

## a. COST-EFFECTIVENESS ANALYSIS

A Benefit-Cost Analysis (BCA) was prepared for the Laredo Bundle project using the *California Life-Cycle Benefit/Cost Analysis Model* (Cal-B/C). The California Department of Transportation developed the 2016 Cal-B/C TIGER Grant Application Model as an adaptable tool intended for conducting economic analysis in accordance with US DOT guidance. The publically available spreadsheet model is capable of assessing both highway and transit projects. A separate BCA was conducted for each of the two projects comprising the Laredo Bundle: the US 59 westbound to IH 35 southbound Direct Connector (the Direct Connector) and the US 59 Overpass (the Overpass). Individual analysis inputs and results are presented for each project, along with composite results where appropriate.

The Cal-B/C model uses project-specific input data to calculate life-cycle costs, life-cycle benefits, annual benefits, net present values of costs and benefits, a resulting benefit/cost ratio, and the internal rate of return and payback period. Cal-B/C evaluates benefits in the following four categories: travel time, vehicle operation, accidents, and emissions. A summary of the BCA is provided in Section (i) of this appendix. Section (ii) discusses the Cal-B/C inputs used for analysis of the Direct Connector and Overpass projects, and Section (iii) provides details regarding the individual and composite BCA results. All monetary values presented in this appendix were adjusted to 2015 dollars, the default value of the “2016 TIGER” version of the Cal B/C model, based on the Gross Domestic Product Price Index, unless otherwise stated. A seven percent (7%) discount rate was used to compute net present value of benefits and costs.

### (i) BENEFIT-COST ANALYSIS SUMMARY

The BCA results indicate a *positive* benefit/cost ratio for both the Direct Connector project and the Overpass project reflecting that the life-cycle benefits of the projects exceed their estimated project-related costs. The Cal-B/C model calculates the benefit/cost ratio based on inputs including the type of project, existing and anticipated highway design and traffic data, current accident data, and estimated project costs. Table 1 and Table 2 provide a summary of the Cal-B/C results.

TABLE 1: DIRECT CONNECTOR CAL-B/C RESULTS

<b>Life-Cycle Costs (mil. \$)</b>	\$18.0
<b>Life-Cycle Benefits (mil. \$)</b>	\$35.3
<b>Net Present Value (mil. \$)</b>	\$17.3
<b>Benefit / Cost Ratio:</b>	2.0
<b>Rate of Return on Investment:</b>	15.5%
<b>Payback Period:</b>	6 years

TABLE 2: OVERPASS CAL-B/C RESULTS

<b>Life-Cycle Costs (mil. \$)</b>	\$36.1
<b>Life-Cycle Benefits (mil. \$)</b>	\$67.8
<b>Net Present Value (mil. \$)</b>	\$31.7
<b>Benefit / Cost Ratio:</b>	1.9
<b>Rate of Return on Investment:</b>	15.0%
<b>Payback Period:</b>	6 years

## (ii) CAL-B/C MODEL INPUTS

The Cal-B/C model includes a number of default parameters including hourly wage, value of time, fuel price and taxes, accident costs by type of accident, and a maximum volume-to-capacity ratio. Sources for these default values include the Office of Management and Budget (OMB), the Bureau of Labor Statistics (BLS), USDOT Department Guidance, the IDAS model, the American Transportation Research Institute, AAA, the California Department of Transportation, and the California Board of Equalization. Parameters were updated by Caltrans to support 2016 TIGER applications. These default values were used in this BCA unless otherwise stated.<sup>1</sup>

Users are also required to input project-specific data into the model. These inputs are discussed in the following subsections. The model identifies project-specific data required to be input by users with green cells.

### (a) PROJECT DATA

The Cal-B/C model requires users to select the project type from a list. The Direct Connector was identified as a Freeway Connector and the Overpass project was identified as a General Highway project. Users must also select a project location that corresponds to California urban or rural peak traffic and accident parameters. The Direct Connector and Overpass projects were identified as rural. The model allows users to override default settings that indicate whether other inputs reflect one-way or two-way data. Data for the Direct Connector project was entered as one-way data and coded in this section accordingly. Data for the Overpass project was entered as two-way. The default length of peak period was accepted as five hours.

TABLE 3: DIRECT CONNECTOR CAL-B/C PROJECT DATA

<b>Type of Project</b> Select project type from list	Check percent traffic in weave in section 1B Freeway Connector
<b>Project Location</b> (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural)	3
<b>Length of Construction Period</b>	3 years
<b>One- or Two-Way Data</b>	1 enter 1 or 2
<b>Length of Peak Period(s)</b> (up to 24 hrs)	Current 5 hours

<sup>1</sup>California Department of Transportation. 2016. 2016 Cal-B/C TIGER Grant Application Model. Retrieved on 3/25/2016 from [http://www.dot.ca.gov/hq/tpp/offices/eab/LCBC\\_Analysis\\_Model.html](http://www.dot.ca.gov/hq/tpp/offices/eab/LCBC_Analysis_Model.html)

TABLE 4: OVERPASS CAL-B/C PROJECT DATA

<b>Type of Project</b>	
Select project type from list	General Highway
<b>Project Location</b> (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural)	
	3
Length of Construction Period	3 years
One- or Two-Way Data	2 enter 1 or 2
	Current
<b>Length of Peak Period(s)</b> (up to 24 hrs)	5 hours

## (b) HIGHWAY DESIGN AND TRAFFIC DATA

The Cal-B/C model also requires project-specific information regarding highway design and traffic data. In the highway design section, users must enter the roadway type, number of lanes, free-flow speed, ramp design speed, the length of the highway segment. The model has the capacity to account for HOV lane information and bus ROW information, though these features were not used as part of the Direct Connector and Overpass project analyses. The model also requires average daily traffic (ADT) data. This information must be provided for the current (or “base”) year, and also forecasted for year 20 under a “no build” scenario. The model then calculates the “build” scenario. Users may overwrite the calculated build scenario ADT data if more precise data has been obtained through a regional travel demand model.

Table 5 and Table 6 summarize the project specific data entered in the highway design and traffic data sections. The No Build speed was estimated based on data for at-grade intersections and multiple (3) traffic signals. Build speed was based on the posted speed limit for other flyover ramps at the same interchange. Average Daily Traffic (ADT) was based on 2013 and 2033 data for US-59 (Loop 20) between IH-35 and McPherson Road. Turning movements were estimated using the Florida DOT TURNS5 Spreadsheet macro.<sup>2</sup> The percentage of trucks was identified as 5.3% percent for both projects.<sup>3</sup>

<sup>2</sup> 2013 and 2033 AADT based on US-59 (Loop 20) between IH-35 and McPherson Road (per Statewide Planning Map available at [http://www.txdot.gov/apps/statewide\\_mapping/StatewidePlanningMap.html](http://www.txdot.gov/apps/statewide_mapping/StatewidePlanningMap.html)). Turning movements were estimated using the FDOT TURNS5 Spreadsheet macro

<sup>3</sup> Truck percent based on US-59 (Loop 20) between IH-35 and McPherson Road per Statewide Planning Map available at [http://www.txdot.gov/apps/statewide\\_mapping/StatewidePlanningMap.html](http://www.txdot.gov/apps/statewide_mapping/StatewidePlanningMap.html)

TABLE 5: DIRECT CONNECTOR CAL-B/C HIGHWAY DESIGN AND TRAFFIC DATA

<b>Highway Design</b>		No Build	Build
Roadway Type (Fwy, Exp, Conv Hwy)	C	E	
Number of General Traffic Lanes	2	2	
Number of HOV/HOT Lanes	0	0	
HOV Restriction (2 or 3)			
Exclusive ROW for Buses (y/n)	N		
Highway Free-Flow Speed	22	45	
Ramp Design Speed (if aux. lane/off-ramp proj.)	22	45	
Length (in miles) Highway Segment	1.0	1.0	
Impacted Length	0.6	0.6	
<b>Average Daily Traffic</b>			
Current	13,316		
	No Build	Build	
Base (Year 1)	14,701	14,701	
Forecast (Year 20)	21,625	21,625	
<b>Average Hourly HOV/HOT Lane Traffic</b>			
Percent of Induced Trips in HOV (if HOT or 2-to-3 conv.)		100%	
<b>Percent Traffic in Weave</b>	2.5%	0.0%	
<b>Percent Trucks</b> (include RVs, if applicable)	5.3%	5.3%	
<b>Truck Speed</b>			

TABLE 6: OVERPASS CAL-B/C HIGHWAY AND TRAFFIC DATA

<b>Highway Design</b>		No Build	Build
Roadway Type (Fwy, Exp, Conv Hwy)	C	F	
Number of General Traffic Lanes	4	4	
Number of HOV/HOT Lanes	0	0	
HOV Restriction (2 or 3)			
Exclusive ROW for Buses (y/n)	N		
Highway Free-Flow Speed	30.5	55	
Ramp Design Speed (if aux. lane/off-ramp proj.)	45	45	
Length (in miles) Highway Segment	1.0	1.0	
Impacted Length	1.0	1.0	
<b>Average Daily Traffic</b>			
Current	6,300		
	No Build	Build	
Base (Year 1)	6,900	6,900	
Forecast (Year 20)	10,200	10,200	
<b>Average Hourly HOV/HOT Lane Traffic</b>			
Percent of Induced Trips in HOV (if HOT or 2-to-3 conv.)		100%	
<b>Percent Traffic in Weave</b>		0.0%	
<b>Percent Trucks</b> (include RVs, if applicable)	5.3%	5.3%	
<b>Truck Speed</b>			

## (c) ACCIDENT DATA

Model users must enter three-year accident data for the project area and statewide accidents rates. Three-year accident data<sup>4</sup> was based on CRIS data and statewide average data was based on the crash rate for two lane, two-way highways.<sup>5</sup> **Error! Reference source not found.** and Table 8 show the Cal-B/C accident data inputs for the Direct Connector and Overpass projects.

TABLE 7: DIRECT CONNECTOR CAL-B/C HIGHWAY ACCIDENT DATA

<b>Actual 3-Year Accident Data (from Table B)</b>		
	Count (No.)	Rate
Total Accidents (Tot)	46	3.15
Fatal Accidents (Fat)	0.0	0.000
Injury Accidents (Inj)	14	0.96
Property Damage Only (PDO) Accidents	32	2.19
<b>Statewide Basic Average Accident Rate</b>		
	No Build	Build
Rate Group		
Accident Rate (per million vehicle-miles)	1.91	1.33
Percent Fatal Accidents (Pct Fat)	0.2%	0.2%
Percent Injury Accidents (Pct Inj)	39.7%	39.7%

TABLE 8: OVERPASS CAL-B/C HIGHWAY ACCIDENT DATA

<b>Actual 3-Year Accident Data (from Table B)</b>		
	Count (No.)	Rate
Total Accidents (Tot)	260	37.69
Fatal Accidents (Fat)	0.0	0.000
Injury Accidents (Inj)	89	12.90
Property Damage Only (PDO) Accidents	171	24.79
<b>Statewide Basic Average Accident Rate</b>		
	No Build	Build
Rate Group		
Accident Rate (per million vehicle-miles)	292.97	133.25
Percent Fatal Accidents (Pct Fat)	0.2%	0.2%
Percent Injury Accidents (Pct Inj)	36.6%	36.6%

## (iii) PROJECT COSTS

Estimated project costs and the anticipated length of the construction period must also be entered into the Cal-B/C model. Project costs are entered under the following categories, as appropriate: Project Support, Right-of-Way (ROW), Construction, Maintenance/Operations, Rehabilitation, or Mitigation. No Maintenance/Operations, Rehabilitation, or Mitigation costs were included in the BCA. These costs are presented as constant dollars and then discounted using a seven percent (7%) annual rate to reflect their present value.

The initial design and construction costs for the Direct Connector project are approximately **\$19.5 million** as described in more detail in the project narrative of this application. Support and ROW costs are each assumed to account for ten percent (10%) of the overall cost of the Direct Connector project and to be accrued in the first year of the construction period (2016). The entire construction period is assumed to be three years with the remaining

<sup>4</sup> CRIS Data, US59 WB to I-35 SB, one mile segment total, 2013-2016.

<sup>5</sup> Texas statewide 2014 crash rate for 2 lane, 2 way highways (representing at-grade intersection), available at <http://ftp.dot.state.tx.us/pub/txdot/trf/crash-statistics/2014/02.pdf>

eighty percent (80%) of the total project costs allocated equally between the second (2017) and third (2018) year of the construction period. The total project costs equal **\$18 million** in present value terms. The breakdown of project costs as reflected in the Cal B/C analysis is indicated in Table 9 below.

The initial design and construction costs for the Overpass project are approximately **\$39 million** as described in more detail in the project narrative of this application. Support and ROW costs are each assumed to account for ten percent (10%) of the overall cost of the Overpass project and to be accrued in the first year of the construction period (2016). The entire construction period is assumed to be three years with the remaining eighty percent (80%) of the total project costs allocated equally between the second (2017) and third (2018) year of the construction period. The total project costs equal **\$36 million** in present value terms. The breakdown of project costs as reflected in the Cal B/C analysis is indicated in Table 10 below.

**TABLE 9: DIRECT CONNECTOR CAL-B/C PROJECT COSTS**

Year	DIRECT PROJECT COSTS (Mil \$)									
	INITIAL COSTS						SUBSEQUENT COSTS			
	Project Support	Present Value 7%	R / W	Present Value 7%	Construction	Present Value 7%	Maint./ Op.	Present Value 7%	Rehab.	Present Value 7%
<b>Construction Period</b>										
1	\$1,950,000	\$1,950,000	\$1,950,000	\$1,950,000	\$0	\$0				
2	\$0	\$0	\$0	\$0	\$7,800,000	\$7,289,720				
3	\$0	\$0	\$0	\$0	\$7,800,000	\$6,812,822				
4	\$0	\$0	\$0	\$0	\$0	\$0				
5	\$0	\$0	\$0	\$0	\$0	\$0				
6	\$0	\$0	\$0	\$0	\$0	\$0				
7	\$0	\$0	\$0	\$0	\$0	\$0				
8	\$0	\$0	\$0	\$0	\$0	\$0				
Subtotal	\$1,950,000	\$1,950,000	\$1,950,000	\$1,950,000	\$15,600,000	\$14,102,542				
<b>Project Open</b>										
1							\$0.000	\$0	\$0.000	\$0
2							\$0.000	\$0	\$0.000	\$0
3							\$0.000	\$0	\$0.000	\$0
4							\$0.000	\$0	\$0.000	\$0
5							\$0.000	\$0	\$0.000	\$0
6							\$0.000	\$0	\$0.000	\$0
7							\$0.000	\$0	\$0.000	\$0
8							\$0.000	\$0	\$0.000	\$0
9							\$0.000	\$0	\$0.000	\$0
10							\$0.000	\$0	\$0.000	\$0
11							\$0.000	\$0	\$0.000	\$0
12							\$0.000	\$0	\$0.000	\$0
13							\$0.000	\$0	\$0.000	\$0
14							\$0.000	\$0	\$0.000	\$0
15							\$0.000	\$0	\$0.000	\$0
16							\$0.000	\$0	\$0.000	\$0
17							\$0.000	\$0	\$0.000	\$0
18							\$0.000	\$0	\$0.000	\$0
19							\$0.000	\$0	\$0.000	\$0
20							\$0.000	\$0	\$0.000	\$0
Subtotal							\$0.000	\$0.000	\$0.000	\$0.000
<b>Total</b>		\$1,950,000		\$1,950,000		\$14,102,542				

TABLE 10: OVERPASS CAL-B/C PROJECT COSTS

Year	DIRECT PROJECT COSTS (Mil \$)									
	INITIAL COSTS						SUBSEQUENT COSTS			
	Project Support	Present Value 7%	R / W	Present Value 7%	Construction	Present Value 7%	Maint./ Op.	Present Value 7%	Rehab.	Present Value 7%
<b>Construction Period</b>										
1	\$3,910,000	\$3,910,000	\$3,910,000	\$3,910,000	\$0	\$0				
2	\$0	\$0	\$0	\$0	\$15,640,000	\$14,616,822				
3	\$0	\$0	\$0	\$0	\$15,640,000	\$13,660,582				
4	\$0	\$0	\$0	\$0	\$0	\$0				
5	\$0	\$0	\$0	\$0	\$0	\$0				
6	\$0	\$0	\$0	\$0	\$0	\$0				
7	\$0	\$0	\$0	\$0	\$0	\$0				
8	\$0	\$0	\$0	\$0	\$0	\$0				
Subtotal	\$3,910,000	\$3,910,000	\$3,910,000	\$3,910,000	\$31,280,000	\$28,277,404				
<b>Project Open</b>										
1							\$0.000	\$0	\$0.000	\$0
2							\$0.000	\$0	\$0.000	\$0
3							\$0.000	\$0	\$0.000	\$0
4							\$0.000	\$0	\$0.000	\$0
5							\$0.000	\$0	\$0.000	\$0
6							\$0.000	\$0	\$0.000	\$0
7							\$0.000	\$0	\$0.000	\$0
8							\$0.000	\$0	\$0.000	\$0
9							\$0.000	\$0	\$0.000	\$0
10							\$0.000	\$0	\$0.000	\$0
11							\$0.000	\$0	\$0.000	\$0
12							\$0.000	\$0	\$0.000	\$0
13							\$0.000	\$0	\$0.000	\$0
14							\$0.000	\$0	\$0.000	\$0
15							\$0.000	\$0	\$0.000	\$0
16							\$0.000	\$0	\$0.000	\$0
17							\$0.000	\$0	\$0.000	\$0
18							\$0.000	\$0	\$0.000	\$0
19							\$0.000	\$0	\$0.000	\$0
20							\$0.000	\$0	\$0.000	\$0
Subtotal							\$0.000	\$0.000	\$0.000	\$0.000
<b>Total</b>		\$3,910,000		\$3,910,000		\$28,277,404				

(iv) CAL-B/C MODEL RESULTS

The Cal-B/C model evaluates benefits related to travel time savings, vehicle operating cost savings, accident reduction, and emissions reduction, as described below. Figures 1 and 2 graphically depict the share by category of total project life-cycle costs and total project life-cycle benefits associated with the Direct Connector project, as discussed in more detail in the following sub-sections. Figures 3 and 4 provide project costs and benefit information for the Overpass project.

FIGURE 1: DIRECT CONNECTOR PROJECT COSTS, NET PRESENT VALUE

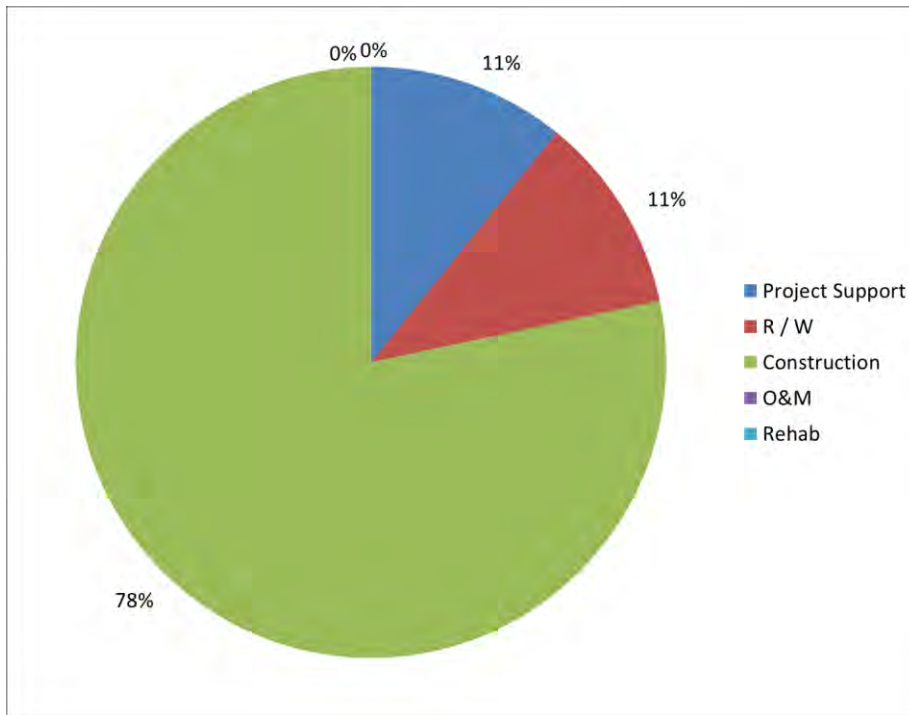


FIGURE 2: DIRECT CONNECTOR ITEMIZED BENEFITS, NET PRESENT VALUE

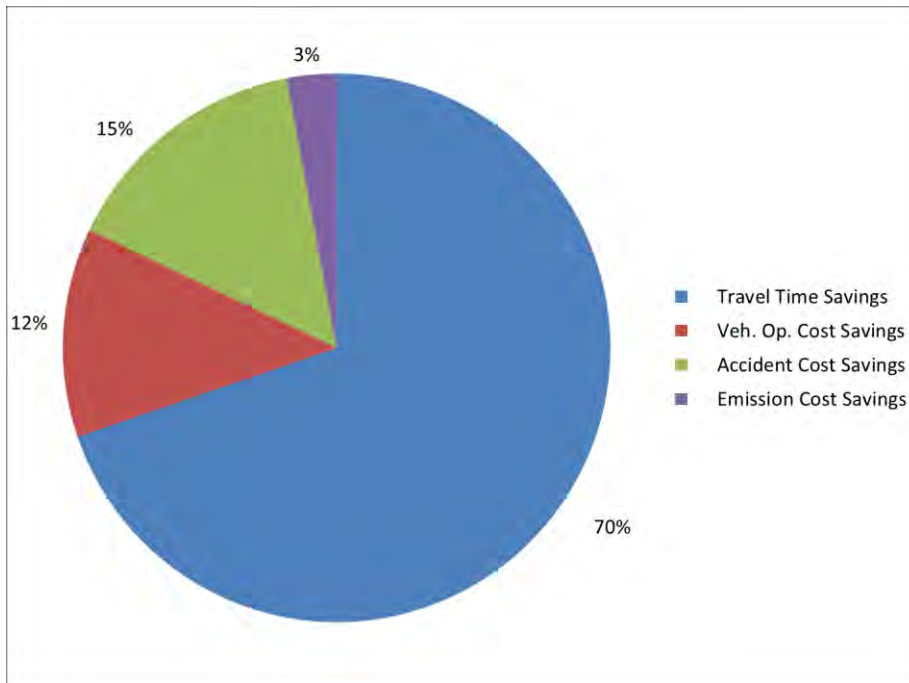




FIGURE 3: OVERPASS PROJECT COSTS, NET PRESENT VALUE

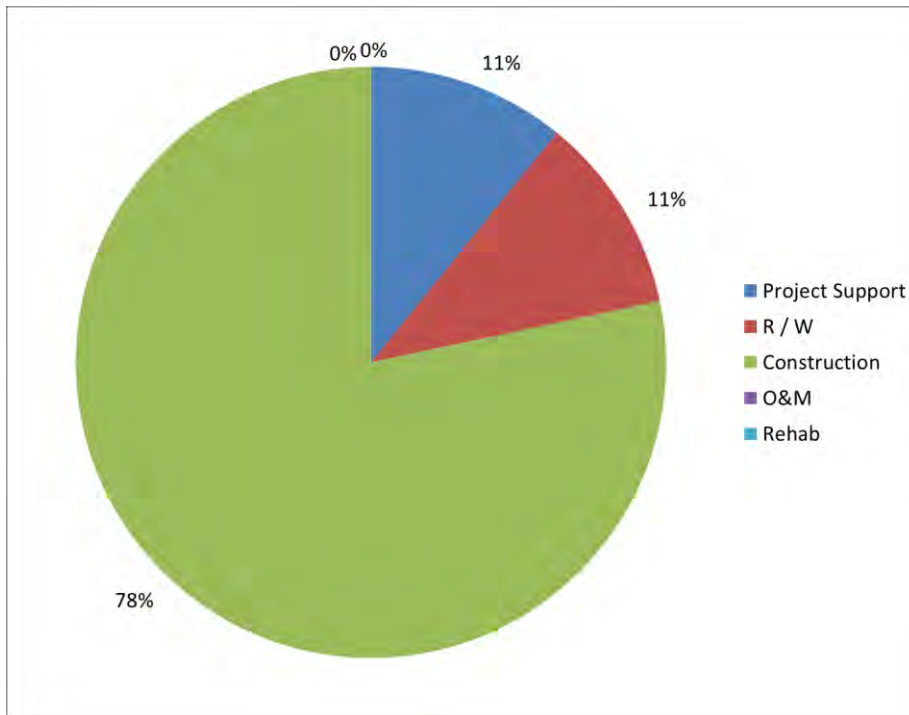
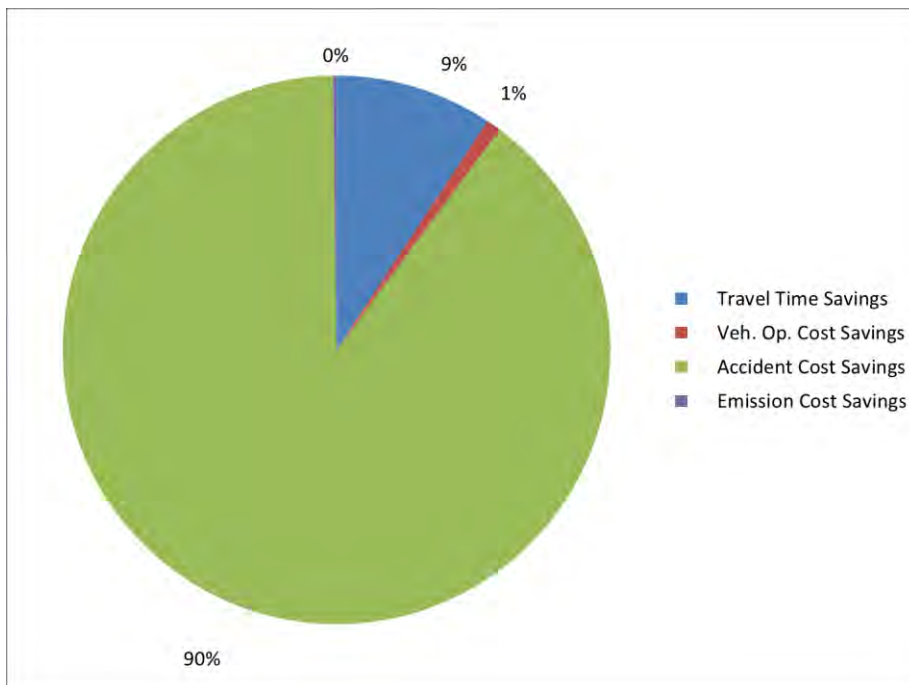


FIGURE 4: OVERPASS ITEMIZED BENEFITS, NET PRESENT VALUE



## (a) TRAVEL TIME SAVINGS

The Cal-B/C model evaluates travel time benefits with five formulas that calculate average annual volume, travel time, travel time savings, and induced travel. Average value of time varies by vehicle type. The Cal-B/C model interpolates traffic volumes and travel speeds between the base year and year 20 of the project. Refer to the formulas provided for more information about each calculation. Average Vehicle Occupancy was obtained from a University of South Florida analysis of statewide rates based on Census data.<sup>6</sup> Table 11 and Table 12 show the total travel time benefit and the travel time benefit by year for the Direct Connector and Overpass project.

$$\text{Average Annual Volume} = \text{Average Daily Traffic} \times \text{Number of Days in Model Year}$$

$$\text{Travel Time} = \text{Average Vehicle Occupancy} \times \text{Average Annual Volume} \times \text{Affected Length/ Speed}$$

$$\text{Travel Time Savings} = \text{Travel Time Reduction} \times \text{Average Value of Time}$$

$$\text{Induced Travel} = \text{Change in Trips} \times \text{Change in Travel Time} \times 0.5$$

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<sup>6</sup> Average vehicle occupancy for Texas based on University of South Florida, State Averages for Private Vehicle Occupancy, Carpool Size and Vehicles per 100 Workers, analysis based on 2000 Census. Available at <http://www.nctr.usf.edu/clearinghouse/censusavo.htm>

TABLE 11: DIRECT CONNECTOR CAL-B/C TRAVEL TIME SAVINGS BENEFITS

Year	AVERAGE VOLUME (vehicles/yr)		AVERAGE SPEED (mph)		ANNUAL PERSON-TRIPS (trips/yr)		AVERAGE TRAVEL TIME (hours)		TIME BENEFIT (person-hours/yr)		Constant Dollars	Present Value at 7%
	No Build	Build	No Build	Build	No Build	Build	No Build	Build	Existing Users	New (Induced)		
1	5,365,865	5,365,865			5,851,639	5,851,639			151,458	0	\$2,173,129	\$1,773,921
20	7,893,125	7,893,125			8,607,692	8,607,692			241,206	0	\$3,460,848	\$781,159
2	5,498,879	5,498,879			5,996,694	5,996,694			155,813	0	\$2,235,614	\$1,705,539
3	5,631,892	5,631,892			6,141,750	6,141,750			160,204	0	\$2,298,624	\$1,638,887
4	5,764,906	5,764,906			6,286,805	6,286,805			164,633	0	\$2,362,170	\$1,574,014
5	5,897,920	5,897,920			6,431,861	6,431,861			169,100	0	\$2,426,262	\$1,510,954
6	6,030,933	6,030,933			6,576,916	6,576,916			173,606	0	\$2,490,911	\$1,449,733
7	6,163,947	6,163,947			6,721,971	6,721,971			178,151	0	\$2,556,126	\$1,390,363
8	6,296,961	6,296,961			6,867,027	6,867,027			182,737	0	\$2,621,918	\$1,332,850
9	6,429,974	6,429,974			7,012,082	7,012,082			187,363	0	\$2,688,300	\$1,277,192
10	6,562,988	6,562,988			7,157,138	7,157,138			192,031	0	\$2,755,281	\$1,223,378
11	6,696,002	6,696,002			7,302,193	7,302,193			196,742	0	\$2,822,875	\$1,171,393
12	6,829,016	6,829,016			7,447,249	7,447,249			201,497	0	\$2,891,093	\$1,121,216
13	6,962,029	6,962,029			7,592,304	7,592,304			206,296	0	\$2,959,946	\$1,072,821
14	7,095,043	7,095,043			7,737,360	7,737,360			211,140	0	\$3,029,449	\$1,026,179
15	7,228,057	7,228,057			7,882,415	7,882,415			216,030	0	\$3,099,614	\$981,258
16	7,361,070	7,361,070			8,027,471	8,027,471			220,967	0	\$3,170,454	\$938,023
17	7,494,084	7,494,084			8,172,526	8,172,526			225,953	0	\$3,241,983	\$896,435
18	7,627,098	7,627,098			8,317,582	8,317,582			230,987	0	\$3,314,216	\$856,456
19	7,760,111	7,760,111			8,462,637	8,462,637			236,071	0	\$3,387,166	\$818,045
<b>Total</b>												<b>\$24,539,816</b>

TABLE 12: OVERPASS CAL-B/C TRAVEL TIME SAVINGS BENEFITS

Year	AVERAGE VOLUME (vehicles/yr)		AVERAGE SPEED (mph)		ANNUAL PERSON-TRIPS (trips/yr)		AVERAGE TRAVEL TIME (hours)		TIME BENEFIT (person-hours/yr)		Constant Dollars	Present Value at 7%
	No Build	Build	No Build	Build	No Build	Build	No Build	Build	Existing Users	New (Induced)		
1	2,518,500	2,518,500			2,746,501	2,746,501			40,113	0	\$575,542	\$469,814
20	3,723,000	3,723,000			4,060,045	4,060,045			59,297	0	\$850,801	\$192,037
2	2,581,895	2,581,895			2,815,635	2,815,635			41,123	0	\$590,029	\$450,130
3	2,645,289	2,645,289			2,884,768	2,884,768			42,132	0	\$604,516	\$431,012
4	2,708,684	2,708,684			2,953,902	2,953,902			43,142	0	\$619,004	\$412,468
5	2,772,079	2,772,079			3,023,036	3,023,036			44,152	0	\$633,491	\$394,506
6	2,835,474	2,835,474			3,092,170	3,092,170			45,161	0	\$647,978	\$377,129
7	2,898,868	2,898,868			3,161,304	3,161,304			46,171	0	\$662,466	\$360,337
8	2,962,263	2,962,263			3,230,438	3,230,438			47,181	0	\$676,953	\$344,129
9	3,025,658	3,025,658			3,299,572	3,299,572			48,190	0	\$691,440	\$328,498
10	3,089,053	3,089,053			3,368,706	3,368,706			49,200	0	\$705,928	\$313,440
11	3,152,447	3,152,447			3,437,840	3,437,840			50,210	0	\$720,415	\$298,947
12	3,215,842	3,215,842			3,506,973	3,506,973			51,220	0	\$734,902	\$285,008
13	3,279,237	3,279,237			3,576,107	3,576,107			52,229	0	\$749,390	\$271,613
14	3,342,632	3,342,632			3,645,241	3,645,241			53,239	0	\$763,877	\$258,752
15	3,406,026	3,406,026			3,714,375	3,714,375			54,249	0	\$778,364	\$246,410
16	3,469,421	3,469,421			3,783,509	3,783,509			55,258	0	\$792,852	\$234,576
17	3,532,816	3,532,816			3,852,643	3,852,643			56,268	0	\$807,339	\$223,236
18	3,596,211	3,596,211			3,921,777	3,921,777			57,278	0	\$821,826	\$212,376
19	3,659,605	3,659,605			3,990,911	3,990,911			58,288	0	\$836,314	\$201,981
<b>Total</b>												<b>\$6,306,399</b>

**(b) VEHICLE OPERATING COST SAVINGS**

The Cal-B/C model determines the vehicle operating costs benefit by calculating vehicle miles traveled, fuel cost, and non-fuel costs. The model generates calculations for vehicles and trucks based on a Percent Trucks input value. The Percent Trucks was assumed to be 5.3% according to the Texas DOT Statewide Planning Map.<sup>7</sup> Refer to the formulas for more information about each calculation. Table 13 and Table 14 provide the total vehicle operating cost benefit and the vehicle operating cost benefit by year for the Direct Connector and Overpass projects.

$$\text{Vehicles Miles Traveled} = \text{Affected Length} \times \text{Average Annual Volume}$$

$$\text{Fuel Cost} = \text{Vehicle Miles Traveled} \times \text{Fuel Consumption} \times \text{Fuel Price}$$

$$\text{Non - Fuel Cost} = \text{Vehicle Miles Traveled} \times \text{Cost Per Mile}$$

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<sup>7</sup> Percent Trucks is based on Statewide Planning Map available at [http://www.txdot.gov/apps/statewide\\_mapping/StatewidePlanningMap.html](http://www.txdot.gov/apps/statewide_mapping/StatewidePlanningMap.html)

TABLE 13: DIRECT CONNECTOR CAL-B/C VEHICLE OPERATING COST SAVINGS BENEFITS

Year	AVERAGE VOLUME (vehicles/yr)		AVERAGE SPEED (mph)		TOTAL VMT (veh-miles/yr)		BENEFITS (\$/yr)		Constant Dollars	Present Value at 7%
	No Build	Build	No Build	Build	No Build	Build	Fuel Costs	Non-Fuel Costs		
1	5,365,865	5,365,865	232.2	350.0	3,302,853	3,302,853	\$384,394	\$0	\$384,394	\$313,780
20	7,893,125	7,893,125	228.6	350.0	4,858,458	4,858,458	\$616,744	\$0	\$616,744	\$139,207
2	5,498,879	5,498,879	232.0	350.0	3,384,726	3,384,726	\$393,923	\$0	\$393,923	\$300,522
3	5,631,892	5,631,892	231.8	350.0	3,466,600	3,466,600	\$403,452	\$0	\$403,452	\$287,656
4	5,764,906	5,764,906	231.6	350.0	3,548,474	3,548,474	\$412,981	\$0	\$412,981	\$275,186
5	5,897,920	5,897,920	231.4	350.0	3,630,348	3,630,348	\$422,509	\$0	\$422,509	\$263,118
6	6,030,933	6,030,933	231.3	350.0	3,712,222	3,712,222	\$432,038	\$0	\$432,038	\$251,450
7	6,163,947	6,163,947	231.1	350.0	3,794,096	3,794,096	\$461,411	\$0	\$461,411	\$250,977
8	6,296,961	6,296,961	230.9	350.0	3,875,970	3,875,970	\$471,368	\$0	\$471,368	\$239,620
9	6,429,974	6,429,974	230.7	350.0	3,957,844	3,957,844	\$481,325	\$0	\$481,325	\$228,674
10	6,562,988	6,562,988	230.5	350.0	4,039,718	4,039,718	\$491,282	\$0	\$491,282	\$218,135
11	6,696,002	6,696,002	230.3	350.0	4,121,592	4,121,592	\$501,239	\$0	\$501,239	\$207,996
12	6,829,016	6,829,016	230.1	350.0	4,203,466	4,203,466	\$511,196	\$0	\$511,196	\$198,251
13	6,962,029	6,962,029	229.9	350.0	4,285,340	4,285,340	\$521,153	\$0	\$521,153	\$188,890
14	7,095,043	7,095,043	229.7	350.0	4,367,214	4,367,214	\$531,110	\$0	\$531,110	\$179,905
15	7,228,057	7,228,057	229.5	350.0	4,449,088	4,449,088	\$541,067	\$0	\$541,067	\$171,288
16	7,361,070	7,361,070	229.4	350.0	4,530,962	4,530,962	\$551,024	\$0	\$551,024	\$163,028
17	7,494,084	7,494,084	229.2	350.0	4,612,836	4,612,836	\$585,564	\$0	\$585,564	\$161,913
18	7,627,098	7,627,098	229.0	350.0	4,694,710	4,694,710	\$595,957	\$0	\$595,957	\$154,007
19	7,760,111	7,760,111	228.8	350.0	4,776,584	4,776,584	\$606,351	\$0	\$606,351	\$146,442
<b>Total</b>										<b>\$4,340,045</b>

TABLE 14: OVERPASS CAL-B/C VEHICLE OPERATING COST SAVINGS BENEFITS

Year	AVERAGE VOLUME (vehicles/yr)		AVERAGE SPEED (mph)		TOTAL VMT (veh-miles/yr)		BENEFITS (\$/yr)		Constant Dollars	Present Value at 7%
	No Build	Build	No Build	Build	No Build	Build	Fuel Costs	Non-Fuel Costs		
1	2,518,500	2,518,500	292.0	390.0	2,518,500	2,518,500	\$53,543	\$0	\$53,543	\$43,707
20	3,723,000	3,723,000	292.0	390.0	3,723,000	3,723,000	\$79,150	\$0	\$79,150	\$17,865
2	2,581,895	2,581,895	292.0	390.0	2,581,895	2,581,895	\$54,890	\$0	\$54,890	\$41,876
3	2,645,289	2,645,289	292.0	390.0	2,645,289	2,645,289	\$56,238	\$0	\$56,238	\$40,097
4	2,708,684	2,708,684	292.0	390.0	2,708,684	2,708,684	\$57,586	\$0	\$57,586	\$38,372
5	2,772,079	2,772,079	292.0	390.0	2,772,079	2,772,079	\$58,934	\$0	\$58,934	\$36,701
6	2,835,474	2,835,474	292.0	390.0	2,835,474	2,835,474	\$60,281	\$0	\$60,281	\$35,084
7	2,898,868	2,898,868	292.0	390.0	2,898,868	2,898,868	\$61,629	\$0	\$61,629	\$33,522
8	2,962,263	2,962,263	292.0	390.0	2,962,263	2,962,263	\$62,977	\$0	\$62,977	\$32,014
9	3,025,658	3,025,658	292.0	390.0	3,025,658	3,025,658	\$64,325	\$0	\$64,325	\$30,560
10	3,089,053	3,089,053	292.0	390.0	3,089,053	3,089,053	\$65,672	\$0	\$65,672	\$29,159
11	3,152,447	3,152,447	292.0	390.0	3,152,447	3,152,447	\$67,020	\$0	\$67,020	\$27,811
12	3,215,842	3,215,842	292.0	390.0	3,215,842	3,215,842	\$68,368	\$0	\$68,368	\$26,514
13	3,279,237	3,279,237	292.0	390.0	3,279,237	3,279,237	\$69,716	\$0	\$69,716	\$25,268
14	3,342,632	3,342,632	292.0	390.0	3,342,632	3,342,632	\$71,063	\$0	\$71,063	\$24,072
15	3,406,026	3,406,026	292.0	390.0	3,406,026	3,406,026	\$72,411	\$0	\$72,411	\$22,924
16	3,469,421	3,469,421	292.0	390.0	3,469,421	3,469,421	\$73,759	\$0	\$73,759	\$21,823
17	3,532,816	3,532,816	292.0	390.0	3,532,816	3,532,816	\$75,107	\$0	\$75,107	\$20,768
18	3,596,211	3,596,211	292.0	390.0	3,596,211	3,596,211	\$76,454	\$0	\$76,454	\$19,757
19	3,659,605	3,659,605	292.0	390.0	3,659,605	3,659,605	\$77,802	\$0	\$77,802	\$18,790
<b>Total</b>										<b>\$586,684</b>

(c) ACCIDENT REDUCTION

The model evaluates the accident cost benefits by calculating vehicle-miles traveled and highway accident costs. Highway accident costs are calculated by accident type. Refer to the formulas provided for more information about each calculation. Table 15 and Table 16 show the total accident cost savings benefit and the accident cost savings benefit by year for the Direct Connector and Overpass projects.

$$\textit{Vehicle Miles Traveled} = \textit{Affected Length} \times \textit{Average Volume}$$

$$\textit{Highway Accident Costs} = \textit{Vehicle Miles Traveled} \times \textit{Rate} \times \textit{Cost/Mile}$$



TABLE 15: DIRECT CONNECTOR CAL-B/C ACCIDENT REDUCTION BENEFITS

Year	AVERAGE VOLUME (vehicles/yr)		TOTAL VMT (veh-miles/yr)		ACCIDENT COSTS (\$/yr)		Constant Dollars	Present Value at 7%
	No Build	Build	No Build	Build	No Build	Build		
1	5,365,865	5,365,865	3,302,853	3,302,853	\$1,639,250	\$1,145,893	\$493,357	\$402,727
20	7,893,125	7,893,125	4,858,458	4,858,458	\$2,411,318	\$1,685,595	\$725,723	\$163,805
2	5,498,879	5,498,879	3,384,726	3,384,726	\$1,679,885	\$1,174,298	\$505,587	\$385,710
3	5,631,892	5,631,892	3,466,600	3,466,600	\$1,720,521	\$1,202,704	\$517,817	\$369,196
4	5,764,906	5,764,906	3,548,474	3,548,474	\$1,761,156	\$1,231,109	\$530,047	\$353,193
5	5,897,920	5,897,920	3,630,348	3,630,348	\$1,801,791	\$1,259,514	\$542,276	\$337,703
6	6,030,933	6,030,933	3,712,222	3,712,222	\$1,842,426	\$1,287,920	\$554,506	\$322,728
7	6,163,947	6,163,947	3,794,096	3,794,096	\$1,883,061	\$1,316,325	\$566,736	\$308,267
8	6,296,961	6,296,961	3,875,970	3,875,970	\$1,923,696	\$1,344,731	\$578,966	\$294,317
9	6,429,974	6,429,974	3,957,844	3,957,844	\$1,964,331	\$1,373,136	\$591,196	\$280,873
10	6,562,988	6,562,988	4,039,718	4,039,718	\$2,004,967	\$1,401,541	\$603,425	\$267,928
11	6,696,002	6,696,002	4,121,592	4,121,592	\$2,045,602	\$1,429,947	\$615,655	\$255,475
12	6,829,016	6,829,016	4,203,466	4,203,466	\$2,086,237	\$1,458,352	\$627,885	\$243,505
13	6,962,029	6,962,029	4,285,340	4,285,340	\$2,126,872	\$1,486,757	\$640,115	\$232,007
14	7,095,043	7,095,043	4,367,214	4,367,214	\$2,167,507	\$1,515,163	\$652,344	\$220,972
15	7,228,057	7,228,057	4,449,088	4,449,088	\$2,208,142	\$1,543,568	\$664,574	\$210,387
16	7,361,070	7,361,070	4,530,962	4,530,962	\$2,248,778	\$1,571,974	\$676,804	\$200,242
17	7,494,084	7,494,084	4,612,836	4,612,836	\$2,289,413	\$1,600,379	\$689,034	\$190,524
18	7,627,098	7,627,098	4,694,710	4,694,710	\$2,330,048	\$1,628,784	\$701,263	\$181,220
19	7,760,111	7,760,111	4,776,584	4,776,584	\$2,370,683	\$1,657,190	\$713,493	\$172,318
<b>Total</b>								<b>\$5,393,094</b>

TABLE 16: OVERPASS CAL-B/C ACCIDENT REDUCTION BENEFITS

Year	AVERAGE VOLUME (vehicles/yr)		TOTAL VMT (veh-miles/yr)		ACCIDENT COSTS (\$/yr)		Constant Dollars	Present Value at 7%
	No Build	Build	No Build	Build	No Build	Build		
1	2,518,500	2,518,500	2,518,500	2,518,500	\$10,179,837	\$4,630,042	\$5,549,796	\$4,530,286
20	3,723,000	3,723,000	3,723,000	3,723,000	\$15,048,455	\$6,844,410	\$8,204,046	\$1,851,761
2	2,581,895	2,581,895	2,581,895	2,581,895	\$10,436,080	\$4,746,587	\$5,689,493	\$4,340,487
3	2,645,289	2,645,289	2,645,289	2,645,289	\$10,692,324	\$4,863,133	\$5,829,190	\$4,156,132
4	2,708,684	2,708,684	2,708,684	2,708,684	\$10,948,567	\$4,979,679	\$5,968,888	\$3,977,322
5	2,772,079	2,772,079	2,772,079	2,772,079	\$11,204,810	\$5,096,224	\$6,108,585	\$3,804,120
6	2,835,474	2,835,474	2,835,474	2,835,474	\$11,461,053	\$5,212,770	\$6,248,283	\$3,636,557
7	2,898,868	2,898,868	2,898,868	2,898,868	\$11,717,296	\$5,329,316	\$6,387,980	\$3,474,638
8	2,962,263	2,962,263	2,962,263	2,962,263	\$11,973,539	\$5,445,861	\$6,527,677	\$3,318,340
9	3,025,658	3,025,658	3,025,658	3,025,658	\$12,229,782	\$5,562,407	\$6,667,375	\$3,167,622
10	3,089,053	3,089,053	3,089,053	3,089,053	\$12,486,025	\$5,678,953	\$6,807,072	\$3,022,421
11	3,152,447	3,152,447	3,152,447	3,152,447	\$12,742,268	\$5,795,499	\$6,946,769	\$2,882,662
12	3,215,842	3,215,842	3,215,842	3,215,842	\$12,998,511	\$5,912,044	\$7,086,467	\$2,748,254
13	3,279,237	3,279,237	3,279,237	3,279,237	\$13,254,754	\$6,028,590	\$7,226,164	\$2,619,094
14	3,342,632	3,342,632	3,342,632	3,342,632	\$13,510,997	\$6,145,136	\$7,365,862	\$2,495,072
15	3,406,026	3,406,026	3,406,026	3,406,026	\$13,767,240	\$6,261,681	\$7,505,559	\$2,376,068
16	3,469,421	3,469,421	3,469,421	3,469,421	\$14,023,483	\$6,378,227	\$7,645,256	\$2,261,955
17	3,532,816	3,532,816	3,532,816	3,532,816	\$14,279,726	\$6,494,773	\$7,784,954	\$2,152,605
18	3,596,211	3,596,211	3,596,211	3,596,211	\$14,535,969	\$6,611,318	\$7,924,651	\$2,047,880
19	3,659,605	3,659,605	3,659,605	3,659,605	\$14,792,212	\$6,727,864	\$8,064,348	\$1,947,646
<b>Total</b>								<b>\$60,810,924</b>

(d) EMISSIONS REDUCTION

The Cal-B/C model determines an emissions reduction benefit by calculating vehicles-miles traveled and highway emissions costs. Emissions costs are calculated by emissions type. Refer to the formulas for more information about each calculation. Table 17 and Table 18 provide the total emissions benefit and the emissions benefit by year for the Direct Connector and Overpass projects.

$$\textit{Vehicle Miles Traveled} = \textit{Affected Length} \times \textit{Average Annual Volume}$$

$$\textit{Highway Emissions Cost} = \left( \textit{VMT} \times \textit{Rate} \times \frac{\textit{CostMile}}{\textit{Rate}} \right)$$

TABLE 17: DIRECT CONNECTOR CAL-B/C EMISSIONS REDUCTION BENEFITS

Year	AVERAGE VOLUME (vehicles/yr)		AVERAGE SPEED (mph)		TOTAL VMT (veh-miles/yr)		RUNNING EMISSIONS (\$/yr)		STARTING EMISSIONS (\$/yr)		Constant Dollars	Present Value at 7%
	No Build	Build	No Build	Build	No Build	Build	No Build	Build	No Build	Build		
1	5,365,865	5,365,865	182.2	300.0	3,302,853	3,302,853	\$203,188	\$127,398	\$58,510	\$58,510	\$75,790	\$61,867
20	7,893,125	7,893,125	178.6	300.0	4,858,458	4,858,458	\$423,891	\$234,080	\$81,105	\$81,105	\$189,810	\$42,843
2	5,498,879	5,498,879	182.0	300.0	3,384,726	3,384,726	\$211,777	\$132,180	\$60,613	\$60,613	\$79,597	\$60,724
3	5,631,892	5,631,892	181.8	300.0	3,466,600	3,466,600	\$220,646	\$137,090	\$62,768	\$62,768	\$83,556	\$59,574
4	5,764,906	5,764,906	181.6	300.0	3,548,474	3,548,474	\$229,808	\$142,134	\$64,976	\$64,976	\$87,674	\$58,421
5	5,897,920	5,897,920	181.4	300.0	3,630,348	3,630,348	\$239,273	\$147,316	\$67,240	\$67,240	\$91,956	\$57,266
6	6,030,933	6,030,933	181.3	300.0	3,712,222	3,712,222	\$249,053	\$152,643	\$69,563	\$69,563	\$96,410	\$56,112
7	6,163,947	6,163,947	181.1	300.0	3,794,096	3,794,096	\$263,810	\$158,120	\$71,945	\$71,945	\$105,690	\$57,489
8	6,296,961	6,296,961	180.9	300.0	3,875,970	3,875,970	\$258,531	\$154,029	\$51,532	\$51,532	\$104,502	\$53,124
9	6,429,974	6,429,974	180.7	300.0	3,957,844	3,957,844	\$269,265	\$159,636	\$53,568	\$53,568	\$109,628	\$52,084
10	6,562,988	6,562,988	180.5	300.0	4,039,718	4,039,718	\$280,378	\$165,413	\$55,673	\$55,673	\$114,964	\$51,046
11	6,696,002	6,696,002	180.3	300.0	4,121,592	4,121,592	\$291,885	\$171,366	\$57,848	\$57,848	\$120,519	\$50,011
12	6,829,016	6,829,016	180.1	300.0	4,203,466	4,203,466	\$303,802	\$177,502	\$60,097	\$60,097	\$126,300	\$48,981
13	6,962,029	6,962,029	179.9	300.0	4,285,340	4,285,340	\$316,145	\$183,828	\$62,423	\$62,423	\$132,317	\$47,958
14	7,095,043	7,095,043	179.7	300.0	4,367,214	4,367,214	\$328,929	\$190,351	\$64,828	\$64,828	\$138,578	\$46,941
15	7,228,057	7,228,057	179.5	300.0	4,449,088	4,449,088	\$342,173	\$197,079	\$67,315	\$67,315	\$145,094	\$45,933
16	7,361,070	7,361,070	179.4	300.0	4,530,962	4,530,962	\$355,893	\$204,020	\$69,888	\$69,888	\$151,873	\$44,934
17	7,494,084	7,494,084	179.2	300.0	4,612,836	4,612,836	\$377,085	\$211,182	\$72,550	\$72,550	\$165,902	\$45,873
18	7,627,098	7,627,098	179.0	300.0	4,694,710	4,694,710	\$392,133	\$218,574	\$75,305	\$75,305	\$173,560	\$44,851
19	7,760,111	7,760,111	178.8	300.0	4,776,584	4,776,584	\$407,728	\$226,203	\$78,155	\$78,155	\$181,525	\$43,841
<b>Total</b>											<b>\$1,029,870</b>	

TABLE 18: OVERPASS CAL-B/C EMISSIONS REDUCTION BENEFITS

Year	AVERAGE VOLUME (vehicles/yr)		AVERAGE SPEED (mph)		TOTAL VMT (veh-miles/yr)		RUNNING EMISSIONS (\$/yr)		STARTING EMISSIONS (\$/yr)		Constant Dollars	Present Value at 7%
	No Build	Build	No Build	Build	No Build	Build	No Build	Build	No Build	Build		
1	2,518,500	2,518,500	242.0	340.0	2,518,500	2,518,500	\$109,223	\$98,796	\$27,462	\$27,462	\$10,426	\$8,511
20	3,723,000	3,723,000	242.0	340.0	3,723,000	3,723,000	\$207,416	\$183,122	\$38,255	\$38,255	\$24,294	\$5,483
2	2,581,895	2,581,895	242.0	340.0	2,581,895	2,581,895	\$113,521	\$102,566	\$28,460	\$28,460	\$10,955	\$8,358
3	2,645,289	2,645,289	242.0	340.0	2,645,289	2,645,289	\$117,943	\$106,438	\$29,482	\$29,482	\$11,506	\$8,203
4	2,708,684	2,708,684	242.0	340.0	2,708,684	2,708,684	\$122,494	\$110,416	\$30,530	\$30,530	\$12,078	\$8,048
5	2,772,079	2,772,079	242.0	340.0	2,772,079	2,772,079	\$127,179	\$114,505	\$31,604	\$31,604	\$12,674	\$7,893
6	2,835,474	2,835,474	242.0	340.0	2,835,474	2,835,474	\$132,002	\$118,709	\$32,705	\$32,705	\$13,294	\$7,737
7	2,898,868	2,898,868	242.0	340.0	2,898,868	2,898,868	\$136,970	\$123,032	\$33,835	\$33,835	\$13,938	\$7,581
8	2,962,263	2,962,263	242.0	340.0	2,962,263	2,962,263	\$133,772	\$119,798	\$24,242	\$24,242	\$13,974	\$7,103
9	3,025,658	3,025,658	242.0	340.0	3,025,658	3,025,658	\$138,885	\$124,227	\$25,207	\$25,207	\$14,658	\$6,964
10	3,089,053	3,089,053	242.0	340.0	3,089,053	3,089,053	\$144,161	\$128,790	\$26,204	\$26,204	\$15,371	\$6,825
11	3,152,447	3,152,447	242.0	340.0	3,152,447	3,152,447	\$149,606	\$133,494	\$27,235	\$27,235	\$16,112	\$6,686
12	3,215,842	3,215,842	242.0	340.0	3,215,842	3,215,842	\$155,228	\$138,344	\$28,300	\$28,300	\$16,884	\$6,548
13	3,279,237	3,279,237	242.0	340.0	3,279,237	3,279,237	\$161,032	\$143,345	\$29,402	\$29,402	\$17,687	\$6,411
14	3,342,632	3,342,632	242.0	340.0	3,342,632	3,342,632	\$167,027	\$148,504	\$30,542	\$30,542	\$18,523	\$6,274
15	3,406,026	3,406,026	242.0	340.0	3,406,026	3,406,026	\$173,219	\$153,827	\$31,720	\$31,720	\$19,392	\$6,139
16	3,469,421	3,469,421	242.0	340.0	3,469,421	3,469,421	\$179,616	\$159,319	\$32,940	\$32,940	\$20,297	\$6,005
17	3,532,816	3,532,816	242.0	340.0	3,532,816	3,532,816	\$186,226	\$164,988	\$34,201	\$34,201	\$21,238	\$5,872
18	3,596,211	3,596,211	242.0	340.0	3,596,211	3,596,211	\$193,057	\$170,840	\$35,506	\$35,506	\$22,217	\$5,741
19	3,659,605	3,659,605	242.0	340.0	3,659,605	3,659,605	\$200,117	\$176,882	\$36,857	\$36,857	\$23,235	\$5,612
<b>Total</b>												<b>\$137,995</b>