258	1	142	10,989	19,687
Passenger Vehicles	%	FRA Highway-Rail Crossing Inventory Database. Some School Bus data is provided by Pima County.	75%	75%	75%	80%	75%	60%
Trucks	%		25%	25%	25%	20%	25%	40%
School Bus	school bus/day		99	99	0	0	0	99
Transit Bus	transit bus/day	Sun Trans Bus Schedule	0	0	0	11	11	11
Average Freight Train Speed	miles/hour	HDR calculated using the average between the minimum track speed and the maximum timetable speed. Data from the FRA Highway-Rail Crossing Inventory database	30.0	30.0	30.0	30.0	30.0	30.0
Average Local Train Speed	miles/hour		30.0	30.0	30.0	30.0	30.0	30.0

10.5 Demand Projections by Grade Crossing (1)

Category	Year	Toole Ave	17th St	18th St	19th St	20th St	22nd St	29th St	36th St	Ajo Way	Fair St	Irvington Rd	Fletcher Ave
Total Annual Traffic	2018	529	529	6,304	529	530	33,670	11,651	9,063	27,581	1,416	31,700	529
	2023	565	565	6,739	565	566	35,987	12,455	9,688	29,480	1,514	33,868	565
	2033	635	635	7,570	635	636	40,412	13,990	10,882	33,107	1,700	38,010	635
	2043	702	702	8,367	702	703	44,660	15,463	12,028	36,588	1,879	41,986	702
	2053	772	772	9,206	772	774	49,128	17,014	13,234	40,251	2,067	46,169	772
Total Vehicle Hours Delay - Passenger Vehicles	2018	551	551	6,570	661	196	14,332	4,972	3,868	11,747	604	13,416	826
	2023	650	650	7,754	780	231	16,916	5,868	4,565	13,865	713	15,834	975
	2033	890	890	10,618	1,069	317	23,162	8,035	6,250	18,985	976	21,680	1,336
	2043	1,200	1,200	14,306	1,440	427	31,208	10,827	8,421	25,580	1,315	29,212	1,800
	2053	1,609	1,609	19,187	1,931	572	41,856	14,521	11,295	34,308	1,764	39,179	2,414
Total Vehicle Hours Delay - Trucks	2018	551	551	6,570	441	106	4,777	1,657	1,289	3,916	201	4,472	275
	2023	650	650	7,754	520	125	5,639	1,956	1,522	4,622	238	5,278	325
	2033	890	890	10,618	712	171	7,721	2,678	2,083	6,328	325	7,227	445
	2043	1,200	1,200	14,306	960	230	10,403	3,609	2,807	8,527	438	9,737	600
	2053	1,609	1,609	19,187	1,287	308	13,952	4,840	3,765	11,436	588	13,060	805
Total Vehicle Hours Delay - Bus Driver and Passengers	2018	0	0	0	0	0	50	0	0	31	0	95	0
	2023	0	0	0	0	0	55	0	0	34	0	105	0
	2033	0	0	0	0	0	67	0	0	42	0	128	0
	2043	0	0	0	0	0	82	0	0	51	0	156	0
	2053	0	0	0	0	0	100	0	0	62	0	190	0

10.6 Demand Projections by Grade Crossing (2)

Category	Year	Drexel Rd	Bilby Rd	Valencia Rd	Teton Rd	Vamori Rd	Hermans Rd	Hughes Access Rd
Total Annual Traffic	2018	10,999	6,321	50,121	1	155	11,170	20,102
	2023	11,741	6,750	53,572	1	165	11,940	21,481
	2033	13,157	7,570	60,164	1	184	13,411	24,116
	2043	14,517	8,357	66,491	2	203	14,822	26,645
	2053	15,947	9,185	73,147	2	222	16,307	29,305
Total Vehicle Hours Delay - Passenger Vehicles	2018	1,353	783	6,297	0	19	1,405	2,013
	2023	1,597	924	7,431	0	23	1,658	2,376
	2033	2,187	1,266	10,176	0	31	2,270	3,253
	2043	2,946	1,705	13,711	0	42	3,059	4,384
	2053	3,951	2,287	18,389	0	56	4,102	5,879
Total Vehicle Hours Delay - Trucks	2018	451	261	2,099	0	5	468	1,342
	2023	532	308	2,477	0	6	553	1,584
	2033	729	422	3,392	0	8	757	2,169
	2043	982	568	4,570	0	11	1,020	2,922
	2053	1,317	762	6,130	0	14	1,367	3,920
Total Vehicle Hours Delay - Bus Driver and Passengers	2018	0	0	0	0	2	2	2
	2023	0	0	0	0	2	2	2
	2033	0	0	0	0	3	3	3
	2043	0	0	0	0	3	3	3
	2053	0	0	0	0	4	4	4

10.7 Annual Demand Projections – Corridor

Calendar Year	Project Year	Total Annual Traffic	Annual Freight Trains	Annual Local Trains	Total Vehicle Hours of Delay	Total Passenger Hours of Delay
2018	1	222,901	2,190	730	99,779	152,965
2019	2	226,085	2,234	745	103,232	158,201
2020	3	229,143	2,278	759	106,725	163,497
2021	4	232,178	2,324	775	110,305	168,926
2022	5	235,202	2,371	790	113,980	174,497
2023	6	238,209	2,418	806	117,750	180,213
2024	7	241,201	2,466	822	121,617	186,075
2025	8	244,178	2,516	839	125,585	192,089
2026	9	247,140	2,566	855	129,653	198,255
2027	10	250,083	2,617	872	133,825	204,578
2028	11	253,007	2,670	890	138,102	211,058
2029	12	255,917	2,723	908	142,488	217,704
2030	13	258,818	2,777	926	146,989	224,524
2031	14	261,716	2,833	944	151,611	231,527
2032	15	264,593	2,890	963	156,347	238,701
2033	16	267,451	2,947	982	161,200	246,053
2034	17	270,296	3,006	1,002	166,178	253,592
2035	18	273,129	3,067	1,022	171,281	261,322
2036	19	275,951	3,128	1,043	176,516	269,249
2037	20	278,762	3,190	1,063	181,884	277,378
2038	21	281,562	3,254	1,085	187,389	285,714
2039	22	284,352	3,319	1,106	193,035	294,262
2040	23	287,133	3,386	1,129	198,826	303,029
2041	24	289,918	3,453	1,151	204,773	312,032
2042	25	292,711	3,522	1,174	210,885	321,284
2043	26	295,518	3,593	1,198	217,169	330,795
2044	27	298,344	3,665	1,222	223,636	340,581
2045	28	301,191	3,738	1,246	230,289	350,650
2046	29	304,062	3,813	1,271	237,139	361,012
2047	30	306,963	3,889	1,296	244,194	371,685
2048	31	309,897	3,967	1,322	251,462	382,680
2049	32	312,864	4,046	1,349	258,952	394,007
2050	33	315,865	4,127	1,376	266,670	405,678
2051	34	318,896	4,210	1,403	274,618	417,696
2052	35	321,956	4,294	1,431	282,803	430,070
2053	36	325,045	4,380	1,460	291,232	442,812
Total		**9,872,237**	**113,868**	**37,956**	**6,528,118**	**9,954,392**

10.8 Travel Time Costs: Pertinent Quantifiable Impacts

Calendar Year	Project Year	Avoided Person Hours of Delay at Rail Crossings	Avoided Vehicle Hours of Delay at Rail Crossings
2018	1	0	0
2019	2	0	0
2020	3	0	0
2021	4	0	0
2022	5	0	0
2023	6	0	0
2024	7	186,075	121,787
2025	8	192,089	125,758
2026	9	198,255	129,830
2027	10	204,578	134,006
2028	11	211,058	138,286
2029	12	217,704	142,675
2030	13	224,524	147,180
2031	14	231,527	151,807
2032	15	238,701	156,546
2033	16	246,053	161,404
2034	17	253,592	166,385
2035	18	261,322	171,493
2036	19	269,249	176,732
2037	20	277,378	182,104
2038	21	285,714	187,614
2039	22	294,262	193,264
2040	23	303,029	199,059
2041	24	312,032	205,011
2042	25	321,284	211,128
2043	26	330,795	217,417
2044	27	340,581	223,888
2045	28	350,650	230,547
2046	29	361,012	237,401
2047	30	371,685	244,462
2048	31	382,680	251,736
2049	32	394,007	259,231
2050	33	405,678	266,954
2051	34	417,696	274,908
2052	35	430,070	283,099
2053	36	442,812	291,534
Total		**8,956,092**	**5,883,245**

10.9 Travel Time Costs: Annual Benefit Estimates

Calendar Year	Project Year	Total Undiscounted Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2018	1	$0	$0	$0
2019	2	$0	$0	$0
2020	3	$0	$0	$0
2021	4	$0	$0	$0
2022	5	$0	$0	$0
2023	6	$0	$0	$0
2024	7	$3,254,747	$2,168,775	$2,725,799
2025	8	$3,360,019	$2,092,451	$2,732,003
2026	9	$3,467,981	$2,018,396	$2,737,656
2027	10	$3,578,672	$1,946,560	$2,742,754
2028	11	$3,692,119	$1,876,886	$2,747,283
2029	12	$3,808,472	$1,809,377	$2,751,321
2030	13	$3,927,863	$1,744,018	$2,754,924
2031	14	$4,050,472	$1,680,802	$2,758,174
2032	15	$4,176,073	$1,619,553	$2,760,876
2033	16	$4,304,790	$1,560,254	$2,763,081
2034	17	$4,436,777	$1,502,890	$2,764,853
2035	18	$4,572,114	$1,447,414	$2,766,204
2036	19	$4,710,909	$1,393,788	$2,767,162
2037	20	$4,853,238	$1,341,961	$2,767,734
2038	21	$4,999,181	$1,291,883	$2,767,925
2039	22	$5,148,843	$1,243,513	$2,767,757
2040	23	$5,302,345	$1,196,809	$2,767,254
2041	24	$5,459,977	$1,151,765	$2,766,525
2042	25	$5,621,966	$1,108,352	$2,765,635
2043	26	$5,788,498	$1,066,526	$2,764,619
2044	27	$5,959,843	$1,026,258	$2,763,548
2045	28	$6,136,134	$987,490	$2,762,420
2046	29	$6,317,580	$950,178	$2,761,267
2047	30	$6,504,461	$914,285	$2,760,144
2048	31	$6,696,979	$879,763	$2,759,067
2049	32	$6,895,316	$846,559	$2,758,038
2050	33	$7,099,685	$814,626	$2,757,070
2051	34	$7,310,122	$783,899	$2,756,108
2052	35	$7,526,809	$754,332	$2,755,150
2053	36	$7,749,931	$725,881	$2,754,197
Total		**$156,711,913**	**$39,945,245**	**$82,726,549**

10.10 Vehicle Operating Costs: Pertinent Quantifiable Impacts

Calendar Year	Project Year	Avoided Vehicle Hours of Delay at Rail Crossings	Avoided Gasoline Consumption (Gallons)	Avoided Diesel Consumption (Gallons)	Avoided Motor Oil Consumption (Quarts)
2018	1	0	0	0	0
2019	2	0	0	0	0
2020	3	0	0	0	0
2021	4	0	0	0	0
2022	5	0	0	0	0
2023	6	0	0	0	0
2024	7	121,787	30,578	17,746	4,202
2025	8	125,758	31,576	18,323	4,339
2026	9	129,830	32,600	18,915	4,479
2027	10	134,006	33,650	19,522	4,623
2028	11	138,286	34,725	20,144	4,771
2029	12	142,675	35,829	20,782	4,922
2030	13	147,180	36,961	21,437	5,078
2031	14	151,807	38,124	22,109	5,237
2032	15	156,546	39,316	22,798	5,401
2033	16	161,404	40,537	23,504	5,568
2034	17	166,385	41,789	24,228	5,740
2035	18	171,493	43,074	24,971	5,917
2036	19	176,732	44,391	25,732	6,097
2037	20	182,104	45,741	26,513	6,283
2038	21	187,614	47,126	27,313	6,473
2039	22	193,264	48,547	28,134	6,668
2040	23	199,059	50,004	28,977	6,868
2041	24	205,011	51,500	29,841	7,073
2042	25	211,128	53,038	30,730	7,284
2043	26	217,417	54,619	31,644	7,501
2044	27	223,888	56,247	32,584	7,724
2045	28	230,547	57,921	33,552	7,954
2046	29	237,401	59,644	34,548	8,190
2047	30	244,462	61,419	35,574	8,434
2048	31	251,736	63,249	36,630	8,685
2049	32	259,231	65,133	37,719	8,943
2050	33	266,954	67,075	38,841	9,210
2051	34	274,908	69,075	39,997	9,484
2052	35	283,099	71,135	41,187	9,767
2053	36	291,534	73,256	42,412	10,058
Total		**5,883,245**	**1,477,882**	**856,410**	**202,972**

10.11 Vehicle Operating Costs: Annual Benefit Estimates

Calendar Year	Project Year	Total Undiscounted Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2018	1	$0	$0	$0
2019	2	$0	$0	$0
2020	3	$0	$0	$0
2021	4	$0	$0	$0
2022	5	$0	$0	$0
2023	6	$0	$0	$0
2024	7	$150,273	$100,133	$125,851
2025	8	$154,941	$96,490	$125,981
2026	9	$159,780	$92,993	$126,132
2027	10	$166,069	$90,331	$127,278
2028	11	$172,823	$87,854	$128,596
2029	12	$179,507	$85,283	$129,680
2030	13	$185,919	$82,550	$130,400
2031	14	$193,842	$80,438	$131,997
2032	15	$200,409	$77,722	$132,494
2033	16	$207,755	$75,300	$133,350
2034	17	$215,811	$73,103	$134,486
2035	18	$223,431	$70,732	$135,179
2036	19	$231,072	$68,366	$135,731
2037	20	$240,907	$66,613	$137,386
2038	21	$249,357	$64,439	$138,063
2039	22	$258,575	$62,449	$138,997
2040	23	$267,867	$60,461	$139,798
2041	24	$277,458	$58,529	$140,586
2042	25	$286,944	$56,570	$141,158
2043	26	$296,357	$54,603	$141,542
2044	27	$306,319	$52,747	$142,039
2045	28	$316,746	$50,974	$142,595
2046	29	$326,290	$49,075	$142,614
2047	30	$337,700	$47,468	$143,302
2048	31	$349,799	$45,952	$144,112
2049	32	$361,132	$44,337	$144,448
2050	33	$373,656	$42,874	$145,105
2051	34	$384,791	$41,263	$145,076
2052	35	$396,258	$39,713	$145,048
2053	36	$408,067	$38,221	$145,020
Total		**$7,879,856**	**$1,957,582**	**$4,114,044**

10.12 Safety Outcomes: Pertinent Quantifiable Impacts

Calendar Year	Project Year	Fatalities Avoided - At Grade Crossing	Injuries Avoided - At Grade Crossing	PDO-Accidents Avoided	Fatalities Avoided - Trespasser Incidents	Injuries Avoided - Trespasser Incidents
2018	1	0.00	0.00	0.00	0.00	0.00
2019	2	0.00	0.00	0.00	0.00	0.00
2020	3	0.00	0.00	0.00	0.00	0.00
2021	4	0.00	0.00	0.00	0.00	0.00
2022	5	0.00	0.00	0.00	0.00	0.00
2023	6	0.00	0.00	0.00	0.00	0.00
2024	7	0.08	0.48	1.84	0.14	0.86
2025	8	0.08	0.48	1.86	0.14	0.87
2026	9	0.09	0.49	1.88	0.15	0.88
2027	10	0.09	0.49	1.90	0.15	0.89
2028	11	0.09	0.50	1.92	0.15	0.90
2029	12	0.09	0.50	1.94	0.15	0.91
2030	13	0.09	0.51	1.96	0.15	0.92
2031	14	0.09	0.51	1.98	0.15	0.93
2032	15	0.09	0.52	1.99	0.16	0.94
2033	16	0.09	0.52	2.01	0.16	0.95
2034	17	0.09	0.53	2.03	0.16	0.96
2035	18	0.09	0.53	2.05	0.16	0.97
2036	19	0.09	0.54	2.07	0.16	0.98
2037	20	0.10	0.54	2.09	0.16	0.99
2038	21	0.10	0.55	2.11	0.17	1.00
2039	22	0.10	0.55	2.13	0.17	1.01
2040	23	0.10	0.56	2.15	0.17	1.02
2041	24	0.10	0.56	2.17	0.17	1.03
2042	25	0.10	0.57	2.19	0.17	1.04
2043	26	0.10	0.57	2.21	0.17	1.05
2044	27	0.10	0.58	2.23	0.18	1.06
2045	28	0.10	0.58	2.25	0.18	1.07
2046	29	0.10	0.59	2.27	0.18	1.08
2047	30	0.10	0.59	2.29	0.18	1.09
2048	31	0.11	0.60	2.31	0.18	1.10
2049	32	0.11	0.60	2.33	0.18	1.11
2050	33	0.11	0.61	2.36	0.19	1.12
2051	34	0.11	0.62	2.38	0.19	1.13
2052	35	0.11	0.62	2.40	0.19	1.14
2053	36	0.11	0.63	2.42	0.19	1.15
Total		**2.90**	**16.50**	**63.75**	**5.01**	**30.15**

10.13 Safety Outcomes: Annual Benefit Estimates

Calendar Year	Project Year	Total Discounted Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2018	1	$0	$0	$0
2019	2	$0	$0	$0
2020	3	$0	$0	$0
2021	4	$0	$0	$0
2022	5	$0	$0	$0
2023	6	$0	$0	$0
2024	7	$2,406,287	$1,603,410	$2,015,227
2025	8	$2,434,301	$1,515,961	$1,979,310
2026	9	$2,462,248	$1,433,051	$1,943,721
2027	10	$2,490,117	$1,354,458	$1,908,467
2028	11	$2,517,889	$1,279,967	$1,873,546
2029	12	$2,545,613	$1,209,402	$1,839,005
2030	13	$2,573,321	$1,142,585	$1,804,875
2031	14	$2,601,066	$1,079,350	$1,771,199
2032	15	$2,628,702	$1,019,456	$1,737,882
2033	16	$2,656,258	$962,750	$1,704,951
2034	17	$2,683,774	$909,087	$1,672,439
2035	18	$2,711,252	$858,313	$1,640,352
2036	19	$2,738,707	$810,285	$1,608,702
2037	20	$2,766,139	$764,860	$1,577,490
2038	21	$2,793,545	$721,905	$1,546,718
2039	22	$2,820,936	$681,293	$1,516,392
2040	23	$2,848,326	$642,905	$1,486,520
2041	24	$2,875,796	$606,640	$1,457,142
2042	25	$2,903,394	$572,394	$1,428,277
2043	26	$2,931,148	$540,062	$1,399,933
2044	27	$2,959,115	$509,546	$1,372,126
2045	28	$2,987,295	$480,746	$1,344,847
2046	29	$3,015,714	$453,570	$1,318,099
2047	30	$3,044,422	$427,933	$1,291,889
2048	31	$3,073,434	$403,748	$1,266,214
2049	32	$3,102,756	$380,935	$1,241,062
2050	33	$3,132,403	$359,415	$1,216,428
2051	34	$3,162,331	$339,112	$1,192,282
2052	35	$3,192,541	$319,954	$1,168,613
2053	36	$3,223,036	$301,879	$1,145,414
Total		**$84,281,863**	**$23,684,973**	**$46,469,123**

10.14 Environmental Sustainability: Pertinent Quantifiable Impacts

Calendar Year	Project Year	Annual Emissions Avoided - NOx (lbs)	Annual Emissions Avoided - VOC (lbs)	Annual Emissions Avoided - PM (lbs)	Annual Emissions Avoided - SO_2 (lbs)	Avoided Vehicle-hours of Delay Time
2018	1	0.000	0.000	0.000	0.000	0
2019	2	0.000	0.000	0.000	0.000	0
2020	3	0.000	0.000	0.000	0.000	0
2021	4	0.000	0.000	0.000	0.000	0
2022	5	0.000	0.000	0.000	0.000	0
2023	6	0.000	0.000	0.000	0.000	0
2024	7	0.378	0.004	0.002	0.056	121,787
2025	8	0.393	0.004	0.002	0.056	125,758
2026	9	0.409	0.004	0.002	0.055	129,830
2027	10	0.425	0.003	0.002	0.054	134,006
2028	11	0.441	0.003	0.002	0.054	138,286
2029	12	0.458	0.003	0.002	0.053	142,675
2030	13	0.476	0.003	0.002	0.051	147,180
2031	14	0.494	0.003	0.002	0.050	151,807
2032	15	0.513	0.003	0.002	0.049	156,546
2033	16	0.533	0.002	0.002	0.047	161,404
2034	17	0.553	0.002	0.002	0.046	166,385
2035	18	0.573	0.002	0.002	0.044	171,493
2036	19	0.595	0.002	0.002	0.042	176,732
2037	20	0.613	0.002	0.002	0.043	182,104
2038	21	0.631	0.002	0.002	0.044	187,614
2039	22	0.650	0.002	0.002	0.046	193,264
2040	23	0.670	0.002	0.002	0.047	199,059
2041	24	0.690	0.002	0.003	0.048	205,011
2042	25	0.710	0.002	0.003	0.050	211,128
2043	26	0.732	0.002	0.003	0.051	217,417
2044	27	0.753	0.002	0.003	0.053	223,888
2045	28	0.776	0.002	0.003	0.054	230,547
2046	29	0.799	0.002	0.003	0.056	237,401
2047	30	0.823	0.002	0.003	0.058	244,462
2048	31	0.847	0.002	0.003	0.059	251,736
2049	32	0.872	0.002	0.003	0.061	259,231
2050	33	0.898	0.002	0.003	0.063	266,954
2051	34	0.925	0.002	0.003	0.065	274,908
2052	35	0.952	0.002	0.003	0.067	283,099
2053	36	0.981	0.003	0.004	0.069	291,534
Total		**19.56**	**0.07**	**0.07**	**1.59**	**5,883,245**

10.15 Environmental Sustainability: Annual Benefit Estimates

Calendar Year	Project Year	Total Discounted Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2018	1	$0	$0	$0
2019	2	$0	$0	$0
2020	3	$0	$0	$0
2021	4	$0	$0	$0
2022	5	$0	$0	$0
2023	6	$0	$0	$0
2024	7	$5,961	$3,972	$4,992
2025	8	$6,060	$3,774	$4,927
2026	9	$6,158	$3,584	$4,861
2027	10	$6,256	$3,403	$4,794
2028	11	$6,351	$3,229	$4,726
2029	12	$6,446	$3,062	$4,656
2030	13	$6,539	$2,903	$4,586
2031	14	$6,631	$2,751	$4,515
2032	15	$6,720	$2,606	$4,443
2033	16	$6,808	$2,468	$4,370
2034	17	$6,894	$2,335	$4,296
2035	18	$6,978	$2,209	$4,222
2036	19	$7,059	$2,089	$4,147
2037	20	$7,274	$2,011	$4,148
2038	21	$7,494	$1,936	$4,149
2039	22	$7,719	$1,864	$4,149
2040	23	$7,950	$1,795	$4,149
2041	24	$8,188	$1,727	$4,149
2042	25	$8,432	$1,662	$4,148
2043	26	$8,683	$1,600	$4,147
2044	27	$8,941	$1,540	$4,146
2045	28	$9,207	$1,482	$4,145
2046	29	$9,481	$1,426	$4,144
2047	30	$9,762	$1,372	$4,143
2048	31	$10,053	$1,321	$4,142
2049	32	$10,352	$1,271	$4,141
2050	33	$10,660	$1,223	$4,140
2051	34	$10,977	$1,177	$4,139
2052	35	$11,304	$1,133	$4,138
2053	36	$11,641	$1,090	$4,137
Total		**$242,979**	**$64,015**	**$129,989**

10.16 Maintenance Cost Savings: Annual Estimated Benefits

Calendar Year	Project Year	Total Discounted Benefits	Total Discounted Benefits at 7%	Total Discounted Benefits at 3%
2018	1	$0	$0	$0
2019	2	$0	$0	$0
2020	3	$0	$0	$0
2021	4	$0	$0	$0
2022	5	$0	$0	$0
2023	6	$0	$0	$0
2024	7	$255,000	$169,917	$213,558
2025	8	$255,000	$158,801	$207,338
2026	9	$255,000	$148,412	$201,299
2027	10	$255,000	$138,703	$195,436
2028	11	$255,000	$129,629	$189,744
2029	12	$255,000	$121,149	$184,217
2030	13	$255,000	$113,223	$178,852
2031	14	$255,000	$105,816	$173,643
2032	15	$255,000	$98,893	$168,585
2033	16	$255,000	$92,424	$163,675
2034	17	$255,000	$86,377	$158,908
2035	18	$255,000	$80,726	$154,279
2036	19	$255,000	$75,445	$149,786
2037	20	$255,000	$70,510	$145,423
2038	21	$255,000	$65,897	$141,187
2039	22	$255,000	$61,586	$137,075
2040	23	$255,000	$57,557	$133,083
2041	24	$255,000	$53,791	$129,206
2042	25	$255,000	$50,272	$125,443
2043	26	$255,000	$46,984	$121,789
2044	27	$255,000	$43,910	$118,242
2045	28	$255,000	$41,037	$114,798
2046	29	$255,000	$38,353	$111,455
2047	30	$255,000	$35,844	$108,208
2048	31	$255,000	$33,499	$105,057
2049	32	$255,000	$31,307	$101,997
2050	33	$255,000	$29,259	$99,026
2051	34	$255,000	$27,345	$96,142
2052	35	$255,000	$25,556	$93,341
2053	36	$255,000	$23,884	$90,623
Total		**$7,650,000**	**$2,256,106**	**$4,311,416**

10.17 Daily Vehicle Delays by Crossing

Crossing	Year Exceed	2018	2023	2028	2033	2038	2043	2048	2053
Toole Ave	-	3.0	3.6	4.2	4.9	5.7	6.6	7.6	8.8
17th St	-	3.0	3.6	4.2	4.9	5.7	6.6	7.6	8.8
18th St	2022	36.0	42.5	49.8	58.2	67.6	78.4	90.8	105.1
19th St	-	3.0	3.6	4.2	4.9	5.7	6.6	7.6	8.8
20th St	-	0.8	1.0	1.1	1.3	1.6	1.8	2.1	2.4
22nd St	2018	52.5	61.9	72.6	84.8	98.6	114.2	132.3	153.2
29th St	2044	18.2	21.4	25.1	29.4	34.1	39.6	45.8	53.0
36th St	2052	14.1	16.7	19.6	22.8	26.5	30.8	35.6	41.3
Ajo Way	2018	43.0	50.7	59.5	69.5	80.8	93.6	108.4	125.5
Fair St	-	2.2	2.6	3.1	3.6	4.1	4.8	5.6	6.4
Irvington Rd	2018	49.4	58.3	68.3	79.8	92.7	107.4	124.3	143.9
Fletcher Ave	-	3.0	3.6	4.2	4.9	5.7	6.6	7.6	8.8
Drexel Rd	-	5.1	6.0	7.0	8.1	9.5	11.0	12.7	14.7
Bilby Rd	-	2.9	3.4	4.0	4.7	5.4	6.3	7.3	8.4
Valencia Rd	2036	23.0	27.2	31.9	37.2	43.3	50.2	58.1	67.3
Teton Rd	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vamori Rd	-	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
Hermans Rd	-	5.1	6.1	7.1	8.3	9.6	11.2	12.9	15.0
Hughes Access Rd	-	9.2	10.9	12.8	14.9	17.3	20.1	23.3	26.9