Appendix A: Benefit-Cost Analysis (BCA)
300 West BUILD Application
Background Analysis Report

Submitted by:

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1. Overview

The purpose of this appendix is to provide the technical documentation for the quantitative analysis undertaken for the Benefit Cost Analysis (BCA) associated with this BUILD grant application. As such, it provides an overview of the methodology used to derive the long-term outcomes provided in **Table 1**, which summarizes the types of outcomes that have been identified for Salt Lake City 300 West Complete Street conversion. These outcomes are organized according to BUILD selection criteria and likely benefits given the proposed improvements. As detailed in Section 1 of this report, the quantification of benefits involves an Excel spreadsheet available electronically as Appendix BC-2.

The time horizon of the benefit-cost analysis covers the construction period in 2020-2022, and an operational period from 2022-2057. All benefits are expressed in constant 2022 dollars and discounted to 2022. Net Present Value discounting for the BCA over the period was carried out using three percent and seven percent discount rates, following the guidance. **Table 1** also shows a summary of benefits as computed with the methods documented here.

Table 1: Quantitative Factors Assessed in BCA, and Summary of Benefits

Long-Term Outcome	Type of Societal Benefits (And Where Addressed)
Travel Time Savings and Reliability	Value of travel times and dependability for personal autos and trucks based on projected changes in trip characteristics due to the proposed improvement. For this project, time and reliability are *dis-benefits* (i.e., build reduces speed, which increases travel time).
Vehicle Operating Costs	The savings of vehicle operating costs due to a reduction of travel throughout the region and the corridor.
Safety	The value gained by the reduction of crashes due to the reduction of travel throughout the region and corridor.
Environmental Sustainability	The value associated with the reduction of emissions due to a reduction of travel throughout the region and corridor.

35-Year Benefit Summary Based on Initial $20.2 M Cost

Discount Rate	Veh. Op. Cost	Time & Reliability	Improved Safety	Env. Benefit	Total Benefit	Total Cost	Benefit / Cost Ratio
7%	$17	$10	$36	$1	$63	$15	4.2
3%	$45	$41	$83	$3	$172	$17	9.9

2. Travel Characteristics

The purpose of this section is to provide an overview of the technical analysis and assumptions made to derive the projected Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT) under the no build and build scenarios:

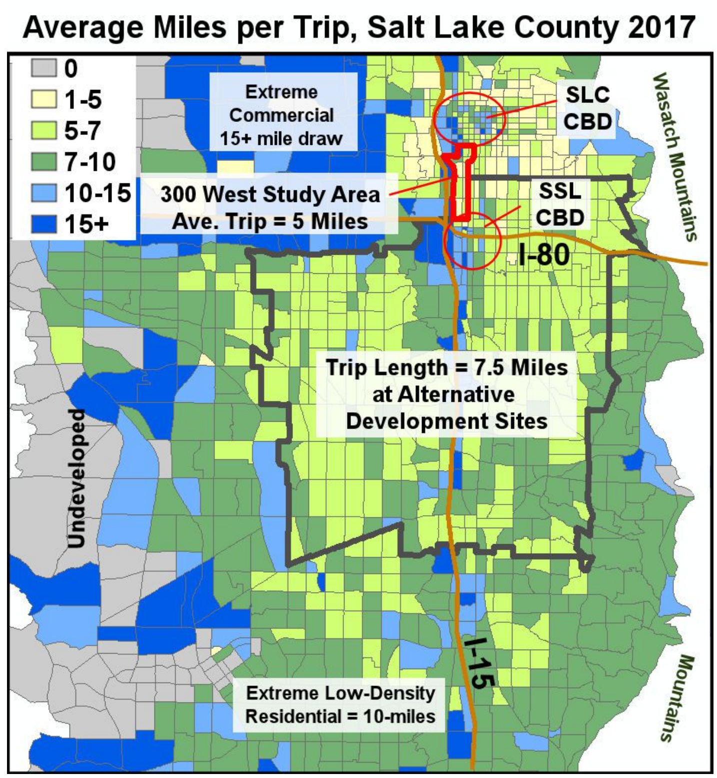
- Assessment of land uses and development density along the corridor to project the number of dwelling units and jobs within the corridor
- Estimating the percentage of trips by car, truck, and other modes based on projected land use to develop the number of trips by each mode
- Factors for assessing delay and travel speeds along the corridor

These factors provide the means to calculate the following key quantitative assessments in the BCA noted in **Table 1** above.

Background Assumptions for Analysis

Because the project is to be built as a Complete Street, there is significant precedent that it will catalyze more mixed-use development than would otherwise occur. Trips generated by those incremental uses will therefore enjoy shorter trip lengths, better multi-modal options, and safer conditions than would have occurred had the same development occurred elsewhere in the county.

The regional travel demand model was used to identify average trip lengths within the study area (5.0 miles/trip, inside red area), vs the trip lengths in the most likely areas where this development otherwise would have occurred (7.5 miles/trip, inside black outline). This differential of 2.5 miles/trip results in significantly lower overall VMT, which in turn positively affects operating costs, environmental costs, and safety costs (due to less driving exposure).



A market study was commissioned by Salt Lake City to determine how much development might occur both with and without the proposed project. Study results are in the table below. The study concluded that about 400 residential units are likely to be built from 2026 to 2035 if the complete street is not built, but that number will increase to 1,200 units due to developer excitement regarding the changes. The effect continues to 2055, but with increasingly fewer incremental units because available land starts to run out. At that point, the corridors influence will spread to the next blocks east and west, but those effects are not considered.

Start	End	No Build Res Units	Build Res Units	Incr. Res Units	No Build Com SF	Build Com SF	Incr. Com SF	No Build Jobs	Build Jobs	Incr. Jobs
2026	2035	400	1,200	800	75,000	200,000	125,000	210	570	360
2036	2045	300	700	400	75,000	150,000	75,000	210	430	220
2046	2055	300	700	400	75,000	150,000	75,000	210	430	220
	Total	**1,000**	**2,600**	**1,600**	**225,000**	**500,000**	**275,000**	**630**	**1,430**	**800**

For purposes of this analysis, the most important values are the totals: **1,600 incremental residential units, and 800 additional jobs**. Accessible data beyond the market study for the scale of development could be spurred by this type of improvement is difficult to discern. However, over roughly 35-years, this seems like a conservative estimate which is supported by several examples of similar scales of development within much shorter timeframes:

- A complete street in Normal, IL cost $47-million and spurred $160-million in development in roughly 10-years. If that investment were split 50-50 across residential and commercial, our estimation is that this should equate to nearly 800 dwelling units and over 2,000 jobs in 10-years.
- Lancaster, California added pedestrian safety features as part of a downtown revitalization effort, including a pedestrian-only plaza, wider sidewalks, landscaping and traffic calming. The project spurred $125 million in private investment, a 26% increase in sales tax revenue, and 800 new jobs, after a public investment of $10.6 million.
- In Mountain View, California, the addition of space for sidewalk cafes and a redesign of the street for pedestrians were followed by private investment of $150 million, including residential, retail and offices, resulting in a vibrant downtown destination.

Source for three examples: (http://old.smartgrowthamerica.org/complete-streets/complete-streets-fundamentals/factsheets/economic-revitalization)

In this analysis the assumptions used are deliberately conservative in estimating the likely market changes, and their effects on VMT and VHT. Other assumptions for VMT and VHT associated with the Complete Street concept along the 300 West Corridor include:

1. The base existing traffic (about 20,000 AADT) conservatively does not increase going forward.

2. Nonetheless, traffic will increase due to catalyzed development, detailed in the next section.

3. The complete street will attract redevelopment that would have occurred elsewhere. Probably not at the fringe of the region, but in nearby suburban locations, probably within ten miles of the corridor project site where average trip lengths are longer, and where mode split is more auto-based.

Compilation of Additional Dwelling Units and Jobs

A spreadsheet model was created, and calibrated to the results of the market study. As noted in **Table 2**, the process for estimating the number of incremental dwelling units and jobs as a result of the proposed project was a process of determining the affected area that would be influenced by the Complete Street project. Based on local trends, there are key reasonable assumptions that drive this analysis:

- An affected area of 200 acres was identified through an aerial survey.
- A percentage of acreage that is likely to intensify through the forecast horizon year 2057 was identified as 30 percent under the no build alternative and 50 percent under the build alternative.
- Of the square footage of new development, 80 percent would be residential, and the remaining 20 percent would be non-residential (primarily retail and office space). These values were selected to match the market study.
- The average dwelling unit would be 700 square feet.
- The average job would require 350 square feet.

Table 2: Calculations and Assumptions for Projecting Dwelling Units and Employment

	Item	No Build	Build	Notes
A	Total acres directly adjacent to 300 West project area	200	200	Based on aerial survey.
B	Percent of acres likely to intensify	30%	50%	Intensification assumed in No Build, but slightly higher intensification assumed for Build
C	Additional acres likely to intensify due to the project	60	100	Applies the percentage of acreage to the total acreage (A * B)
D	Acres likely to stay the same by end of analysis (2057)	140	100	The remainder of acreage from that projected to intensify (A - C)
E	Existing Floor Area Ratio (to avoid double counting when replacing old with new)	0.20	0.20	To be applied to acreage with no change in density (D)
F	Additional floor area ratio of new development, above todays base (calculations based on this increment)	0.20	0.44	To be applied to acreage with change in density (C)
G	Overall FAR for Study Area	0.4	0.64	Total Floor Area = ((D * E) + (C * F))
	Total Square Footage (S.F.) of New Development	522,720	1,916,640	Total Square Footage = (E* I * 43,650)
K	Total Residential S.F.	418,176	1,533,312	Assumes 80% of new development will be residential
L	Total Non-Residential S.F.	104,544	383,328	Assumes 20% of new development will be nonresidential
M	**Total New Dwelling Units**	597	2190	**Res. SF / 700 SF/unit = total dwelling units (K / 700)**
N	**Total New Jobs**	299	1095	**Non-res SF / 350 SF/unit = total jobs (L / 350)**

Developing Projected Number of Trips by Mode

The number of additional dwelling units and jobs in the corridor provide the basis for projecting the future number of trips based by mode. The calculation methodology is reflected in **Table 3**, which is based on 7 daily trips/dwelling unit, and 8 daily trips per job, (average values as per the WFRC travel demand model for the expected development types).

Table 3: Incremental Dwelling Units, Jobs, and Person-Trips Catalyzed by the project.

	Dwelling Units	Jobs
Market Study	1,600	800
Calibrated Spreadsheet Model	1,593	797
Person trips per unit or per job	7	8
New person trips (spreadsheet mdl)	11,151	6,372
Total person trips above No Build		17,524

It is assumed that catalyzed development resulting from the proposed project would have occurred elsewhere in Salt Lake County by the horizon year (for the no-build condition). As such, a key step in this process is to track both build and no-build effects on development and associated trips:

- **Suburban No Build:** The purpose of this model run is to account for trips along the corridor that would occur if future development occurs randomly across the county as opposed to the study area. Trip lengths under this scenario are longer given the suburban nature of the region. Average trip lengths are 7.5 miles rather than in the corridor's 5.0 miles. This serves as the baseline for projecting trips that would be displaced under the no build scenario.
- **300 West No Build:** This accounts for trips that would have already occurred on the 300 West corridor in the no build scenario. This is used to serve as a baseline for comparison to the build scenario for on-corridor trips. While the suburban no build provides the baseline for the overall region, it is also important to derive a corridor-specific no build, as noted in Table 5.
- **300 West Build:** This accounts for trip characteristics that would occur in the build alternative. This run is used to provide the comparative baseline for all the quantitative factors used for this BCA (noted in **Table 1**).

The key characteristics for each of these model runs is provided in **Table 4**. As shown, the following assumptions were made for these runs.

- A percent of person trips-to-vehicle trips of 90 percent for the suburban no build, 85 percent for the 300 West No Build, and 80 percent for the 300 West Build.
- A three percent freight truck share based on regional characteristics
- A 12 percent delivery truck share of total trips based on regional characteristics.

Table 4: Trips by Model Scenario

Item	Suburban No Build	300 West Build	Notes
Percent of person trips along corridor via auto	90%	80%	Assumes increased multimodal travel as a result of intensified development
Person trips along corridor via car	15,800	14,000	Equals percentage applied to *total* new trips calculated in Table 3.
Auto occupancy factor	1.68	1.68	FHWA Statistics, 2015
Average trip length (miles)	7.5	5.0	Taken from WFRC model
Percent of Freight Trucks	3%	3%	Taken from UDOT Count along corridor
Percent of Delivery Trucks	12%	12%	Taken from UDOT Count along corridor
Vehicle Trips	9,400	8,300	Person trips divided by auto occupancy
Car Trips	7,990	7,050	Vehicle trips minus freight and delivery trucks
Truck Trips	280	250	Vehicle trips multiplied by % freight
Delivery Trips	1,130	1,000	Vehicle trips multiplied by % delivery

By applying the factors noted above, two sets of VMT calculations were developed for the build and no build:

- On Corridor Trips – Comparing the 300 West No Build and 300 West Build scenarios for a comparison of background traffic
- Displaced Trips – Comparing the Suburban No Build and 300 West Build scenarios for a comparison of new traffic along the corridor

Table 5: Projected Daily On-Corridor and Displaced Trips for Horizon Year (2057)

	On-Corridor Trips (Background)		Displaced Trips (Induced)	
	300 West No Build	300 West Build*	Suburban No Build	300 West Build
Average Trip Length**	2.4	2.4	7.5	5.0
Vehicle trips	20,000	19,200	9,400	9,600
Car trips	17,000	16,200	8,000	8,300
Freight Trips	600	600	280	250
Delivery Trips	2,400	2,400	1,130	1,000

* - Assumes a 5 percent decrease in car trips due to more intensive development making the corridor more suitable for alternative modes.

** - Taken from WFRC model and used for VHT calculations.

By multiplying the trips and trip lengths as shown in **Table 5**, the projected on-corridor and displaced VMT was calculated for each modeling scenario and is presented in **Table 6**. (See Development Assumptions tab in Spreadsheet).

Table 6: Projected Daily On-Corridor and Displaced VMT for Horizon Year (2057)

	On-Corridor Trips (Background)		Displaced Trips (Induced)	
	300 West No Build	300 West Build*	Suburban No Build	300 West Build
Car VMT	40,800	38,900	59,900	35,300
Freight VMT	1,400	1,400	2,100	1,300
Delivery VMT	5,800	1,400	8,500	1,300
Total VMT	**48,000**	**41,700**	**70,500**	**37,900**

Developing Projected Delay and Vehicle Miles Traveled

Projected delay and associated VHT were based on the following assumptions for each model runs:

- Starting 85th percentile cruise speeds for general traffic based on observed radar detector speeds
- Starting 85th percentile cruise speeds for truck traffic based on observed radar detector speeds
- Reduction factor to account for signals, congestion, etc. based on floating car speed runs
- Percent congestion for peak hour and off-peak traffic based on travel model estimates

Table 7: Projected On-Corridor and Displaced Travel Speeds for Horizon Year (2057)

	On-Corridor (Background)			Displaced Trips (Induced)		
	300 West No Build	**300 West Build***	**On Corridor Speed Difference**	**Suburban No Build**	**300 West Build**	**Displaced Trips Speed Difference**
Starting 85th% cruise speed: General Traffic	43	35	8.0	45	35	10.0
Starting 85th% cruise speed: Trucks & Delivery	37	34	3.0	40	34	6.0
Reduction factor to account for signals, congestion, etc.)	0.6	0.65	-0.05	0.6	0.65	-0.05
General Traffic average speed, w/signals & cong.	**25.8**	**22.75**	**3.1**	**27**	**22.75**	**4.3**
Truck average speed, with signals & congestion	**22.2**	**22.1**	**0.1**	**24**	**22.1**	**1.9**
Percent Congestion, Peak Hour	65%	55%	0.1	75%	55%	0.2
Percent Congestion, Off Peak	10%	10%	0.0	10%	10%	0.0

Based on the travel speeds presented in **Table 7**, the following represent the number of VHT derived when taking the average travel speeds with stop lights and congestion for cars and freight and delivery trucks shown on **Table 6**.

Table 8: Projected Daily On-Corridor and Displaced VHT for Horizon Year (2057)

	On-Corridor (Background)		Displaced Trips (Induced)	
	300 West No Build	**300 West Build***	**Suburban No Build**	**300 West Build**
General traffic average speed, with stop lights & congestion	25.8	22.8	27.0	22.8
Truck traffic average speed, with stop lights & congestion	22.2	22.1	24.0	22.1
Total Daily VHT	1,900	19,200	9,400	9,600
VHT Cars	1,600	1,700	2,200	1,600
VHT Freight	60	60	90	60
VHT Delivery	260	330	350	230

Developing Background and Induced Trip Tables

This section describes how the travel demand factors developed in the previous section were used to develop the overall trip tables that are applied to the fixed factors described in the BCA Analysis Guidance to drive the calculation of the benefits streams.

A key factor is the assumption of a percentage of commute trips, other trips, and truck trips for peak hour and off-peak periods for each of the scenarios based on regional characteristics. These peak hour factors are as follows. Note that for cars in peak hour .15+.10 = 25%, while off-peak is .15+.60 = 75% for a total of 100%.

Table 9: Assumed Peak Hour Factors for Background and Induced Traffic

	Peak Hour	Off-Peak
Percent Passenger Car – Commuter	0.15	0.15
Percent Car – Other	0.10	0.60
Percent Truck	0.20	0.80

In order to develop the benefit streams, the following travel characteristics were developed:

- Background Traffic **(Tables 10a and 10b)**
- Induced Traffic **(Tables 11a and 11b)**
- Background and Induced Traffic Combined **(Tables 12a and 12b)**

Daily value tables were created for the 20,000 background trips and how they are affected by build and no-build, and a similar set of tables were developed for induced traffic and how those trips are affected within the corridor, and how they would have been affected elsewhere in the no-build. **The following applies to both Table sets 10 and 11. Table 12 is the sum of 10 and 11.**

- Vehicle Trips in the peak hour and off-peak for commuting passenger cars, other passenger cars, delivery trucks and freight trucks for the **no-build alternative** – This is equal to the number of **on-corridor** car trips, delivery truck trips and freight trips presented in **Table 5** multiplied by the percentage factors provided in **Table 9**.
- Vehicle Hours in the peak hour and off-peak for commuting passenger cars, other passenger cars, delivery trucks and freight trucks for the **no-build alternative** – This is equal to the **on-corridor** VHT for car trips, delivery truck trips and freight trips presented in **Table 8** multiplied by the percentage factors provided in **Table 9**.
- Vehicle Miles in the peak hour and off-peak for commuting passenger cars, other passenger cars, delivery trucks and freight trucks for the **no-build alternative**– This is equal to the **on-corridor** VMT for car trips, delivery truck trips and freight trips presented in **Table** multiplied by the percentage factors provided in **Table 9**.

- Vehicle Trips in the peak hour and off-peak for commuting passenger cars, other passenger cars, delivery trucks and freight trucks for the **build alternative** – This is equal the number of **on-corridor** car trips, delivery truck trips and freight trips presented in **Table 5** multiplied by the percentage factors provided in **Table 9**.
- Vehicle Hours in the peak hour and off-peak for commuting passenger cars, other passenger cars, delivery trucks and freight trucks for the **build alternative** – This is equal the VHT for **on-corridor** car trips, delivery truck trips and freight trips presented in **Table 8** multiplied by the percentage factors provided in **Table 9**.
- Vehicle Miles in the peak hour and off-peak for commuting passenger cars, other passenger cars, delivery trucks and freight trucks for the **build alternative**– This is equal the VMT for **on-corridor** car trips, delivery truck trips and freight trips presented in **Table 6** multiplied by the percentage factors provided in **Table 9**.

The annual values are computed by multiplying daily values by 312 days per year (assuming remaining days are accounted for within the estimates).

Table 10a: Background Traffic – Daily Values

		Vehicle Trips (Peak)	Vehicle Trips (Off Peak)	Vehicle Hours (Peak)	Vehicle Hours (Off Peak)	Vehicle Miles (Peak)	Vehicle Miles (Off Peak)	% VMT Congested (Peak)	% VMT Congested (Off Peak)
No Build Case	Passenger Car - Commuting	2,552	2,552	237	237	6,120	6,120	0.75	0.10
	Passenger Car – Other/Personal	1,701	10,208	158	948	4,080	24,480	0.75	0.10
	Freight Truck	120	480	12	48	280	1,120	0.75	0.10
	Delivery Truck	480	1,922	52	208	1,160	4,640	0.75	0.10
	All Modes and Purposes	4,854	15,162	459	1,441	11,640	36,360	-	-
Build Case	Passenger Car - Commuting	2,430	2,430	257	257	5,835	5,835	0.55	0.10
	Passenger Car – Other/Personal	1,620	9,720	171	1,026	3,890	23,340	0.55	0.10
	Freight Truck	120	480	12	48	280	1,120	0.55	0.10
	Delivery Truck	480	1,922	52	280	1,160	4,640	0.55	0.10
	All Modes and Purposes	4,650	14,552	492	1,611	11,165	34,935	-	-

Table 10b: Background Traffic – Annual Values

		Vehicle Trips (Peak)	Vehicle Trips (Off Peak)	Vehicle Hours (Peak)	Vehicle Hours (Off Peak)	Vehicle Miles (Peak)	Vehicle Miles (Off Peak)	% VMT Congested (Peak)	% VMT Congested (Off Peak)
No Build Case	Passenger Car - Commuting	800,000	800,000	70,000	70,000	1,910,000	1,910,000	0.75	0.10
	Passenger Car – Other/Personal	530,000	3,180,000	50,000	300,000	1,270,000	7,640,000	0.75	0.10
	Freight Truck	37,000	150,000	4,000	15,000	87,000	349,000	0.75	0.10
	Delivery Truck	150,000	600,000	16,000	65,000	362,000	1,448,000	0.75	0.10
	All Modes and Purposes	1,517,000	4,730,000	140,000	450,000	3,629,000	11,347,000	-	-
Build Case	Passenger Car - Commuting	760,000	760,000	80,000	80,000	1,820,000	1,820,000	0.55	0.10
	Passenger Car – Other/Personal	510,000	3,030,000	50,000	320,000	1,210,000	7,280,000	0.55	0.10
	Freight Truck	37,000	150,000	4,000	15,000	87,000	349,000	0.55	0.10
	Delivery Truck	150,000	600,000	16,000	87,000	362,000	1,448,000	0.55	0.10
	All Modes and Purposes	1,457,000	4,540,000	150,000	502,000	3,479,000	10,897,000	-	-

Table 11a: Induced Traffic – Daily Values

		Vehicle Trips (Peak)	Vehicle Trips (Off Peak)	Vehicle Hours (Peak)	Vehicle Hours (Off Peak)	Vehicle Miles (Peak)	Vehicle Miles (Off Peak)	% VMT Congested (Peak)	% VMT Congested (Off Peak)
No Build Case	Passenger Car - Commuting	1,199	1,199	333	333	8,985	8,985	0.75	0.10
	Passenger Car – Other/Personal	799	4,794	222	1,332	5,990	35,940	0.75	0.10
	Freight Truck	56	224	18	72	420	1,680	0.75	0.10
	Delivery Truck	226	904	70	280	1,700	6,800	0.75	0.10
	All Modes and Purposes	2,280	7,121	643	2,017	17,095	53,405	-	-
Build Case	Passenger Car - Commuting	1,245	1,245	233	233	5,295	5,295	0.55	0.10
	Passenger Car – Other/Personal	830	4,980	155	930	3,530	21,180	0.55	0.10
	Freight Truck	50	200	12	48	260	1,040	0.55	0.10
	Delivery Truck	200	800	46	184	1,000	4,000	0.55	0.10
	All Modes and Purposes	2,325	7,225	446	1,395	10,085	31,515	-	-

Table 11b: Induced Traffic – Annual Values

		Vehicle Trips (Peak)	Vehicle Trips (Off Peak)	Vehicle Hours (Peak)	Vehicle Hours (Off Peak)	Vehicle Miles (Peak)	Vehicle Miles (Off Peak)	% VMT Congested (Peak)	% VMT Congested (Off Peak)
No Build Case	Passenger Car - Commuting	370,000	370,000	100,000	100,000	2,800,000	2,800,000	0.75	0.10
	Passenger Car – Other/Personal	250,000	1,500,000	70,000	420,000	1,870,000	11,210,000	0.75	0.10
	Freight Truck	17,000	70,000	6,000	22,000	131,000	524,000	0.75	0.10
	Delivery Truck	71,000	282,000	22,000	87,000	530,000	2,122,000	0.75	0.10
	All Modes and Purposes	708,000	2,222,000	198,000	629,000	5,331,000	16,656,000	-	-
Build Case	Passenger Car - Commuting	390,000	390,000	70,000	70,000	1,650,000	1,650,000	0.55	0.10
	Passenger Car – Other/Personal	260,000	1,550,000	50,000	290,000	1,100,000	6,610,000	0.55	0.10
	Freight Truck	16,000	62,000	4,000	15,000	81,000	324,000	0.55	0.10
	Delivery Truck	62,000	250,000	14,000	57,000	312,000	1,248,000	0.55	0.10
	All Modes and Purposes	728,000	2,252,000	138,000	432,000	3,143,000	9,832,000	-	-

Table 12a: Background and Induced Traffic Combined – Daily Values

		Vehicle Trips (Peak)	Vehicle Trips (Off Peak)	Vehicle Hours (Peak)	Vehicle Hours (Off Peak)	Vehicle Miles (Peak)	Vehicle Miles (Off Peak)	% VMT Congested (Peak)	% VMT Congested (Off Peak)
No Build Case	Passenger Car - Commuting	3,751	3,751	570	570	15,105	15,105	0.75	0.10
	Passenger Car – Other/Personal	2,500	15,002	380	2,280	10,070	60,420	0.75	0.10
	Freight Truck	176	704	30	120	700	2,800	0.75	0.10
	Delivery Truck	706	2,826	122	488	2,860	11,440	0.75	0.10
	All Modes and Purposes	7,133	22,283	1,102	3,458	28,735	89,765	-	-
Build Case	Passenger Car - Commuting	3,675	3,675	489	489	11,130	11,130	0.55	0.10
	Passenger Car – Other/Personal	2,450	14,700	326	1,956	7,420	44,520	0.55	0.10
	Freight Truck	170	680	24	96	540	2,160	0.55	0.10
	Delivery Truck	680	2,722	98	464	2,160	8,640	0.55	0.10
	All Modes and Purposes	6,975	21,777	937	3,005	21,250	66,450	-	-

Table 12b: Background and Induced Traffic Combined – Annual Values

		Vehicle Trips (Peak)	Vehicle Trips (Off Peak)	Vehicle Hours (Peak)	Vehicle Hours (Off Peak)	Vehicle Miles (Peak)	Vehicle Miles (Off Peak)	% VMT Congested (Peak)	% VMT Congested (Off Peak)
No Build Case	Passenger Car - Commuting	1,170,000	1,170,000	170,000	170,000	4,710,000	4,710,000	0.75	0.10
	Passenger Car – Other/Personal	780,000	4,680,000	120,000	720,000	3,140,000	18,850,000	0.75	0.10
	Freight Truck	54,000	220,000	10,000	37,000	218,000	873,000	0.75	0.10
	Delivery Truck	221,000	882,000	38,000	152,000	892,000	3,570,000	0.75	0.10
	All Modes and Purposes	2,225,000	6,952,000	338,000	1,079,000	8,960,000	28,003,000	-	-
Build Case	Passenger Car - Commuting	1,150,000	1,150,000	150,000	150,000	3,470,000	3,470,000	0.55	0.10
	Passenger Car – Other/Personal	770,000	4,580,000	100,000	610,000	2,310,000	13,890,000	0.55	0.10
	Freight Truck	53,000	212,000	8,000	30,000	168,000	673,000	0.55	0.10
	Delivery Truck	212,000	850,000	30,000	144,000	674,000	2,696,000	0.55	0.10
	All Modes and Purposes	2,185,000	6,792,000	288,000	934,000	6,622,000	20,729,000	-	-

3. Safety Analysis

The following section provides the background analysis used to calculate the safety benefits included in the BCA. As such, it details the methodology for:

- Developing the no build scenario crash rate based on historical crash data and estimated travel demand
- Application of Crash Modification Factors (CMFs) to develop the crash reduction rate for a best case and worst-case scenarios
- Application of reduced crash rates to the projected number of person trips
- Calculation of safety benefits based on projected travel demand and delay (documented in Section 2)

Development of No Build Crash Rate

The no build crash rate for the corridor was developed based on the historical crash data provided by UDOT for seven years from 2010-2016, which is provided in **Table 13**. The crashes were classified by the Maximum Abbreviated Injury Scale (MAIS) categories.

Table 13: Historical Crash Data

	PDO	**Slight**	**Moderate**	**Serious**	**Fatalities**
Severity	Property Damage Only	Minor Injuries	Significant Injuries	Serious Injuries	Fatalities
2010	27	18	7	1	0
2011	24	7	16	2	0
2012	34	14	12	3	0
2013	35	9	5	2	0
2014	23	14	12	0	0
2015	29	14	14	0	0
2016	48	18	22	3	0
7-Year Average	**31.4**	**13.4**	**12.6**	**1.6**	**0.0**

Source: Utah Department of Transportation

The number of crashes was applied to the annual background VMT of 15.0 million to derive the baseline crash rates per million VMT. This background VMT is the weighted average of UDOT counts multiplied by the 2.4 mile length multiplied by the number of effective days per year (312). Based on this, the no-build crash rates for the crash types listed in **Table 13** are as follows:

- Property Damage Only – 2.10 crashes per million VMT
- Minor Injuries – 0.90 crashes per million VMT
- Moderate Injuries – 0.84 crashes per million VMT
- Serious Injuries – 0.10 crashes per million VMT
- Fatalities – 0.00 crashes per million VMT

IMPORTANT NOTE: While no fatalities were recorded from 2010-2016, it is reasonable to assume that eventually a fatality would occur. However, this analysis conservatively assumes no fatalities in either no build or build.

Application of Crash Modification Factors

In order to develop an overall safety benefit, best-case and worst-case Crash Modification Factors (CMFs) were researched and applied to corridor travel characteristics and safety rates. A worst-case scenario was developed to represent a case where the full safety benefits were not realized. The CMFs used for this analysis were derived from the CMF Clearinghouse (www.cmfclearinghouse.org) and included the following:

- 15% reduction in speed (**Table 7**) and its effects on fatalities, injuries, and property damage
- Removal of on-street parking
- Raised medians
- Reduced driveways
- Protected or buffered bike lanes

Given that additional factors beyond speed reduction are not entirely additive, benefit reduction factors are shown in red for on-street parking, raised medians, and reduced driveways were developed for application to the build alternative. Furthermore, new bike lanes also have their own CMF, it was assumed that benefits already shown would adequately reflect benefits. The CMF factors along with their sources as well as the reduced factors to be applied to calculate the safety benefits for building the proposed project are provided in **Table 14**.

Table 14: Crash Modification Factors

Crash Modification Factors for 300 West	Best Case		Worst-Case	
	CMF	Reduced*	CMF	Reduced*
15% reduction in speed, effect on fatalities[1]	0.56	0.56	0.59	0.59
15% reduction in speed, effect on injuries[1]	0.78	0.78	0.81	0.81
15% reduction in speed, property damage[1]	0.85	0.85	0.88	0.88
Remove on-street parking[2]	0.72	0.91	0.78	0.93
Raised median[3]	0.61	0.87	0.78	0.93
Reduce driveways[4]	0.69	0.90	0.75	0.92
Protected/buffered bike lanes[5]	0.92	0.97	0.95	0.98

Sources:

1 - *Speed and Road Accidents: An Evaluation of the Power Model* - Elvik, R., Christensen, P., and Amundsen, A., Oslo, Norway, Transportokonomisk Institutt, 2014

2 - *Highway Safety Manual*, 2010

3 - *Highway Safety Manual*, 2010

4 – *Handbook of Road Safety Measures*, Elvik, R. and Vaa, T., 2004

5 - *Evaluating the Safety Effects of Bicycle Lanes in New York City*, Chen et al., June 2012

Based on the factors noted above, **Table 15** presents the reduction rates for best case and worst-case safety factors as developed for crash types. For example, the best-case property damage only reduction factor of 0.60 is derived by multiplying the factor for property damage (.85) by the reduced rates for on-street parking removal (0.91), raised medians (0.87), and reduced driveways (0.90). For PDO, the .97 rate for bike lanes is not used, as a crash involving a bike likely results in negligible property damage compared to vehicle to vehicle.

Table 15: Best Case and Worst-Case CMFs for Accident Types

Crash Modification Factors for 300 West*	Best Case	Worst-Case
Fatalities	0.39	0.46
Injury Accidents	0.54	0.63
Property Damage Only	0.60	0.69

Note: A value of .60 means that the new accident rate will be 60% of the previous, or a 40% reduction would occur as a result of the project.

By applying the factors in **Table 15** to the no build crash rates, the estimated best case and worst case crash rates are provided in **Table 16**.

Table 16: No Build, Best Case and Worst-Case Crash Rates

Crash Modification Factors for 300 West*	No Build	Best Case	Worst-Case
Property Damage Only	2.10	1.26	1.45
Minor Injuries	0.90	0.48	0.56
Significant Injuries	0.84	0.45	0.53
Serious Injuries	0.10	0.06	0.07
Fatalities	0.00	0.00	0.00

4. Compilation of Benefit Streams

This section details how the quantitative benefit streams were derived to develop the overall monetary benefits and/or disbenefits resulting from the 300 West project. These benefits are as follows:

- Vehicle Operating Costs
- Value of Time
- Reliability
- Safety
- Non-CO^2 Emissions

Calculating the Key Scenario Values through the Horizon Year 2057

This section describes how travel characteristics were calculated to provide the baseline for the developing the benefit streams. An important consideration of this exercise were the following assumptions:

- No benefits through induced development with shorter trip lengths would occur until after development has measurably started opening, (assumed to be in 2025, 3-years after project opening).
- It would take until near the horizon year, or 2050, to realize 100% of the induced development.
- Because there is a 25-year period for the project to result in full benefits, it is assumed that benefits would increase by 4% per year (100% / 25 yrs) beginning in 2025 through 2050, after which no additional benefits are had through the analysis period of 2057.

As such, the following describes the primary factors used to develop the benefits through 2057. A key part of the calculations needed for benefits are the use of fixed factors provided by the FHWA guidance, which are referred to throughout the methodologies within this section.

Calculation of Key Scenario (Build or No Build) Values

- Passenger Car Commute Trips = (Scenario Background Peak Hour Passenger Car Commute Trips + Background Scenario Off-Peak Passenger Car Commute Trips) + ((% Benefit) * (Induced Scenario Peak Hour Passenger Car Commute Trips + Induced Scenario Off-Peak Passenger Car Commute Trips))
- Passenger Car Other Trips = (Background Scenario Peak Hour Passenger Car Other Trips + Background Scenario Off-Peak Passenger Car Other Trips) + ((% Benefit) * (Induced Scenario Peak Hour Passenger Car Other Trips + Induced Scenario Off-Peak Passenger Car Other Trips))
- Truck Trips = (Background Scenario Peak Hour Truck Trips + Background Scenario Off-Peak Tuck Trips) + ((% Benefit) * (Induced Scenario Peak Truck Trips + Induced Scenario Off-Peak Truck Trips))
- Passenger Car Commute VMT = (Background Scenario Peak Hour Passenger Car Commute VMT + Background Scenario Off-Peak Passenger Car Commute VMT) + ((% Benefit) * (Induced Scenario Peak Hour Passenger Car Commute VMT + Induced Scenario Off-Peak Passenger Car Commute VMT))
- Passenger Car Other VMT = (Background Scenario Peak Hour Passenger Car Other VMT + Background Scenario Off-Peak Passenger Car Other VMT) + ((% Benefit) * (Induced Scenario Peak Hour Passenger Car Other VMT + Induced Scenario Off-Peak Passenger Car Other VMT))
- Truck VMT = (Background Scenario Peak Hour Truck VMT + Background Scenario Off-Peak Tuck VMT) + ((% Benefit) * (Induced Scenario Peak Truck VMT + Induced Scenario Off-Peak Truck VMT))
- Passenger Car Commuting Congestion Percentage = (((Background Scenario Peak Hour Passenger Car Commute VMT * Percent Scenario Passenger Car Commute Peak Hour Congested VMT) + (Background Scenario Off-Peak Passenger Car Commute VMT * Percent Scenario Passenger Car Commute Off Peak Congested VMT) + ((% Benefit) * (Induced Scenario Peak Hour Passenger Car Commute VMT * Percent Scenario Passenger Car Commute Peak Hour Congested VMT) + (Induced Scenario Off-Peak Passenger Car Commute VMT * Percent Scenario Passenger Car Commute Off Peak Congested VMT)) /
  (Background Scenario Peak Hour Passenger Car Commute VMT + Background Scenario Off-Peak Passenger Car Commute VMT) + ((% Benefit) * (Induced Scenario Peak Hour Passenger Car Commute VMT + Induced Scenario Off-Peak Passenger Car Commute VMT)))
- Passenger Car Other Congestion Percentage = (((Background Scenario Peak Hour Passenger Car Other VMT * Percent Scenario Passenger Car Other Peak Hour Congested VMT) + (Background Scenario Off-Peak Passenger Car Other VMT * Percent Scenario Passenger Car Other Off Peak Congested VMT) + ((% Benefit) * (Induced Scenario Peak Hour Passenger Car Other VMT * Percent Scenario Passenger Car Other Peak Hour Congested VMT) + (Induced Scenario Off-Peak Passenger Car Other VMT * Percent Scenario Passenger Car Other Off Peak Congested VMT)) /
  (Background Scenario Peak Hour Passenger Car Other VMT + Background Scenario Off-Peak Passenger Car Other VMT) + ((% Benefit) * (Induced Scenario Peak Hour Passenger Car Other VMT + Induced Scenario Off-Peak Passenger Car Other VMT)))

- Number of Congested Truck Trips = (((Background Scenario Peak Hour Truck VMT * Percent Scenario Truck Peak Hour Congested VMT) + (Background Scenario Off-Peak Truck VMT * Percent Scenario Truck Off Peak Congested VMT) + (Background Scenario Peak Hour Delivery Truck VMT * Percent Scenario Delivery Truck Peak Hour Congested VMT) + (Background Scenario Off-Peak Delivery Truck VMT * Percent Scenario Delivery Truck Off Peak Congested VMT)) + ((% Benefit) * ((Induced Scenario Peak Hour Truck VMT * Percent Scenario Truck Peak Hour Congested VMT) + (Induced Scenario Off-Peak Truck VMT * Percent Scenario Truck Off Peak Congested VMT) + (Induced Scenario Peak Hour Delivery Truck VMT * Percent Scenario Delivery Truck Peak Hour Congested VMT) + (Induced Scenario Off-Peak Delivery Truck VMT * Percent Scenario Delivery Truck Off Peak Congested VMT)))
- Percentage of Congested Trucks = Total Background Truck Congested VMT / Total Background Truck VMT
- Passenger Car Commute VHT = (Background Scenario Peak Hour Passenger Car Commute VHT + Background Scenario Off-Peak Passenger Car Commute VHT) + ((% Benefit) * (Induced Scenario Peak Hour Passenger Car Commute VHT + Induced Scenario Off-Peak Passenger Car Commute VHT))
- Passenger Car Other VHT = (Background Scenario Peak Hour Passenger Car Other VHT + Background Scenario Off-Peak Passenger Car Other VHT) + ((% Benefit) * (Induced Scenario Peak Hour Passenger Car Other VHT + Induced Scenario Off-Peak Passenger Car Other VHT))
- Truck VHT = (Background Scenario Peak Hour Truck VHT + Background Scenario Off-Peak Tuck VHT) + ((% Benefit) * (Induced Scenario Peak Truck VHT + Induced Scenario Off-Peak Truck VHT))
- Passenger Car Commute Buffer Time Hours = Scenario Passenger Car Commuting Congestion Percentage * Scenario Passenger Car Commute VHT * Auto Occupancy Fixed Factor (1.39)
- Passenger Car Other Buffer Time Hours = Scenario Passenger Car Other Congestion Percentage * Scenario Passenger Car Other VHT * Auto Occupancy Fixed Factor (1.39)
- Truck Buffer Time Hours = Scenario Passenger Car Other Congestion Percentage * Scenario Passenger Car Other VHT * Truck Occupancy Fixed Factor (1.00)
- Property Damage Crashes = ((Scenario Passenger Car Commute VMT/1,000,000) * (Scenario Property Damage Accident Rate)) + ((Scenario Passenger Car Other VMT/1,000,000) * ((Scenario Property Damage Accident Rate)) + ((Scenario Truck VMT/1,000,000) * (Scenario Property Damage Accident Rate)). ***Note for the Build Scenario, the Worst Case crash rates were used.***
- Injury Crashes = ((Scenario Passenger Car Commute VMT/1,000,000) * (Scenario Minor Injury Rate + Scenario Moderate Injury Rate + Scenario Serious Injury Rate)) + ((Scenario Passenger Car Other VMT/1,000,000) * (Scenario Minor Injury Rate + Scenario Moderate Injury Rate + Scenario Serious Injury Rate)) + ((Scenario Truck VMT/1,000,000) * (Scenario Minor Injury Rate + Scenario Moderate Injury Rate + Scenario Serious Injury Rate)). ***Note for the Build Scenario, the Worst Case crash rates were used.***

Vehicle Operating Costs

Vehicle operating costs are calculated for passenger car commute trips, passenger car other trips and trucks. The methodology for vehicle operating costs for the no build and build scenarios are as follows:

- Passenger Car Commuter Vehicle Operating Costs = Scenario Passenger Car Commuter VMT * (1 – Scenario Percent of Passenger Car Commuter Congestion) * Free Flow Vehicle Operating Cost Fixed Factor **+** (Scenario Passenger Car Commuter VMT * (1 – Scenario Percent of Passenger Car Commuter Congestion) * (Average Fuel Consumption Gallon per Mile under Free Flow Conditions Fixed Factor * Costs per Gallon Fixed Factor)) + Scenario Passenger Car Commuter VMT * (Scenario Percent of Passenger Car Commuter Congestion * Congested Passenger Car Operating Cost per Mile Fixed Factor) + (Scenario Passenger Car Commuter VMT * Scenario Percent of Passenger Car Commuter Congestion) * (Average Passenger Car Fuel Consumption Gallon per Mile under Congested Conditions Fixed Factor * Costs per Gallon (Gas) Fixed Factor))
- Passenger Car Other Vehicle Operating Costs = Scenario Passenger Car Other VMT * (1 – Scenario Percent of Passenger Car Other Congestion) * Free Flow Passenger Car Operating Cost Fixed Factor **+** (Scenario Passenger Car Other VMT * (1 – Scenario Percent of Passenger Car Other Congestion) * (Average Fuel Consumption Gallon per Mile under Free Flow Conditions Fixed Factor * Costs per Gallon (Gas) Fixed Factor)) + Scenario Passenger Car Other VMT * (Scenario Percent of Passenger Car Other Congestion * Congested Passenger Car Operating Cost per Mile Fixed Factor) + (Scenario Passenger Car Other VMT * Scenario Percent of Passenger Car Other Congestion) * (Average Fuel Consumption Gallon per Mile under Congested Conditions Fixed Factor * Costs per Gallon (Gas) Fixed Factor))
- Truck Vehicle Operating Costs = Scenario Truck VMT * (1 – Scenario Percent of Truck Congestion) * Free Flow Truck Operating Cost Fixed Factor **+** (Scenario Truck VMT * (1 – Scenario Percent of Truck Congestion) * (Average Fuel Consumption Gallon per Mile under Free Flow Conditions Fixed Factor * Costs per Gallon (Gas) Fixed Factor)) + Scenario Truck VMT * (Scenario Percent of Truck Congestion * Congested Truck Operating Cost per Mile Fixed Factor) + (Scenario Truck VMT * Scenario Percent of Truck Congestion) * (Average Fuel Consumption Gallon per Mile under Congested Conditions Fixed Factor * Costs per Gallon (Gas) Fixed Factor))

Value of Time

Value of Time is another benefit stream calculated for passenger car commute trips, passenger car other trips and truck trips. The methodology for calculating value of time costs under the no build and build scenarios are as follows:

- Passenger Car Commute Trips Value of Time = Scenario Passenger Car Commute VHT * Passenger Car Vehicle Occupancy Fixed Factor (1.68) * Value per Hour per Passenger Car occupant Fixed Factor ($14.20)
- Passenger Car Other Trips Value of Time = Scenario Passenger Car Other VHT * Passenger Car Vehicle Occupancy Fixed Factor (1.68) * Value per Hour per Passenger Car occupant Fixed Factor ($14.20)
- Truck Other Trips Value of Time = Scenario Truck VHT * Truck Vehicle Occupancy Fixed Factor (1.00) * Value per Hour per Truck occupant Fixed Factor ($28.60)

Reliability

Reliability refers to the predictability and dependability of travel times on the transportation network. The methodology for calculating reliability costs for the no build and build scenarios are as follows:

- Passenger Car Commute Trips Reliability = Scenario Passenger Car Commute Buffer Time Hours * Value of Passenger Time per Hour for Passenger Cars Fixed Factor ($26.50)
- Passenger Car Other Trips Reliability = Scenario Passenger Car Other Buffer Time Hours * Value of Passenger Time per Hour for Passenger Cars Fixed Factor ($14.80)
- Truck Other Trips Reliability = Scenario Truck Buffer Time Hours * Value of Passenger Time per Hour for Passenger Cars Fixed Factor ($72.60)

Safety

As previously noted, safety is placed into categories for property damage only, injury, and fatalities. Given that there were no fatalities observed in the data used to develop this BCA, no fatalities were assumed through the planning horizon. The methodology for safety costs for the no build and build scenarios are as follows:

- Value of Property Damage Crashes = Scenario Number of Property Damage Crashes * Value of Property Damage Crashes per Incident Fixed Factor ($4,300)
- Value of Injury Crashes = Scenario Number of Injury Crashes * Value of Injury Per Person Fixed Factor ($174,000)

Non-CO^2 Emissions

The primary environmental benefit is the calculation of air quality benefits from reduced emissions under the no build and the build scenarios as follows:

- Value of Non-CO^2 Emissions for Passenger Car Commute Trips = Scenario Passenger Car Commute VMT * Monetary Value of Emissions per VMT for Passenger Car Trips Fixed Factor ($0.0104)
- Value of Non-CO^2 Emissions for Passenger Car Other Trips = Scenario Passenger Car Other VMT * Monetary Value of Emissions per VMT for Passenger Car Trips Fixed Factor ($0. 0104)
- Value of Non-CO^2 Emissions for Truck Trips = Scenario Truck VMT * Monetary Value of Emissions per VMT for Truck Trips Fixed Factor ($0.1678)

Sign Change in Passenger Car Benefit at 7% Discount Rate

At the 7% discount rate, the cumulative discounted benefit stream for passenger car time (or household travel time) changes sign, from a benefit due to shorter trips associated with anticipated land-use effects of the project, to a dis-benefit due to the slowing of traffic in earlier years before this benefit occurs. This is because the land use efficiency (and shorter trip lengths) apply primarily to personal/household travel patterns (more so than truck and delivery patterns) which take time to phase-in (as shown in column B of the travel characteristics worksheet), and by the end of the analysis period these land use changes have had enough years to create substantial cumulative household savings to offset the slowing down of traffic in the early years. By contrast the truck deliveries aren't as different and are less sensitive to the speed-oriented changes in the design. Because this is a late-starting benefit (doesn't really have significant effects until the later years of the horizon); its absence in the early years (and presence in later years) only affects the 7% discount rate (in which the benefits occurring in later years are discounted to a level that the early-years speed-based travel time-dis-benefit outweighs the later-years trip-length (land use) based benefit).

Observations of Final Results

Question: Why is travel time benefit positive when the definition of the project will slow traffic?

The project concept is to utilize traffic calming techniques to create a complete street. This means "slow down traffic," which intuitively would have a safety benefit, but also a value of time disbenefit. In the summary table below, the value of time is positive. Why? In the earliest years, the effect in any given year is negative, as all we have done is slowed existing traffic. But as new construction occurs in later years, yes trips associated with that traffic are travel at a slower speed, but they also travel significantly less distance than they otherwise would have, for an overall shorter trip time despite the slower speed. Thus eventually the positive effects of new development overcome the negative effects to current traffic, for an overall positive effect summed over the entire period. This is plainly visible in the associated spreadsheet that generated this table.

Question: Why is the Environmental Benefit Low?

This benefit is based exclusively on non-CO2 emissions, which are directly connected to VMT. As it takes many years for new development to occur, it also takes many years for VMT reductions associated with that development to occur, so the benefits accrue in the out years, which are also years discounted the heaviest. However, this is permanent environmental benefit because the fabric of the space is fundamentally more sustainable. There would also be associated environmental benefits from reduced CO2, reduced storm drain runoff, carbon sequestering trees, and "copy-cat" projects (communities elsewhere create complete streets due in part to the successful economic development they witnessed from this project). Then there is the fact that any air quality benefit in Salt Lake is really worth a lot more than elsewhere, because the mountains around Salt Lake trap polluted air near the valley floor for weeks at a time, giving SLC the 6th worst air in the nation despite being only the 47th largest urban area. Further, the "quality of life" itself is an environmental factor, and none of these additional realities have attempted to be claimed. Therefore it is our opinion that this environmental benefit is quite conservative.

35-Year Benefit Summary Based on Initial $20.2 M Cost

Discount Rate	Veh. Op. Cost	Time & Reliability	Improved Safety	Env. Benefit	Total Benefit	Total Cost	Benefit / Cost Ratio
7%	$17	$10	$36	$1	$63	$15	4.2
3%	$45	$41	$83	$3	$172	$17	9.9

Observation: Safety Benefits vs. Time Benefits

Historically, roadways have been prioritized for traffic speed, as if the time portion of benefit vastly exceeded any other benefit. However, these calculations bare out that the safety benefit of reduced speed far exceeds the disbenefit of lost time. And in this case, "Lost time" is only lost in the early years. New development eventually results in time saving despite lower speed, because trips are shorter distance.