Attachment A

Benefit-Cost Analysis and Methodology for Nevada SR 49 Corridor Improvements

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Executive Summary

This memorandum summarizes the approach used for conducting a Benefit-Cost Analysis (BCA) for the State Route (SR) 49 improvement project, in the county of Nevada (NEV). Table 1 shows the project matrix, which describes the proposed improvements, types of impacts to all users and the population affected, and a summary of results. The cost effectiveness analysis using the recommended 7-percent discount rate shows the project is expected to generate $84.8 million in benefits, which leads to a net present value of- $20.4 million. The benefit-cost ratio is 0.8. The largest share of benefits is travel time savings driven by the significant increase in average speeds in the project area for: 1) users of SR 49 in the baseline, and 2) users that divert from other parallel routes, better roadway plan and profile, improved sight distance, and faster speeds on SR 49.

The project provides for sizeable benefits in terms of avoided vehicle crashes, however the project is expected to increase VMT (vehicle miles traveled) and the average miles traveled per trip in the project area, which causes an increase in vehicle operating costs, which is small regarding the total travel time savings. The expected increase in traffic volume and VMT on SR 49 is primarily due to re-route of traffic from other local routes. The proposed project may reduce the overall regional VMT and emissions.

To calculate the benefits of the project, all the *FHWA's Benefit-Cost Analysis Guidance for Discretionary Grant Program*, dated December 2018 guidelines. The BCA considers Year 2023 and Year 2043 as the project opening year and horizon year, respectively with a 7-percent discount rates for the Net Present Value (NPV) of benefits and costs.

Table 1: Project Matrix

Current Status and Problem	Changes to Baseline	Type of Impacts	Population Affected	Economic Benefit	Summaryof Results (7% Disc. Millions)
This facility is a highway corridor with a 2-lane highway, with various intersections and driveways, in a rural rolling hills terrain. This project proposes to improve safety and reduce the frequency and severity of collisions.	This project is includes widening the travel lanes from 2 to 4, widening existing shoulders 8', contructing a median barrier, improve horizontal alighnment, remove most at-grade intersections and private driveways by contructing a frontage road system.	Additional travel lanes will result in reduced travel time.	Corridor users: Recreational travelers, trucks, commuters, bicycles, pedestrians, and horses.	Monetized Value of Reduced Travel Time	$83.10
		More opportunities to pass slow vehicles/trucks. Right turn lanes and standard shoulders improves efficiency.		Monetized Value of Vehicle Operating	-$0.59
		Reduced cost of crashes due to more passing opportunities		Monetized Value of Reduced Crashes	$2.11
		Change in air emissions generated by vehicles.		Monetized Value of Emissions	$0.19

Project Background

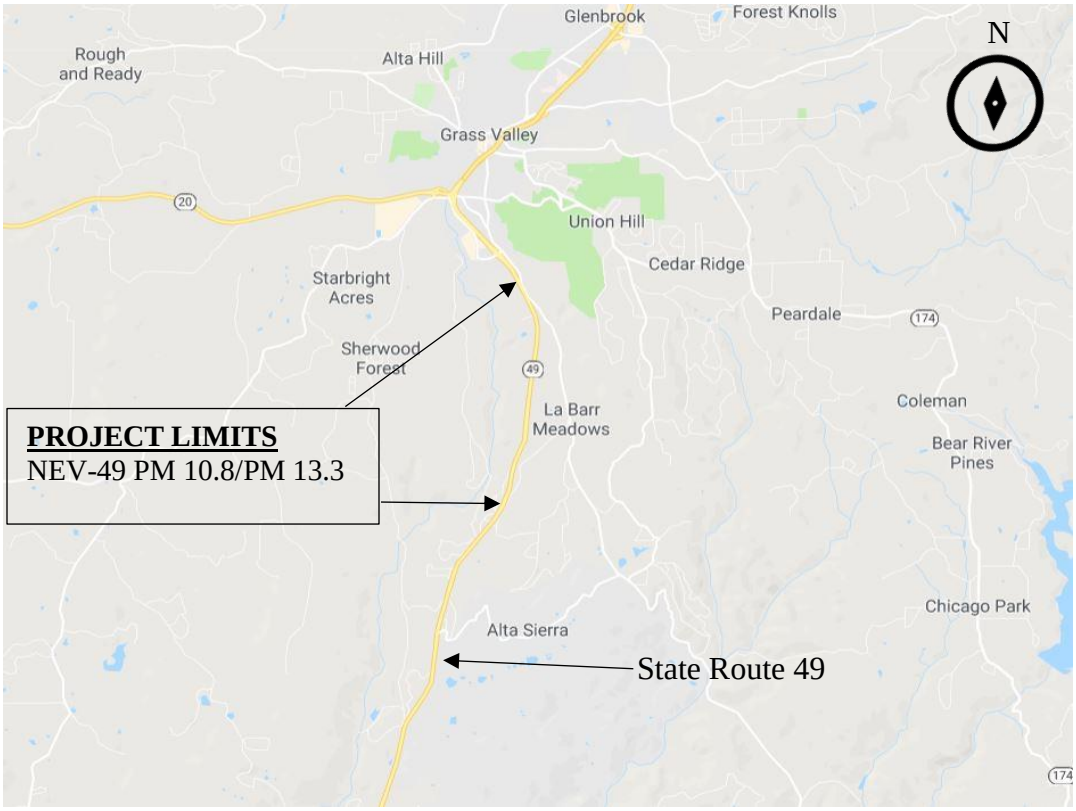
The Nevada County Transportation Commission (NCTC) and the California Department of Transportation (Caltrans) proposes to improve a portion of the interregional transportation facility, State Route 49 (SR 49), in Nevada County from Ponderosa Way to north of Lode Line Way (NEV PM 10.8-13.3) near Grass Valley, California. The facility is a two (2) lane conventional highway with twelve (12) foot lanes and zero (0) to eight (8) foot paved and/or gravel shoulders with various left- and right-turn pockets.

The proposed project proposes to improve the study segment of SR 49 to enhance safety, provide an additional lane, and improve traffic operations. Improvements include:

- Widen to a four-lane conventional access control highway with a median barrier (option of continuous median/two-way-left-turn-lane) and eight (8) foot shoulders.
- Enhance the horizontal alignment
- Removal of various at-grade intersections/driveways
- Construction of a frontage road system to channel traffic from existing at-grade intersections and private driveways to two intersections.

The project is expected to enhance the mobility for all modes of transportation, such as trucks, vehicle traffic, bicyclist, pedestrians, and horses for all travelers throughout the region.

The project location is displayed in the map below.



Cost Effectiveness Analysis

The methodology used for estimating the benefits and costs of the proposed project are described in this section. In calculating the BCA, Caltrans followed the recommended *FHWA's Benefit-Cost Analysis Guidance for Discretionary Grant Program*, dated December 2018 and supporting documents' guidelines, monetization rates, and evaluation methods.

The results tables in the BCA spreadsheets represent the delta or change of the yearly economic benefit for the Build and No-Build alternatives. The positive values represent the plus benefit and the negative values represent the minus benefit for that category.

The BCA incorporates a 7-percent discount rate. Details regarding the BCA methodology is found in the Cal-BC User Guide and Technical Supplements (Volumes 1-4). The Cal-B/C spreadsheet model was updated with INFRA 2017 values by the Caltrans Headquarters Transportation Economic Branch.

1) The BCA was run for a No-Build of 2-lanes and a Build of 4-lanes.
2) The accident data was used for the current facility and a future 4-lane facility in a rural area with rolling hills.

All spreadsheets used in the analysis are provided electronically.

The BCA provides monetized benefits and costs, in present day dollars, associated with the project over the analysis period between 2023 and 2043. The estimated benefits have been categorized in savings in the categories of: 1) Travel Time Costs, 2) Vehicle Operating Costs, 3) Safety (Accident) Cost, and 4) Emissions Cost.

Traffic Data and Travel Demand Analysis

Current traffic data is from Traffic Volumes on California State Highways.

The travel impact of the project was estimated using the results from the NCTC travel demand forecasting model. The land use data provided apply to the model years of 2012 and 2035. A build and no-build scenario were developed by Fehr & Peers Consultants. There was not a mid-year land use of socio-economic data available for interpolation of the travel forecast. To develop the year 2043 forecast volumes the yearly growth was lowered to 1% between years 2035 and 2043. Traffic data was determined by using a weighted averaged of traffic volumes in the project corridor. The traffic volumes are shown in Table 2.

The peak hour period of 5-hours used in the BCA was determined from the 12-hour fifteen-minute count data collected during February and May of 2018. The 2-hour AM and 3-hour PM peak periods indicated sustained hourly volumes between 1,800 to 2,400 vehicles which approaches capacity for a two-lane highway. Hourly count data is included in the BC spreadsheet hourly count data tab.

Table 2: Traffic Data

Year	ADT	Peak Hour
2017	25,240	2,390
2023 NB	27,910	2,620
2043 NB	35,900	3,340
2023 BLD	28,690	2,690
2043 BLD	38,180	3,530

Travel Time Savings

Travel Time savings has the largest resulting share, $83.1 million, of benefit from project even while considering trips will be rerouted in the project area. Also, there will be less percent time following with more opportunities to pass slow moving vehicles resulting in better speeds. The formulas below were used to calculate Travel Time Savings (the formula can also be found in the "Travel Time" tab of the Benefit-Cost spreadsheet, the Travel Time parameters (below) can be found in the "Parameters" tab of the spreadsheet).

Formulas:

Avg. Annual Volume = Avg. Daily Traffic x Number of Days in Model Year
vehicles / yr

Travel Time = AVO x Avg. Annual Volume x Affected Length / Speed
vehicle-hrs / yr vehicles / yr x miles miles/hour

TT Savings = Travel Time Reduction x Avg. Value of Time
$ / year $/hour
Avg. Value of Time (varies by vehicle type)

Induced = Change in Trips x Change in Travel Time * 0.5

Travel Time Parameters

	Value	Units	
Statewide Average Hourly Wage	$ 27.50	$/hr	3
Heavy and Light Truck Drivers			
Average Hourly Wage	$ 20.50	$/hr	3
Benefits and Costs	$ 10.69	$/hr	4
Value of Time			
Automobile	$ 13.75	$/hr/per	5
Truck	$ 31.20	$/hr/veh	5
Auto & Truck Composite	$ 19.05	$/hr/veh	6
Transit	$ 13.75	$/hr/per	5
Out-of-Vehicle Travel	2	times	5
Incident-Related Travel	3	times	7
Travel Time Uprater	0.0%	annual incr	

Sources (see number to the right of the box above and source number below for corresponding source): 3) Bureau of Labor Statistics (BLS) OES, 4) BLS Employment Cost Index, 5) USDOT Department Guidance, 6) California Department of Transportation TSI and Traffic Operations, and 7) IDAS model.

Table 3 summarizes the results in terms of Travel Time Savings for each year from the BCA model between Build and No-Build.

Table 3: Travel Time Savings (from the "Final Calculations" tab)

Year	Calendar Year	PRESENT VALUE OF USER BENEFITS 7%	USER BENEFITS IN CONSTANT DOLLARS
1	2023	$4,543,950	$5,202,369
2	2024	$4,479,574	$5,487,670
3	2025	$4,418,155	$5,791,300
4	2026	$4,359,849	$6,114,914
5	2027	$4,304,819	$6,460,373
6	2028	$4,253,242	$6,829,777
7	2029	$4,205,311	$7,225,506
8	2030	$4,161,237	$7,650,265
9	2031	$4,121,259	$8,107,140
10	2032	$4,085,645	$8,599,677
11	2033	$4,054,699	$9,131,958
12	2034	$4,028,773	$9,708,718
13	2035	$4,008,274	$10,335,472
14	2036	$3,993,680	$11,018,688
15	2037	$3,985,551	$11,766,000
16	2038	$3,984,558	$12,586,484
17	2039	$3,991,504	$13,491,013
18	2040	$4,007,361	$14,492,730
19	2041	$4,033,318	$15,607,668
20	2042	$4,070,846	$16,855,592
Total =		$83,091,604	$192,463,314
Note: positive values represent benefits and negative values respresent disbenefits			

Changes in Vehicle Operating Costs

The Vehicle Operating Costs show a disbenefit based on the results of the BCA, as expected from the increase in travel and associated costs. Along with the added lane-miles, the additional vehicles per year using the facility will cause higher VMT. Therefore, the negative costs in Table 4 indicate a negative benefit between the build and no-build. The formulas below were used to calculate Vehicle Operating Costs (the formula can also be found in the "Vehicle Operating Costs" tab of the Benefit-Cost spreadsheet, the Vehicle Operating Cost parameters (below) can be found in the "Parameters" tab of the spreadsheet).

Formulas:

Vehicle-Miles Traveled = Affected Length x Avg. Annual Volume			Non-Fuel Cost = VMT x Cost Per Mile		
veh-miles/yr	miles	vehicles/yr	dollars	$/miles	
Fuel Cost = VMT x Fuel Consumption x Fuel Price			Benefit = Existing Cost - New Cost		
dollars	gallons/mile	$/gallon			

Vehicle Operating Cost Parameters

Average Fuel Price			
Automobile (regular unleaded)	$ 3.08	$/gal	8
Truck (diesel)	$ 3.07	$/gal	8
Sales and Fuel Taxes			
State Sales Tax (gasoline)	2.25%	%	9
State Sales Tax (diesel)	**13.00%**	%	9
Average Local Sales Tax	0.50%	%	9
Federal Fuel Excise Tax (gasoline)	$ 0.184	$/gal	9
Federal Fuel Excise Tax (diesel)	$ 0.244	$/gal	9
State Fuel Excise Tax (gasoline)	$ 0.417	$/gal	9
State Fuel Excise Tax (diesel)	$ 0.360	$/gal	9
Fuel Cost Per Gallon (Exclude Taxes)			
Automobile	$ 2.40	$/gal	
Truck	$ 2.10	$/gal	
Non-Fuel Cost Per Mile			
Automobile	$ 0.319	$/mi	10
Truck	$ 0.437	$/mi	11
Idling Speed for Op. Costs and Emissions	5	mph	

Sources (see number to the right of the box above and source number below for corresponding source): 8) AAA Daily Fuel Gauge Report, 9) California Board of Equalization, 10) AAA Your Driving Costs, and 11) American Transportation Research Institute

Table 4: Vehicle Operating Costs Savings (from the "Final Calculations" tab)

Year	Calendar Year	PRESENT VALUE OF USER BENEFITS 7%	USER BENEFITS IN CONSTANT DOLLARS
1	2023	($120,728)	($138,222)
2	2024	($135,960)	($166,557)
3	2025	($116,026)	($152,087)
4	2026	($125,259)	($175,683)
5	2027	($95,860)	($143,860)
6	2028	($68,727)	($110,361)
7	2029	($77,046)	($132,380)
8	2030	($53,793)	($98,895)
9	2031	($61,082)	($120,158)
10	2032	($38,937)	($81,957)
11	2033	($18,776)	($42,288)
12	2034	($25,717)	($61,974)
13	2035	$7,665	$19,763
14	2036	$497	$1,371
15	2037	$29,467	$86,992
16	2038	$54,665	$172,675
17	2039	$46,404	$156,841
18	2040	$68,823	$248,901
19	2041	$60,563	$234,360
20	2042	$79,802	$330,425
Total =		($590,028)	($173,094)
Note: positive values represent benefits and negative values respresent disbenefits			

Safety (Accident Reduction Benefits)

The road safety benefits from the project are expected to reduce accidents. This is the second largest benefit, $2.1 million, based on the results of the BCA. Table 5 contains the three-year accident data used in the BCA. Accident information was developed from the Caltrans electronic database of accident history called "Traffic Accident Surveillance and Analysis System" (TASAS). The data in TASAS comes from the California Highway system called "Statewide Integrated Traffic Records System" (SWITRS).

Table 5: Accident Data

Segment	Post Mile	Total	Fatal	Injury
Nev-49	10.8/13.3	58	0	21
TASAS data years 2015, 2016, & 2017				

The formulas below were used to calculate Safety (Accident Reduction Benefits) (the formula can also be found in the "Accident Costs" tab of the Benefit-Cost spreadsheet, the Accident Costs parameters (below) can be found in the "Parameters" tab of the spreadsheet).

Formulas:

Vehicle-Miles Traveled = Affected Length x Avg Volume
veh-miles/yr miles vehicles/yr

Hwy Acc Cost = (VMT x Rate x Cost/Mile) by Acc Type

Transit Acc Cost = Veh-Miles x Acc Cost/Mile

Transit Acc Cost/Mile from PARAMETERS

Accident Cost Parameters

Cost of a Fatality	$ 9,600,000	$/event	12
Cost of an Injury			
Level A (Severe)	$ 459,100	$/event	12
Level B (Moderate)	$ 125,000	$/event	12
Level C (Minor)	$ 63,900	$/event	12
Cost of Property Damage	$ 4,300	$/event	13
Cost of Highway Accident			
Fatal Accident	$ 11,100,000	$/accident	
Injury Accident	$ 154,400	$/accident	
PDO Accident	$ 13,700	$/accident	
Average Cost	$ 280,400	$/accident	
Statewide Highway Accident Rates			
Fatal Accident	0.006	per mil veh-mi	14
Injury Accident	0.29	per mil veh-mi	14
PDO Accident	0.55	per mil veh-mi	14
Non-Freeway	1.05	per mil veh-mi	15

Sources (see number to the right of the box above and source number below for corresponding source): 12) USDOT VSL, 13) NHTSA, 14) TASAS summary 2013, 15) TASAS summary 2009

The values in Table 6 represent the benefits and costs each year for build and no-build alternatives in terms of Safety-Accident Reduction Benefits from the BCA model.

Table 6: Safety (Accident Reduction Benefits) (from the "Final Calculations" tab)

Year	Calendar Year	PRESENT VALUE OF USER BENEFITS 7%	USER BENEFITS IN CONSTANT DOLLARS
1	2023	$183,899	$210,546
2	2024	$172,186	$210,936
3	2025	$161,220	$211,326
4	2026	$150,951	$211,716
5	2027	$141,335	$212,106
6	2028	$132,332	$212,497
7	2029	$123,902	$212,887
8	2030	$116,009	$213,277
9	2031	$108,618	$213,667
10	2032	$101,697	$214,057
11	2033	$95,217	$214,448
12	2034	$89,150	$214,838
13	2035	$83,469	$215,228
14	2036	$78,150	$215,618
15	2037	$73,170	$216,008
16	2038	$68,506	$216,399
17	2039	$64,140	$216,789
18	2040	$60,052	$217,179
19	2041	$56,224	$217,569
20	2042	$52,640	$217,959
Total =		$2,112,866	$4,285,049
Note: positive values represent benefits and negative values respresent disbenefits			

Emission Reduction Benefits

The summary of emissions calculated include CO, CO_2, NO_X, PM_{10}, $PM_{2.5}$, SO_X, and VOC. Yearly positive benefits in emissions between the build and no-build alternatives are in Table 7. The peak-period results in calculated emissions indicate positive costs due to improved speeds for all vehicles.

The formulas below were used to calculate Emission Reduction Benefits (the formula can also be found in the "Emissions" tab of the Benefit-Cost spreadsheet.)

The Emissions parameters and tables can be found in the "Parameters" tab of the spreadsheet, Sources of parameters: McCubbin and Delucchi, 1996 for emissions other than CO_2e, Interagency Working Group on Social Cost of Carbon, United States Government, 2016 for CO_2e. The identified social cost of carbon was adjusted.

Formulas:

Vehicle-Miles Traveled = Affected Length x Avg. Annual Volume
veh-miles/yr miles vehicles/yr

Transit Em Cost = (Veh-Miles x Rate x Cost/Mile) by Em Type

Hwy Emissions Cost = (VMT x Rate x Cost/Mile) by Emissions Type

Table 7 shows the additional benefits and costs for each year between build and no-build alternatives in terms of Emission Reduction Benefits from the BCA model.

Table 7: Emission Reduction Benefits

Year	Calendar Year	PRESENT VALUE OF USER BENEFITS 7%	USER BENEFITS IN CONSTANT DOLLARS
1	2023	$4,166	$4,770
2	2024	$2,478	$3,036
3	2025	$4,213	$5,523
4	2026	$3,660	$5,134
5	2027	$4,660	$6,994
6	2028	$5,327	$8,554
7	2029	$4,792	$8,234
8	2030	$10,581	$19,454
9	2031	$9,966	$19,604
10	2032	$10,477	$22,053
11	2033	$10,937	$24,632
12	2034	$10,313	$24,853
13	2035	$11,856	$30,570
14	2036	$11,189	$30,871
15	2037	$12,590	$37,167
16	2038	$13,830	$43,686
17	2039	$13,065	$44,158
18	2040	$14,078	$50,913
19	2041	$13,302	$51,475
20	2042	$14,007	$57,997
Total =		$185,487	$499,675
Note: positive values represent benefits and negative values respresent disbenefits			

Qualitative Benefits

Besides the quantified benefits from the BCA, there are additional benefits for this highway improvement project. The wider 8-foot shoulders, new frontage roads, the horizontal curve

correction, and reducing highway access to two at grade-controlled intersections will cause more efficient traffic flow in the corridor. The 8-foot shoulders gives a comfort level to the driver. The improved horizontal curve improves site distance. And the frontage road combined with the two at grade-controlled intersections limits access and egress locations on the highway which helps to maintain highway speeds and yields improved traffic operations.

Costs

Project costs include Design/Construction Support, Construction Capital, Utilities, Right-of-Way, Mitigation and Maintenance/Operations. The project costs in constant dollars is approximately $110.3 million. Caltrans maintenance and operation (M & O) information is captured in the Integrated Maintenance Management System (IMMS). The M & O cost was determined from the estimate of a per-mile Preventive and Maintenance cost per -mile of $115 million. The source is Table 8 of the '2015 State of the Pavement Report' by Caltrans Division of Maintenance Pavement Program. The total present value of project costs is $105.2 million with a 7-percent discount rate as described in Table 8.

Table 8: Project Life Cycle Costs

		PRESENT VALUE	UNDISCOUNTED	
Year	Calendar Year	Total Cost 7% Disc.	Capital Costs	O&M Costs
1	2023	$64,270,000	$64,270,000	$0
2	2024	$38,682,243	$41,390,000	$0
3	2025	$200,891	$0	$230,000
4	2026	$187,749	$0	$230,000
5	2027	$175,466	$0	$230,000
6	2028	$163,987	$0	$230,000
7	2029	$153,259	$0	$230,000
8	2030	$143,232	$0	$230,000
9	2031	$133,862	$0	$230,000
10	2032	$125,105	$0	$230,000
11	2033	$116,920	$0	$230,000
12	2034	$109,271	$0	$230,000
13	2035	$102,123	$0	$230,000
14	2036	$95,442	$0	$230,000
15	2037	$89,198	$0	$230,000
16	2038	$83,363	$0	$230,000
17	2039	$77,909	$0	$230,000
18	2040	$72,812	$0	$230,000
19	2041	$68,049	$0	$230,000
20	2042	$63,597	$0	$230,000
21	2043	$59,436	$0	$230,000
22	2044	$55,548	$0	$230,000
TOTALS=		$105,229,461	$105,660,000	$4,600,000

Summary of Benefits

The aggregation of all expected benefits from the project, and their costs are shown in Table 9 below, with discount rates of 7-percent and undiscounted. The metrics indicate a benefit-cost ratio of 0.8 and a net present value of -$20.4 million. The largest share of benefits is $83.1 million resulting from travel time savings.

Table 9: Summary of the Benefit-Cost Analysis

	Monetary Values	
Metrics	**Undiscounted**	**Discount Rate 7%**
Travel Time Savings	$192,463,314	$83,091,604
Vehicle Operating Cost Savings	($173,094)	($590,028)
Safety (Accident Reduction Benefits)	$4,285,049	$2,112,866
Emission Reduction Benefits	$499,675	$185,487
Total Benefits	$197,074,945	$84,799,929
Total Capital and O&M Costs	$110,260,000	$105,229,461
Net present value =		($20,429,532)
Benefit-Cost Ratio		0.8

Also included in the BCA is an investment analysis summary of benefits which include rate of return on investment, payback period, person-hours of time saved, and emission reductions for 7 types of emissions in tons and monetary value. The emissions calculated include CO, CO_2, NO_X, PM_{10}, $PM_{2.5}$, SO_X, and VOC. This information is included in Table 10.

Table 10: Investment Analysis

INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$105.2
Life-Cycle Benefits (mil. $)	$84.8
Net Present Value (mil. $)	-$20.4
Benefit / Cost Ratio:	0.8
Rate of Return on Investment:	4.9%
Payback Period:	14 years

ITEMIZED BENEFITS (mil. $)	Passenger Benefits	Freight Benefits	Total Over 20 Years	Average Annual
Travel Time Savings	$76.3	$6.7	$83.1	$4.2
Veh. Op. Cost Savings	-$0.6	$0.0	-$0.6	-$0.0
Accident Cost Savings	$2.0	$0.1	$2.1	$0.1
Emission Cost Savings	$0.1	$0.1	$0.2	$0.0
TOTAL BENEFITS	$77.8	$7.0	$84.8	$4.2
Person-Hours of Time Saved			13,021,235	651,062

Should benefit-cost results include:

1) Induced Travel? (y/n)	Y (Default = Y)
2) Vehicle Operating Costs? (y/n)	Y (Default = Y)
3) Accident Costs? (y/n)	Y (Default = Y)
4) Vehicle Emissions? (y/n) includes value for CO2e	Y (Default = Y)

	Tons		Value (mil. $)	
EMISSIONS REDUCTION	Total Over 20 Years	Average Annual	Total Over 20 Years	Average Annual
CO Emissions Saved	113	6	$0.0	$0.0
CO2 Emissions Saved	25,696	1,285	$0.0	$0.0
NOX Emissions Saved	35	2	$0.1	$0.0
PM10 Emissions Saved	0	0	$0.1	$0.0
PM2.5 Emissions Saved	0	0		
SOX Emissions Saved	0	0	$0.0	$0.0
VOC Emissions Saved	8	0	$0.0	$0.0

Benefit-Cost Analysis Supporting Files Location

The backup files for the Benefit-Cost Analysis are uploaded to the Nevada County Transportation Commission website and can be view by accessing the following link:

http://www.nctc.ca.gov/INFRA/index.html

If the "Ctrl+Click" option does not work, please copy and paste the web link into Windows Explorer.

If you have any technical difficulties, please contact

Mike Woodman, Deputy Executive Director
Nevada County Transportation Commission
530-265-3202