California Department Of Transportation

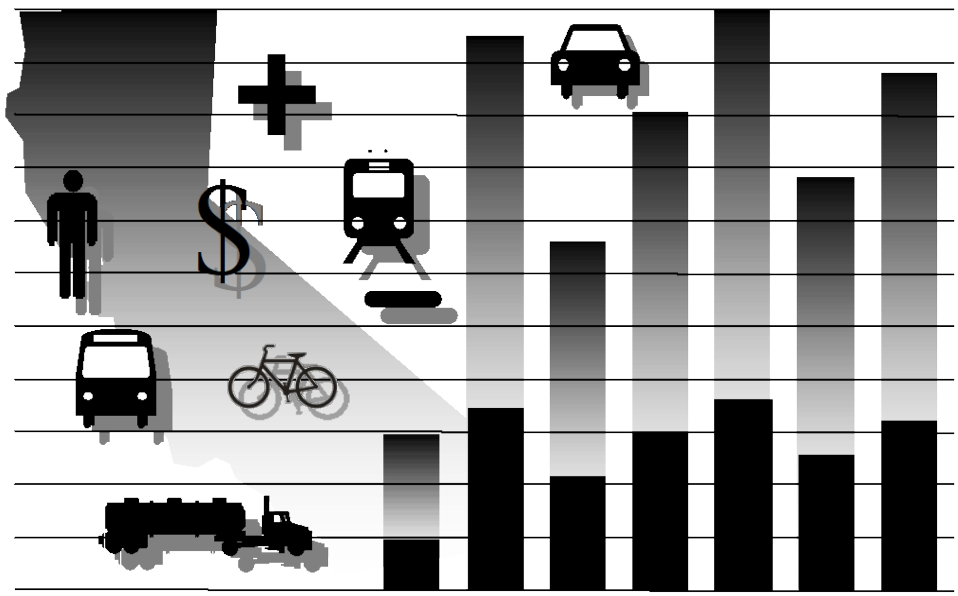
Cal-B/C

Corridor

Version 7.1

User's Guide and Technical Documentation

November 2019



Acknowledgements

The Cal-B/C Corridor model was originally developed by System Metrics Group more than ten years ago with recent updates by HDR. The material included in this user's guide is based upon previous writing and contributions from System Metrics Group and HDR. In many cases, material has been copied verbatim from earlier work.

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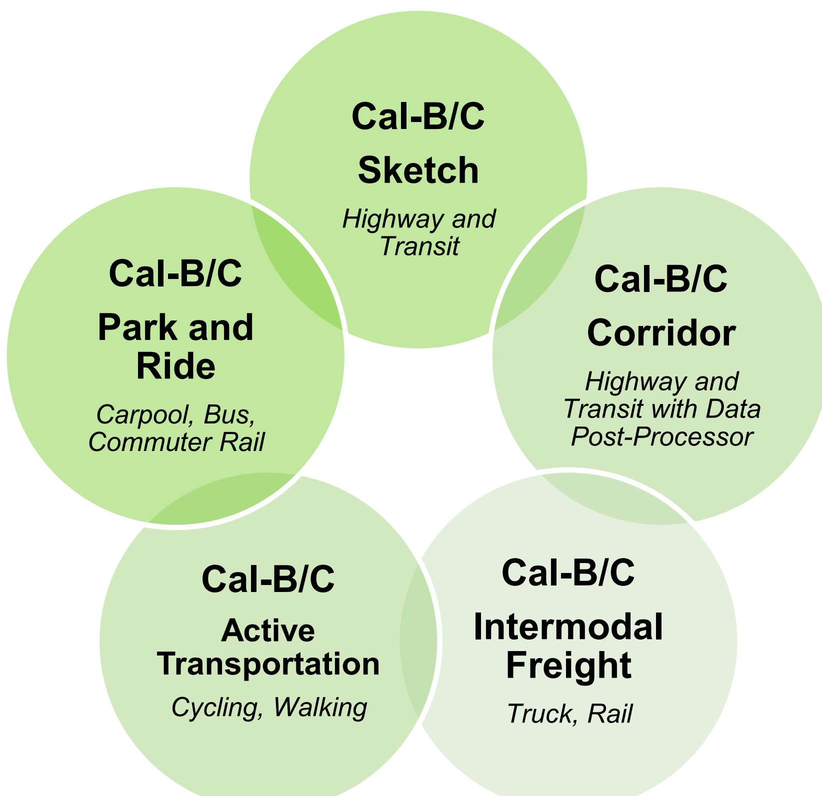
List of Exhibits

1. Overview of Cal-B/C

Welcome to California Department of Transportation (Caltrans) California Lifecycle Benefit/Cost Analysis suite of tools. Caltrans uses this set of spreadsheet-based tools to conduct investment analyses of projects proposed for the interregional portion of the State Transportation Improvement Program (STIP), the State Highway Operations and Protection Program (SHOPP), applications to the Active Transportation Program (ATP), Senate Bill (SB) 1 programs, and other ad hoc analyses requiring benefit-cost analysis.

The original Cal-B/C model focused on highway and transit modes. This model has been updated several times and ultimately renamed as the **Cal-B/C Sketch** model. This model now covers a wide variety of highway and transit physical and operational improvements. Closely related to the Cal-B/C Sketch model is **Cal-B/C Corridor**, which is based on the same platform, but allows users to post-process travel demand and micro-simulation model data. In addition, several relatively new sketch planning models have been tailored to evaluate active transportation (**Cal-B/C AT**) projects (e.g., biking and walking facilities), park-and-ride (**Cal-B/C PnR**) programs (e.g., commuter parking and ride-sharing facilities), and intermodal freight (**Cal-B/C IF**) improvements (e.g., freight network expansion and terminal efficiency). Exhibit 1 shows all five tools in the Cal-B/C framework, which allows users to consider many different types of projects.

Exhibit 1: Suite of Tools in Cal-B/C Framework



All of the tools in the Cal-B/C framework use consistent methods, rely on the same parameters, and produce comparable results. Together, these tools cover multi-modal analyses of highway, transit, bicycle, pedestrian, Intelligent Transportation System (ITS), operational improvement, and passenger rail projects. In addition, there are other versions of the Cal-B/C model available for more experienced analysts. One version incorporates the additional benefits of improved reliability, beyond those of predictable time savings alone, and could be used if the proposed project warrants it. A separate version of Cal-B/C has been developed to enable users to assess the degree to which uncertainty influences project outcomes. Risk analysis is performed on the same model, but with an Excel add-in module called Risk Analyzer that is used to perform Monte Carlo simulation on user-specified parameters.

2. Introduction to User Guide

Welcome to the User's Guide for the *California Lifecycle Benefit/Cost Analysis Model (Cal-B/C)* Corridor, Version 7.1. Cal-B/C Corridor is part of a suite of similarly designed Cal-B/C Microsoft Excel spreadsheet-based tools that can evaluate multi-modal analyses of highway, transit, bicycle, pedestrian, Intelligent Transportation System (ITS), operational improvement, and passenger rail projects. The California Department of Transportation (Caltrans) uses Cal-B/C to conduct benefit-cost analyses (BCAs) of projects proposed for the interregional portion of the State Transportation Improvement Program (STIP), the State Highway Operations and Protection Program (SHOPP) and other ad hoc analyses requiring benefit-cost analysis.

Cal-B/C Corridor serves as a post processor that allows the user to calculate benefits using data from prior traffic and planning analysis, such as micro-simulation and travel demand models. It supports assessments to prioritize highway and transit projects, evaluate alternatives, and compete for project funding. The model follows a similar structure, formatting, and parameters to other models in the Cal-B/C suite of tools. As a result, Cal-B/C Corridor can prepare BCAs for projects comparable to those calculated for projects using other Cal-B/C models.

The Cal-B/C Corridor implements a benefits analysis methodology that:

- Estimates the travel time, safety, emission, and greenhouse gas benefits of highway and transit projects using modeled data provided by the user
- Calculates fuel and emissions savings based on vehicle operating speed using the same assumptions as other Cal-B/C tools
- Includes consumer surplus benefits
- Allows the user to specify the number of model and safety groups (e.g., from one to 500 groups) and the period of analysis (e.g., from two to 50 years)
- Calculates key metrics including person-hours of time saved, fatalities and injuries avoided, and property damage only (PDO) crashes avoided
- Simplifies the input of travel time information.

Appendix B provides additional information on the analytical methods used in the model.

3. User Requirements

At a minimum, the user of Cal-B/C Corridor should have a working knowledge of spreadsheets, particularly Microsoft Excel. To use Cal-B/C Corridor, the reader of this User's Guide must be able to navigate through a multiple-sheet workbook and understand basic principles, functions, and terminology used when discussing spreadsheets.

The user should also understand lifecycle benefit-cost analysis and be able to interpret the results in a highway and transit planning context. The user can refer to the Cal-B/C Resource Guide for additional information, as needed.

4. Operating System and Software Requirements

Cal-B/C Corridor is a Microsoft Excel macro-enabled workbook (.xlsm) called *Cal-B/C 71 Corridor*. The file is approximately 700 kilobytes (KB) in size. Although designed for a Windows environment, Cal-B/C Corridor should work on all computer platforms running Excel.

5. Model Overview

Cal-B/C Corridor is a Microsoft Excel model that allows the user to estimate the economic benefits of highway and transit projects that have already been evaluated in traffic or planning tools such as microsimulation or travel demand models. Cal-B/C Corridor conducts BCAs using the changes in vehicle-miles traveled (VMT), vehicle-hours traveled (VHT), passenger-miles traveled (PMT), and passenger-hours traveled (PHT) estimated in traffic and planning models for highway and transit projects. The model has a flexible design that supports a variety of input data.

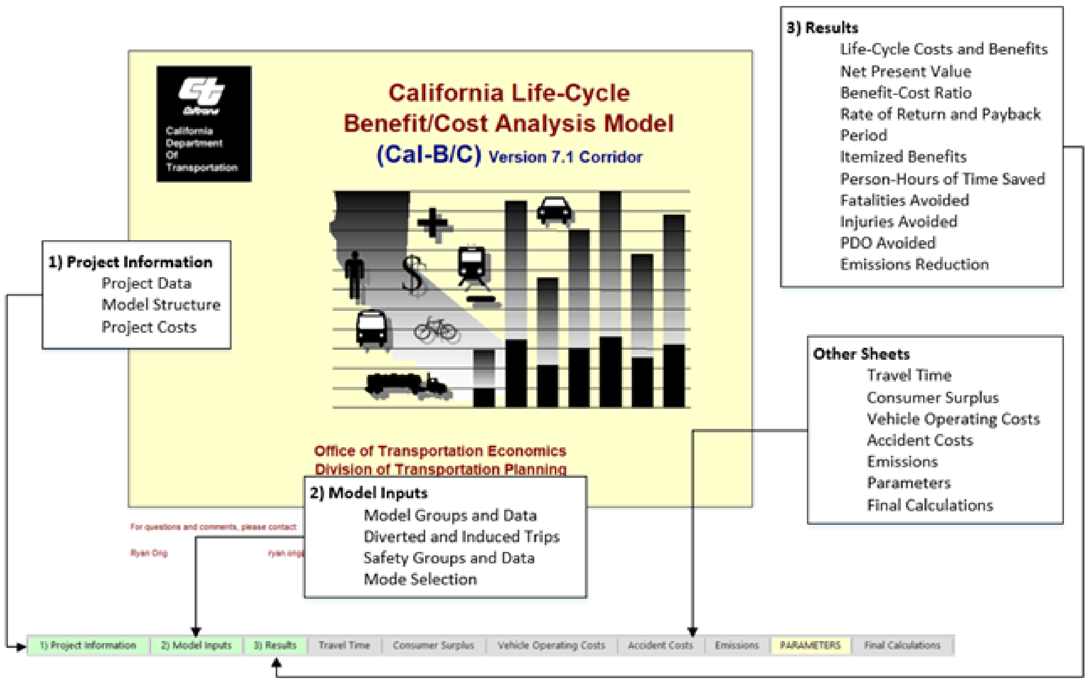
Cal-B/C Corridor estimates user benefits in four main categories:

- **Travel time savings** due to faster travel speeds on highways or faster or more frequent service on transit modes
- **Vehicle operating cost savings** on highways due to lower costs from more efficient travel speeds or avoided vehicle operating and out-of-pocket costs when travelers switch from highways to transit
- **Safety benefits** on highways due to safety improvements or for transit riders who switch from highways to a safer transit mode
- **Emissions benefits** on highways due to travel at less polluting speeds or by reductions in VMT due to suppressed trips or mode shifts to transit.

The Cal-B/C Corridor model consists of a cover page and 11 worksheets in an Excel workbook. The user should generally refer to only the first four worksheets after the cover page (including one that provides instructions and reference materials) to conduct analyses and produce results.

The remaining seven worksheets perform calculations or store defaults and economic parameters. Exhibit 2 shows where these sheets are located in Cal-B/C Corridor.

Exhibit 2: Cal-B/C Graphical User Interface



Cal-B/C Corridor requires various user inputs, but also allows the user to enter many more inputs when available. Cells in the worksheet are color-coded. **Green** cells highlight required data (i.e., the user must input values for the model to work or for the specific aspect mode to be incorporated). **Red** cells provide default values, which the user may change if needed. **Blue** cells contain values calculated by the model, which may be changed if detailed data are available.

Following the cover page, the first worksheet, *Instructions*, provides a short description of the steps required in using the Cal-B/C Corridor model to perform a basic analysis and hints on how to avoid potential errors. The instructions may be printed to serve as a handy desk reference.

The *Project Information* worksheet is the main data-entry worksheet. The user must enter descriptive information about the project such as:

- Location and project timeline
- Number of model groups, safety groups, and years of analysis
- Expected project construction and operating costs.

The *Model Inputs* worksheet is where the user can define model and safety groups based on the available traffic or planning data and enter the data for the No Build and Build scenarios for highway- and transit-related projects.

The *Results* worksheet presents the final investment expenditure as well as annualized and lifecycle benefits. This worksheet allows the user to decide which of the four calculated benefits to include. Cal-B/C Corridor summarizes results using several measures:

- Lifecycle costs (in millions of dollars)
- Lifecycle benefits (in millions of dollars)
- Net present value (in millions of dollars)
- Benefit/cost ratio (benefits divided by costs)
- Rate of return on investment (in percent return over the project)
- Project payback period (in years).

The model itemizes expected benefits (in millions of dollars) over the lifecycle of the investment and provides the average annual value. The model calculates benefits for:

- Travel time savings
- Vehicle operating cost savings
- Accident cost savings
- Emission cost savings.

In addition, the model reports results over the lifecycle of the investment and the annual average:

- Person-hours of time saved
- Fatalities and injuries avoided
- PDO crashes avoided
- Emissions reduction.

Although the model generally requires inputs in the *Project Information* and *Model Inputs* worksheets, additional changes may be made in the *Parameters* worksheet by more experienced users. In particular, the default parameter values in the *Parameters* worksheet may be adjusted to produce tailored results if detailed information is available for specific projects. The *Parameters* worksheet contains all the economic values and rate tables used in the model. Adjusting the economic update factor using the Gross Domestic Product (GDP) deflator changes the economic values in the model.

The worksheet includes the following parameters:

General Economic Values

- Year of current dollars for model[1]
- Economic update factor
- Real discount rate

Highway Operations Measures

- Maximum volume-capacity (v/c) ratio
- Percent ADT in peak period
- Capacity per lane by road type
- Parameters for speed estimation
- Queue departure rates
- Annualization factor

Active Transportation Parameters

- Travel activity characteristics
- User characteristics
- Trip characteristics
- Journey quality
- Health impacts

Travel Time Values

- Automobile, truck, and transit
- Out-of-vehicle; incident-related travel

User Operating Costs

- Fuel cost per gallon
- Non-fuel cost per mile (automobile and truck)

Highway Accident Costs

- Cost of a fatality
- Cost of an injury (Level A Severe, Level B Moderate, Level C Minor)
- Cost of a highway accident (fatal, injury, PDO)
- Statewide highway accident rates (fatal, injury, PDO)

Accident Rates and Transit Costs

- Highway injury severity frequency
- Highway accident type distribution
- Light rail and bus accident rates and costs
- Passenger train accident rates and costs
- Highway-rail grade crossing incidents
- Passing lane accident reduction factors

Highway Emissions Rates

- CO, CO_2, NO_X, PM_{10}, SO_X, and VOC
- Automobile, truck, and bus

Rail Emissions Rates

- CO, NO_X, PM_{10}, and VOC
- Passenger train, light rail, and freight locomotive

Emissions Health Costs

- Urban Southern California, urban Northern California, and rural California
- CO, CO_2e, NO_X, PM_{10}, SO_X, and VOC
- Automobile, truck, and bus

Other Values

- Demand for travel in peak period
- Fuel consumption rates for autos, trucks, and buses
- Pavement adjustment factors
- Weaving adjustment factors
- Transportation Management System (TMS) adjustment factors

[1] Measured in real (constant) dollars, which are a measure of monetary value adjusted for inflation.

6. Worksheet Details and Project Analysis

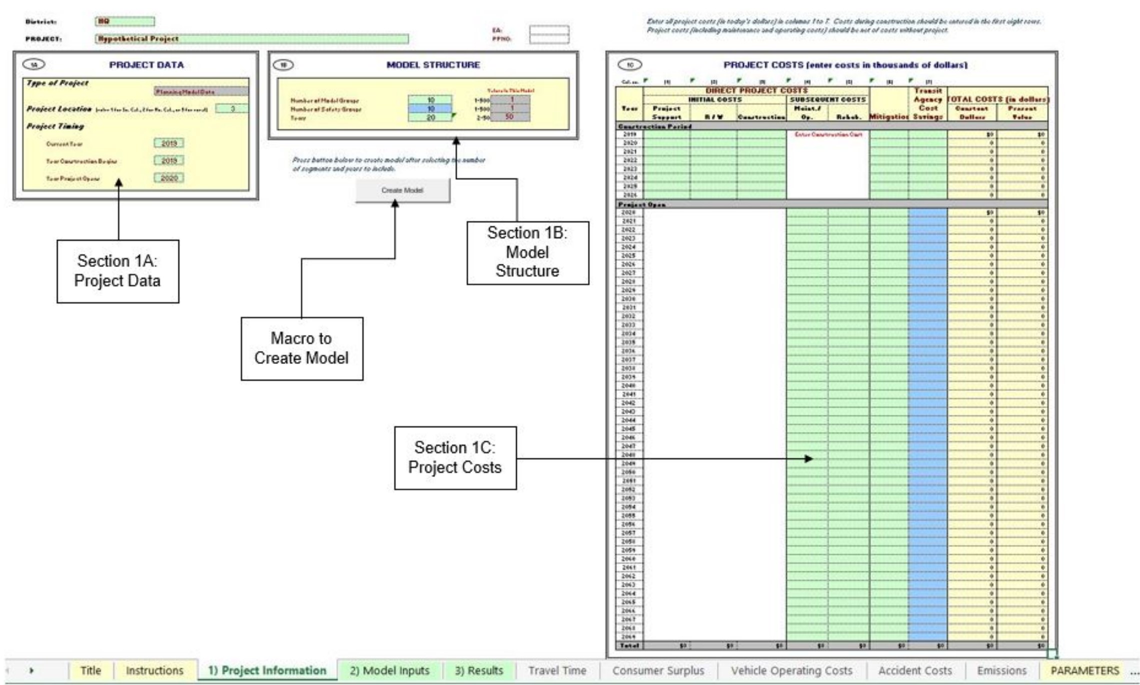
The following sections describe the three primary Cal-B/C Corridor worksheets and walks the user through a hypothetical project. The main text in each section introduces the user to an element of the model and the project examples provide details on the data entry process.

PROJECT INFORMATION WORKSHEET

The *Project Information* worksheet is one of the main data input sheets in Cal-B/C Corridor. The project information worksheet contains three sections, as seen in Exhibit 3 and the table below.

Section Number	Name of Section	Location of Section in Worksheet (Top Left Cell: Bottom Right Cell)
1A	Project Data	B6 : I22
1B	Model Structure	K6 : R15
1C	Project Costs (in thousands of dollars)	U6 : AF75

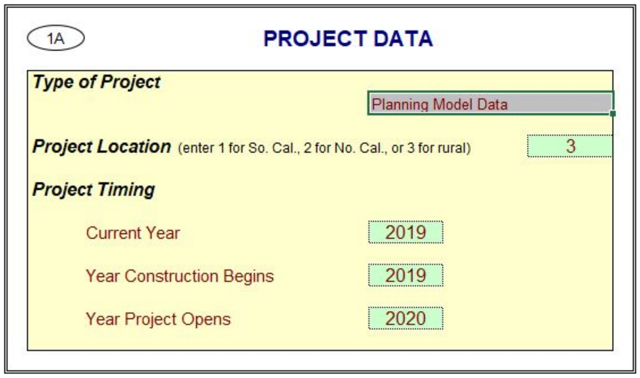
Exhibit 3: Project Information Worksheet



Project Data

In this section, the user enters data regarding the type of project, the project location, the year construction begins (including project development), and the year the project is open to the public.

Exhibit 4: Project Information Worksheet – 1A, Project Data



PROJECT TYPE

The project type selection allows the user to manually enter the type of project. This entry is for documentation purposes and the user may chose not to enter a project type.

PROJECT LOCATION

The Cal-B/C Corridor model considers three unique areas within California (i.e., Northern California Urban, Southern California Urban, or Rural California). The model uses the location information to determine the appropriate accident costs and health costs of transportation emissions parameters to use in calculating the benefits. The user identifies the project location by selecting "1" for Urban Southern California, "2" for Urban Northern California, and "3" for Rural California.

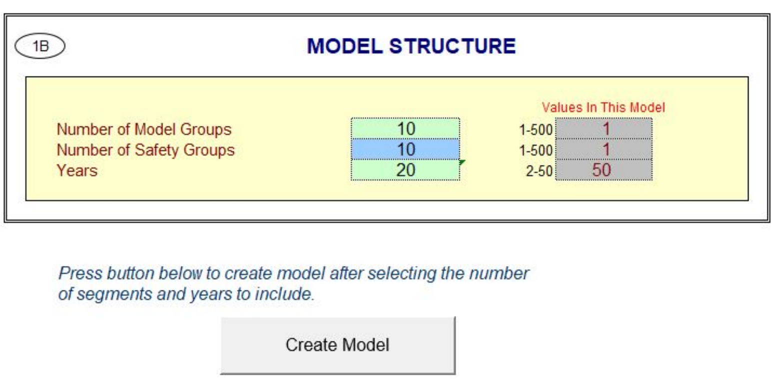
PROJECT TIMING

The model requires the user to input the current year, the first year of construction (including project development), and the project opening year. This information helps determine the length of the construction period (and the total number of years in the study period) and calculate the present value of costs and benefits.

Model Structure

Section 1B allows the user to customize Cal-B/C Corridor and specify the number of model groups, safety groups, and years to be included in the analysis.

Exhibit 5: Project Information Worksheet – 1B, Model Structure



NUMBER OF MODEL GROUPS

The user must enter the number of model groups to be analyzed. Cal-B/C Corridor is flexible in that model groups can be defined by several classifications including time of day, vehicle type, trip purpose, section of roadway, roadway classification, or speed bin. For example, defining data by one mile per hour (mph) speed bins would require about 70 model groups. If these were defined separately for automobiles and trucks, then 140 model groups would be needed. For most applications, 100 to 200 model groups will be adequate. The model accommodates a maximum of 500 model groups.

NUMBER OF SAFETY GROUPS

The user then enters the number of safety groups to be analyzed. By default, this number is set to be equal to the number of model groups. However, the value in this cell can be set to a different number of safety groups, depending on the structure of safety data available to the user.

YEARS

Finally, the user must enter the number of operational years once construction is complete. Lifecycle benefits will be calculated for a total number of years specified. The model will handle a minimum of two years and a maximum of 50 years. The U.S. Department of Transportation recommends a period of at least 20 years after the completion of construction for BCAs. Caltrans typically uses 20 years, which is the standard used in other Cal-B/C models.

Once these inputs have been entered, the user should press the "Create Model" button to save the model with the selected numbers of structure elements. Note that the structure of the model is fixed after the button is pressed.[2]

Project Costs

The user enters project construction, operating, right-of-way, and other costs in this section of the project information worksheet. All costs should be entered as incremental rather than total costs. Costs already incurred are sunk costs and should not be included in the benefit-cost analysis.[3] Incremental costs are estimated as the difference between the "Build" costs and the "No Build" costs.

The project costs table contains seven columns for users to enter cost information in thousands of dollars, as shown in Exhibit 6. All cost values should be in the year of current dollars for the model (as shown in the *Parameters* worksheet) to ensure consistency. For instance, if the year of current dollars for model is 2016, all cost values should be in 2016 dollars to ensure consistency with the benefit calculations. The model automatically calculates the sum and present value of all costs inputted by the user.

The leftmost column of the project costs table indicates the years throughout the lifecycle separating the construction period and project lifecycle years. Cal-B/C Corridor can handle up to

[2] If the user wishes to change the model structure (e.g., number of model groups, safety groups, or years), the user will need to start the analysis again from the beginning.

[3] Sunk costs are included as part of the BCA for federal grant application, but not as part of the amount requested.

eight years of construction, where the number of construction years is determined in the *Project Data* section. For each year of construction where cost data are missing, the message "Must enter a cost" appears in red under the Subsequent Cost section. As well for each year beyond the construction period, if a construction cost is entered, the message "Adjust Construction Period" appears in red under the Subsequent Cost section.

Exhibit 6: Project Information Worksheet – 1C, Project Costs

1C PROJECT COSTS (enter costs in thousands of dollars)

Col. no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
	DIRECT PROJECT COSTS						Transit Agency Cost Savings	TOTAL COSTS (in dollars)	
	INITIAL COSTS			SUBSEQUENT COSTS					
Year	Project Support	R/W	Construction	Maint./ Op.	Rehab.	Mitigation		Constant Dollars	Present Value
Construction Period									
2019				Enter Construction Cost				$0	$0
2020								0	0
2021								0	0
2022								0	0
2023								0	0
2024								0	0
2025								0	0
2026								0	0
Project Open									
2020								$0	$0
2021								0	0
2022								0	0
2023								0	0
2024								0	0
2025								0	0
2026								0	0
2027								0	0
2028								0	0
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2057								0	0
2058								0	0
2059								0	0
2060								0	0
2061								0	0
2062								0	0
2063								0	0
2064								0	0
2065								0	0
2066								0	0
2067								0	0
2068								0	0
2069								0	0
Total	$0	$0	$0	$0	$0	$0	$0	$0	$0

DIRECT PROJECT COSTS (IN THOUSANDS OF DOLLARS)

The direct project costs are broken down into *Initial Costs* and *Subsequent Costs*. Their respective composition is as follows:

- *Initial Costs* include:
  - Project support (e.g., engineering design and management costs)
  - Right-of-way acquisition costs
  - Construction costs.
- *Subsequent Costs* include:
  - Maintenance and operating costs
  - Rehabilitation costs (e.g., pavement overlay, truck, track, or station refurbishment).

The *Initial Costs* should reflect the net capital costs required to complete the project, while the *Subsequent Costs* indicate the estimate future incremental maintenance, operating and rehabilitation costs in constant dollars. Note that in the case of analyzing a long-range plan, the user may want to enter net capital costs as Subsequent Costs (during the plan period). These can be entered in any of the available green cells in the Subsequent Costs section. Costs should be entered in the years they are expected to occur. As previously indicated, these costs should be entered in thousands of dollars.

MITIGATION (IN THOUSANDS OF DOLLARS)

Mitigation costs include costs to protect communities and the environment from negative impacts. These costs include wetland and community preservation, as well as sound walls to reduce highway or rail noise. The user enters these costs in constant dollars during construction and for a number of years after construction has been completed. The number of years depends on what the user entered in Box 1B.

TOTAL COSTS (IN DOLLARS)

The model calculates the total costs automatically and presents the total cost in constant dollars and present value for each year. It should be noted that since total costs are denoted in dollars, the model multiplies the previous columns by 1000 to convert the values from thousands of dollars to actual values. The project cost table summarizes the total constant dollar of the cost element at the bottom in dollars. Using the *Real Discount Rate* defined in the *Parameters* sheet and the *Current Year* defined in the *Project Data* section, the following formula computes the present value:

$$\text{Present Value} = \frac{\text{Future Value (in constant dollars)}}{(1+\text{Real Discount Rate})^{\text{Future Year - Current Year}}}$$

MODEL INPUTS WORKSHEET

The *Model Inputs* worksheet is critical to estimating benefits in Cal-B/C Corridor. This worksheet allows the user to define the model and safety groups and enter model and safety data for the No Build and Build scenarios. The model inputs worksheet contains seven sections, as seen in Exhibit 7 and Exhibit 8 and in the table below.

Section Number	Name of Section	Location of Section in Worksheet (Top Left Cell: Bottom Right Cell)
2A	Definitions of Model Groups and Years	B4 : P15
2B	Average Profile for Diverted Trips/Induced Trips	R4 : AF15
2C	Model Data – Base Year	B18 : P38
2D	Model Data – Forecast Year	R18 : AF38
2E	Definitions of Safety Groups and Years	AH4 : AU15
2F	Safety Data – Base Year	AH18 : AU38
2G	Safety Data – Forecast Year	AW18 : BI38

Exhibit 7: Model Inputs Worksheet – Part 1 of 2

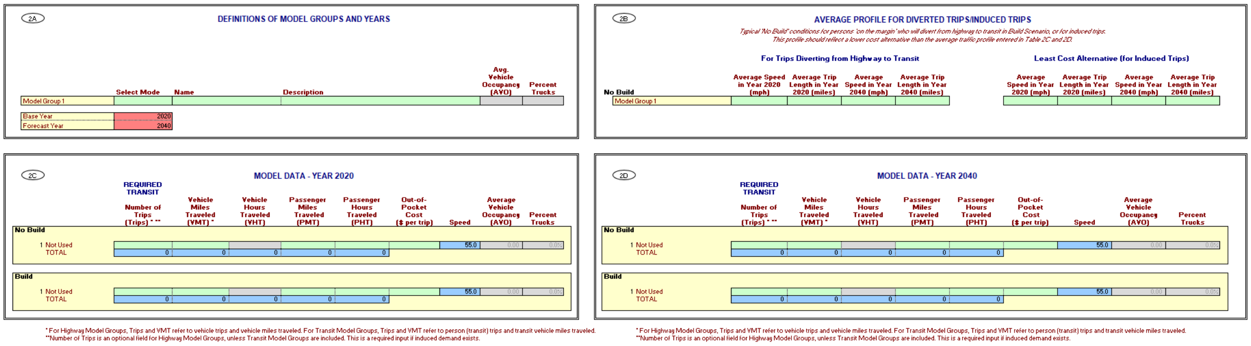
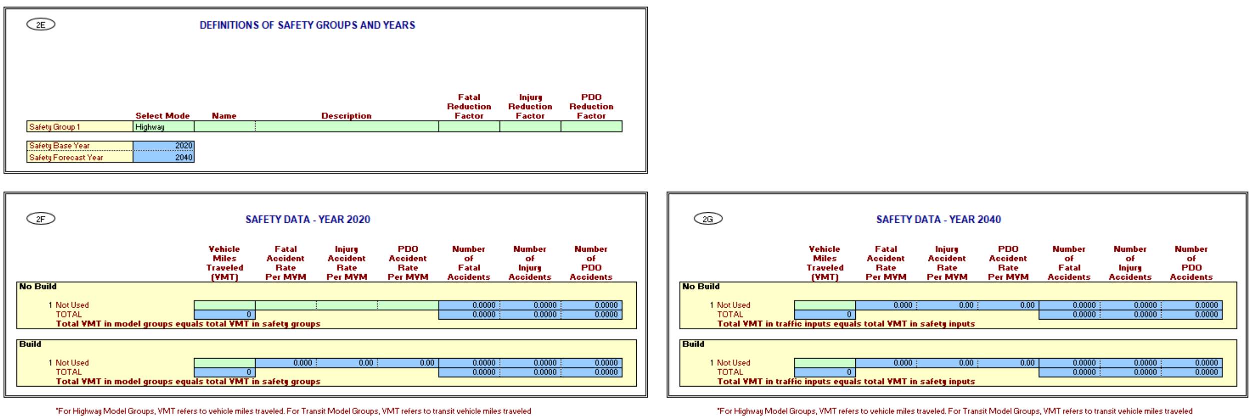


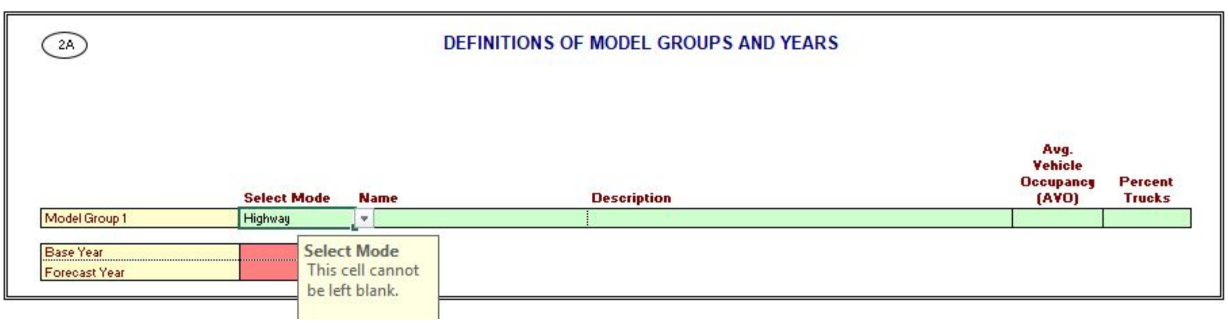
Exhibit 8: Model Inputs Worksheet – Part 2 of 2



Definitions of Model Groups and Years

In Section 2A, the user defines the model groups to be used in the analysis and enters the base and forecast years for the traffic or planning model available.

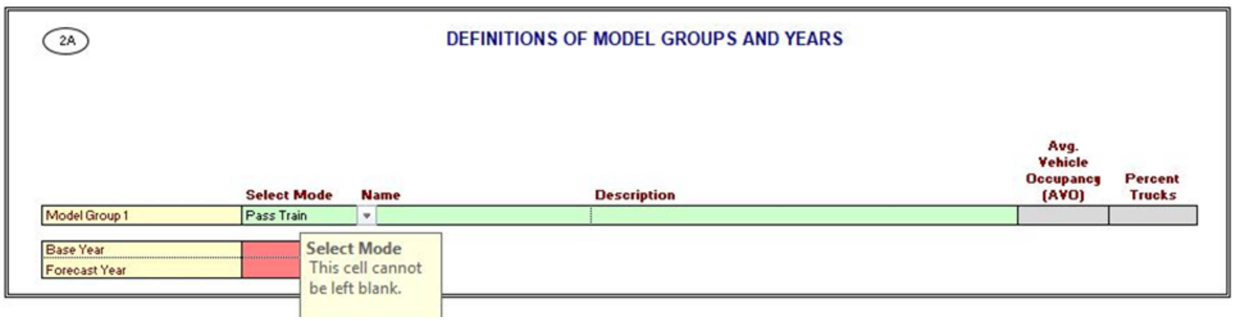
Exhibit 9: Model Inputs Worksheet – 2A, Definitions of Model Groups and Years



The user must select a mode for each model group from the following options: bus, passenger train, light rail, and highway. The user then provides a name and description for each model group. The name is a short "nickname" that will appear on subsequent tables in the Cal-B/C Corridor model. The description column allows the user to define the model group in more detail for reference purposes.

For a highway model group, the user must enter the average vehicle occupancy (AVO).The AVO will automatically be copied to the aggregate model data in Sections 2C and 2D, but the user can manually modify the AVO if there are differences. For example, the AVO may differ between the base year and forecast year or from the No Build scenario to the Build scenario. For a non-highway model group, AVO information is not used in further calculations. This cell is grayed out and the user must not enter any information.

Additionally, the user must enter the percentage of trucks in total traffic for a highway model group. The percent trucks can be set to 0 percent or 100 percent as appropriate if automobile and truck data are entered separately in more than one highway model group. Like the AVO data, this information will be automatically copied to the aggregate model data in Sections 2C and 2D, but can be changed. For non-highway model groups, the percentage of trucks information is not used in further calculations. This cell is grayed out and the user must not enter any information.

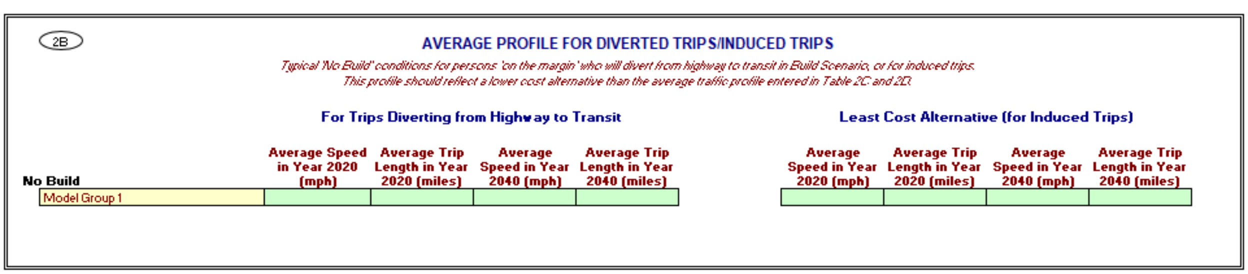


The user then enters the base and forecast years of the travel demand or micro-simulation model outputs. Cal-B/C Corridor will automatically interpolate data for interim years in the analysis.

Average Profile for Diverted Trips/Induced Trips

For every transit model group (model groups that belong to a mode other than highway) in the case transit does not exist in the No Build scenario, the user must enter the parameters for the least cost alternative to that transit mode in Section 2B. This information does not need to be entered for a highway group. Separate tables that ask for inputs on average speed and average trip length for the base and forecast years. These parameters are different for diverting trips and induced trips.

Exhibit 10: Model Inputs Worksheet – 2B, Average Profile for Diverted Trips/Induced Trips



The user enters the average speed and average trip length for diverted and induced trips and for the base and forecast years specified in Section 2A.

If highway is selected in Section 2A or if transit exists in the Build scenario (based on data entered in sections 2C and 2D), the average profile for diverted trips/induced trips data are not required and will not be used in any further calculation for that particular row. These cells are grayed out and the user must not enter any information.

2B

AVERAGE PROFILE FOR DIVERTED TRIPS/INDUCED TRIPS

Typical 'No Build' conditions for persons 'on the margin' who will divert from highway to transit in Build Scenario, or for induced trips.
This profile should reflect a lower cost alternative than the average traffic profile entered in Table 2C and 2D.

	For Trips Diverting from Highway to Transit				Least Cost Alternative (for Induced Trips)			
No Build	Average Speed in Year 2020 (mph)	Average Trip Length in Year 2020 (miles)	Average Speed in Year 2040 (mph)	Average Trip Length in Year 2040 (miles)	Average Speed in Year 2020 (mph)	Average Trip Length in Year 2020 (miles)	Average Speed in Year 2040 (mph)	Average Trip Length in Year 2040 (miles)
Model Group 1								

Aggregate Model Data

The user enters output from a traffic or planning model (e.g., micro-simulation or travel demand model) in Sections 2C and 2D. The inputs that are required for highway are slightly different than the inputs required for transit modes.

For the highway mode, the user must enter VMT and VHT data. Cal-B/C Corridor automatically calculates vehicle speeds from this information. The user may enter data on the number of trips for induced demand calculations, but these data are not required if induced demand will not be included in the calculation. The user should check the AVO and percent trucks information, which is copied from Section 2A.

Exhibit 11: Model Inputs Worksheet – 2C and 2D, Model Data – Base and Forecast Years

2C

MODEL DATA - YEAR 2020

	REQUIRED TRANSIT Number of Trips (Trips) * **	Vehicle Miles Traveled (VMT) *	Vehicle Hours Traveled (VHT)	Passenger Miles Traveled (PMT)	Passenger Hours Traveled (PHT)	Out-of-Pocket Cost ($ per trip)	Speed	Average Vehicle Occupancy (AVO)	Percent Trucks
No Build									
1 Not Used							55.0	0.00	0.0%
TOTAL	0	0	0	0	0				
Build									
1 Not Used							55.0	0.00	0.0%
TOTAL	0	0	0	0	0				

2D

MODEL DATA - YEAR 2040

	REQUIRED TRANSIT Number of Trips (Trips) * **	Vehicle Miles Traveled (VMT) *	Vehicle Hours Traveled (VHT)	Passenger Miles Traveled (PMT)	Passenger Hours Traveled (PHT)	Out-of-Pocket Cost ($ per trip)	Speed	Average Vehicle Occupancy (AVO)	Percent Trucks
No Build									
1 Not Used							55.0	0.00	0.0%
TOTAL	0	0	0	0	0				
Build									
1 Not Used							55.0	0.00	0.0%
TOTAL	0	0	0	0	0				

For transit modes (bus, passenger train, and light rail), another set of inputs is required – PMT and PHT. In addition, entering the number of trips is very important for the calculations to work. The user must pay special attention to Section 2B if transit is not included in the Build scenario, but not in the No Build scenario.

2C

MODEL DATA - YEAR 2020

	REQUIRED TRANSIT Number of Trips (Trips) * **	Vehicle Miles Traveled (VMT) *	Vehicle Hours Traveled (VHT)	Passenger Miles Traveled (PMT)	Passenger Hours Traveled (PHT)	Out-of-Pocket Cost ($ per trip)	Speed	Average Vehicle Occupancy (AVO)	Percent Trucks
No Build									
1 Not Used							55.0	0.00	0.0%
TOTAL	0	0	0	0	0				
Build									
1 Not Used							55.0	0.00	0.0%
TOTAL	0	0	0	0	0				

2D

MODEL DATA - YEAR 2040

	REQUIRED TRANSIT Number of Trips (Trips) * **	Vehicle Miles Traveled (VMT) *	Vehicle Hours Traveled (VHT)	Passenger Miles Traveled (PMT)	Passenger Hours Traveled (PHT)	Out-of-Pocket Cost ($ per trip)	Speed	Average Vehicle Occupancy (AVO)	Percent Trucks
No Build									
1 Not Used							55.0	0.00	0.0%
TOTAL	0	0	0	0	0				
Build									
1 Not Used							55.0	0.00	0.0%
TOTAL	0	0	0	0	0				

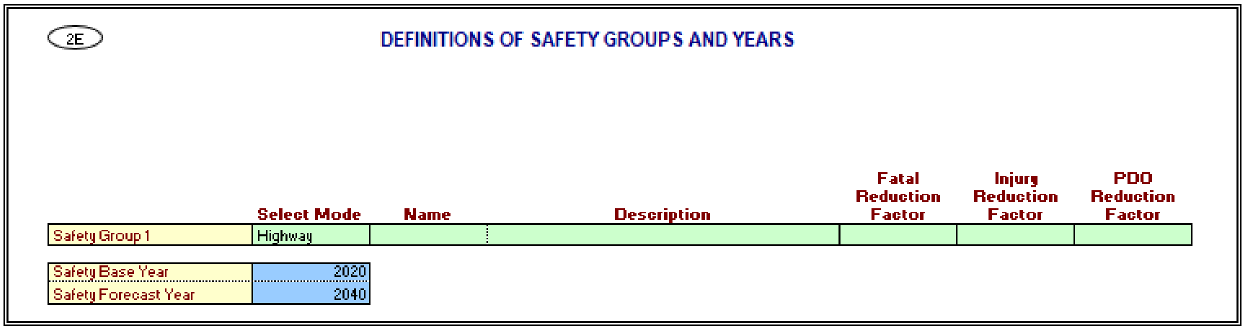
The user should follow these steps:

1. For each highway model group, enter the daily VMT and VHT in the No Build and Build scenarios for the base and forecast years. For each transit model group, enter the daily transit VMT, PMT, and PHT for the base and forecast years. Sections 2C and 2D are labeled with the appropriate years. Additionally, the user can enter out-of-pocket costs, but these are optional for all modes.
2. For each highway model group, the AVO and percent trucks are specified in Section 2A and are automatically populated in Sections 2C and 2D. The user can manually override these values if they vary from the base year to the forecast year or from the No Build scenario to the Build scenario.
3. Cal-B/C Corridor allows the user to enter trip data. For highway model groups, this information is not required unless estimating induced demand. If the trip data are not entered, the model calculates benefits without induced demand. The detailed travel time tables in the Travel Time worksheet list the number of trips as one (1), but this does not affect the calculations and should not be changed. For transit model groups, the number of trips is required in the No Build and Build scenarios.
4. While filling out Sections 2C and 2D, keep in mind that for highway model groups, trips and VMT refer to vehicle trips and vehicle-miles traveled. For transit model groups, trips and VMT refer to transit trips (person trips) and transit vehicle-miles traveled.

Definitions of Safety Groups and Years

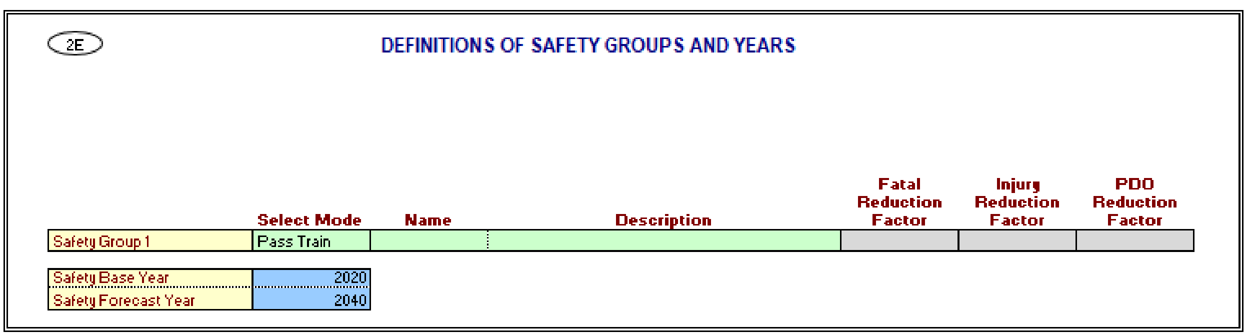
In Section 2E (similar to Section 2A), the user defines the safety groups to be used in the analysis and identifies the base and forecast years for the safety data. Both safety base and forecast years are automatically populated and match the base and forecast years from Section 2A, but the user can manually update these years for the safety data if they are for different years.

Exhibit 12: Model Inputs Worksheet – 2E, Definitions of Safety Groups and Years



In this section, the user selects the mode for each safety model group from the following options: bus, passenger train, light rail, and highway. Similar to Section 2A, the user provides a name and description for each safety group. The description column allows the user to provide details.

Additionally, for each highway safety group, the user must enter reduction factors that indicate the percentage by which the occurrence decreases from the No Build scenario to the Build scenario. The factors may be different for fatal, injury, and PDO accidents. The user is not required to enter reduction factors for bus, passenger train, and light rail as Cal-B/C Corridor uses the default accident rates found in the *Parameters* worksheet. These cells are grayed out.



Safety Data

In Sections 2F and 2G, the user enters data needed to calculate safety benefits. Data needs differ for highway and transit (e.g., bus, passenger train, and light rail) safety groups.

BASE YEAR

For highway safety groups, the user must enter daily VMT and accident rates per million VMT, for each severity of accidents in the No Build scenario. In the Build scenario, the user must enter daily VMT only. Accident rates are automatically calculated based on Build daily VMT and the reduction factors entered in Section 2A.

For transit safety groups, the user must only enter daily transit VMT. Cal-B/C Corridor has built-in accident rates for transit modes. The user may modify these rates in the *Parameters* worksheet (BH12:BJ14) if project specific data are available.

Exhibit 13: Model Inputs Worksheet – 2F, Safety Data Base Year

2F

SAFETY DATA - YEAR 2020

	Vehicle Miles Traveled (VMT)	Fatal Accident Rate Per MVM	Injury Accident Rate Per MVM	PDO Accident Rate Per MVM	Number of Fatal Accidents	Number of Injury Accidents	Number of PDO Accidents
No Build							
1 Not Used					0.0000	0.0000	0.0000
TOTAL	0				0.0000	0.0000	0.0000
Total VMT in model groups equals total VMT in safety groups							
Build							
1 Not Used		0.000	0.00	0.00	0.0000	0.0000	0.0000
TOTAL	0				0.0000	0.0000	0.0000
Total VMT in model groups equals total VMT in safety groups							

2F

SAFETY DATA - YEAR 2020

	Vehicle Miles Traveled (VMT)	Fatal Accident Rate Per MVM	Injury Accident Rate Per MVM	PDO Accident Rate Per MVM	Number of Fatal Accidents	Number of Injury Accidents	Number of PDO Accidents
No Build							
1 Not Used					0.0000	0.0000	0.0000
TOTAL	0				0.0000	0.0000	0.0000
Total VMT in model groups equals total VMT in safety groups							
Build							
1 Not Used		0.000	0.00	0.00	0.0000	0.0000	0.0000
TOTAL	0				0.0000	0.0000	0.0000
Total VMT in model groups equals total VMT in safety groups							

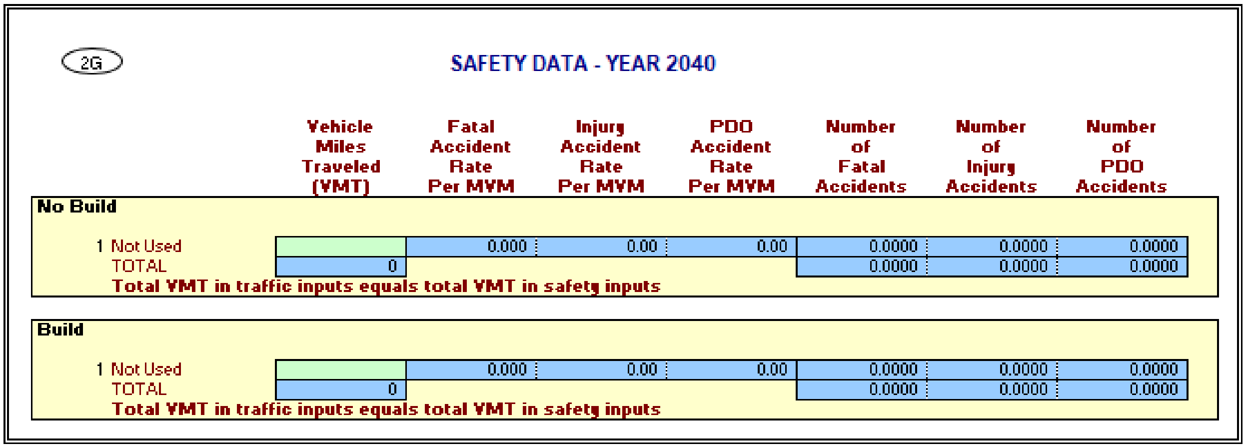
FORECAST YEAR

The user must enter daily VMT or daily transit VMT (if selected safety mode is transit) in the No Build and Build scenarios.

For each highway safety group, Cal-B/C corridor assumes that accident rates are the same for the base and forecast years in the No Build scenario. The user can manually override these assumptions and enter updated Build accident rates if project specific data are available. For transit safety groups, the user must enter only daily transit VMT.

Once the required values are entered in the *Project Information* and *Model Inputs* worksheets, Cal-B/C Corridor calculates the benefits associated with the project and compiles the results of the analysis in the *Results* worksheet.

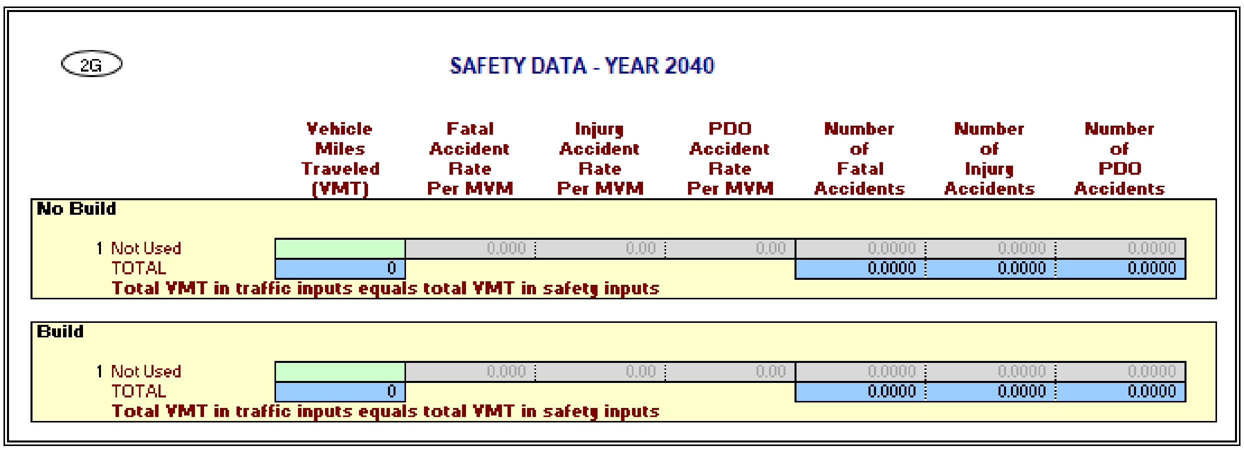
Exhibit 14: Model Inputs Worksheet – 2G, Safety Data Forecast Year



2G

SAFETY DATA - YEAR 2040

	Vehicle Miles Traveled (VMT)	Fatal Accident Rate Per MVM	Injury Accident Rate Per MVM	PDO Accident Rate Per MVM	Number of Fatal Accidents	Number of Injury Accidents	Number of PDO Accidents
No Build							
1 Not Used		0.000	0.00	0.00	0.0000	0.0000	0.0000
TOTAL	0				0.0000	0.0000	0.0000
Total VMT in traffic inputs equals total VMT in safety inputs							
Build							
1 Not Used		0.000	0.00	0.00	0.0000	0.0000	0.0000
TOTAL	0				0.0000	0.0000	0.0000
Total VMT in traffic inputs equals total VMT in safety inputs							



2G

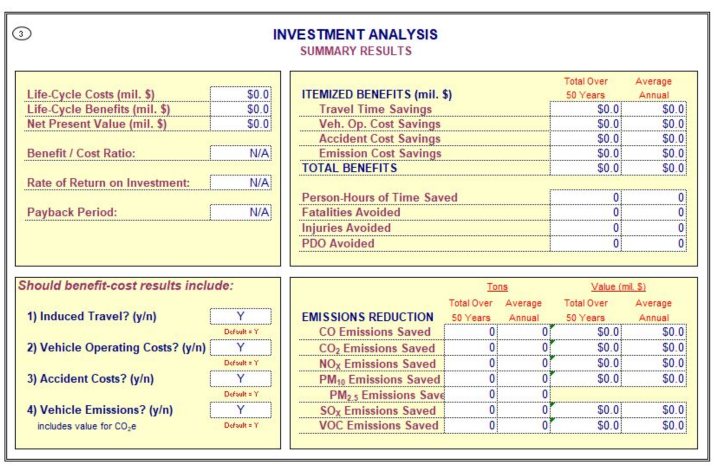
SAFETY DATA - YEAR 2040

	Vehicle Miles Traveled (VMT)	Fatal Accident Rate Per MVM	Injury Accident Rate Per MVM	PDO Accident Rate Per MVM	Number of Fatal Accidents	Number of Injury Accidents	Number of PDO Accidents
No Build							
1 Not Used		0.000	0.00	0.00	0.0000	0.0000	0.0000
TOTAL	0				0.0000	0.0000	0.0000
Total VMT in traffic inputs equals total VMT in safety inputs							
Build							
1 Not Used		0.000	0.00	0.00	0.0000	0.0000	0.0000
TOTAL	0				0.0000	0.0000	0.0000
Total VMT in traffic inputs equals total VMT in safety inputs							

RESULTS WORKSHEET

The final worksheet covered by this User's Guide is the *Results* worksheet, which provides the benefit-cost assessment results from the Cal-B/C Corridor model (see Exhibit 15).

Exhibit 15: Results Worksheet



3

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$0.0
Life-Cycle Benefits (mil. $)	$0.0
Net Present Value (mil. $)	$0.0
Benefit / Cost Ratio:	N/A
Rate of Return on Investment:	N/A
Payback Period:	N/A

ITEMIZED BENEFITS (mil. $)	Total Over 50 Years	Average Annual
Travel Time Savings	$0.0	$0.0
Veh. Op. Cost Savings	$0.0	$0.0
Accident Cost Savings	$0.0	$0.0
Emission Cost Savings	$0.0	$0.0
TOTAL BENEFITS	$0.0	$0.0
Person-Hours of Time Saved	0	0
Fatalities Avoided	0	0
Injuries Avoided	0	0
PDO Avoided	0	0

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 CO_2e	Y (Default = Y)

	Tons		Value (mil. $)	
EMISSIONS REDUCTION	Total Over 50 Years	Average Annual	Total Over 50 Years	Average Annual
CO Emissions Saved	0	0	$0.0	$0.0
CO_2 Emissions Saved	0	0	$0.0	$0.0
NO_X Emissions Saved	0	0	$0.0	$0.0
PM_{10} Emissions Saved	0	0	$0.0	$0.0
$PM_{2.5}$ Emissions Save	0	0		
SO_X Emissions Saved	0	0	$0.0	$0.0
VOC Emissions Saved	0	0	$0.0	$0.0

The *Results* worksheet permits the user to determine if certain benefits (i.e., Vehicle Operating Cost Savings; Accident Cost Savings; and Emission Cost Savings) should be included in the benefit-cost analysis. The decision to exclude a category could be for a variety of reasons including concerns about the adequacy of input data. For the user to decide whether to include or exclude these benefits, the toggle is determined through a binary choice between "Y" and "N," which represents yes and no respectively. The default setting for all benefits is "Y," implying that all benefits listed above are included in the default benefit-cost analysis. The user also has the option to include or exclude induced travel.

Cal-B/C Corridor provides various summary results and calculated project feasibility measures for a user-specified period of analysis, which highlight different aspects of a project:

- **Lifecycle Costs** (in millions of dollars) are the present values for all net project costs, including the initial costs and any subsequent costs in real constant dollars.
- **Lifecycle Benefits** (in millions of dollars) are the sum of the present value of the benefits considered for the project.
- **Net Present Value** (in millions of dollars), provides a measurement of project feasibility and is calculated as the difference between the lifecycle benefits and costs. In particular, if the net present value is positive (i.e., the lifecycle benefits are greater than the lifecycle costs), the project is feasible.
- **Benefit / Cost Ratio** highlights the lifecycle benefits relative to the lifecycle costs of a project. A ratio greater than one (1.0) implies the project has positive economic value.
- **Rate of Return on Investment** is defined as the discount rate that would equalize the lifecycle benefits and costs. If the rate of return on investment is greater than the discount rate used in the model, it implies the project is expected to provide positive economic value. This measurement allows the user to compare a variety of projects that have different lifecycle benefits or costs, as well as across different time periods.
- **Payback Period** is the number of years it would take the project to recover the initial construction costs, net of any ongoing costs. If the payback period is expected to be longer than the lifecycle of the project, it implies the initial construction costs are not recovered. It should be noted that the payback period has an inverse relationship with the benefit-cost ratio – a shorter payback period results in a higher benefit-cost ratio.

Cal-B/C Corridor presents a few additional statistics such as the person-hours of time saved, fatalities avoided, injuries avoided, PDO avoided, and the emissions reduction. For the reduction in emissions, the model presents the reduction by pollutant type. The pollutants considered are: CO, CO_2, NO_X, PM_{10}, $PM_{2.5}$, SO_X, and VOC. The emissions reduction are shown in both the volume (tons) and value (millions of dollars). Results for volume and value are shown as a grand total over the project lifecycle as well as an average annual value.

You are now ready to use Cal-B/C Corridor to model highway and transit projects. For more information about how Cal-B/C Corridor estimates particular impacts, please see Appendix B.

Appendix A: Project Examples

PROJECT EXAMPLE 1: INTERCHANGE EXAMPLE

This section provides a brief hypothetical example of using Cal-B/C Corridor to analyze an interchange project. The project shown was evaluated in a micro-simulation model for the Build and No Build conditions in the base year and forecast year. VMT and VHT results were extracted for each of 12 major travel movements through the interchange. These data can be entered into Cal-B/C Corridor, which monetizes the benefits and calculates the benefit-cost ratio.

The micro-simulation data are critical to the analysis since Cal-B/C Corridor does not have rules of the thumb to estimate project benefits. Unlike Cal-B/C Sketch, the corridor version of the model requires analysis in an external model to generate the VMT and VHT results.

STEP 1: Input Project Data into Project Information Worksheet

Exhibit 16 through Exhibit 18 show the data entered on the Cal-B/C Corridor *Project Information* worksheet to analyze the interchange benefits. The current year is set to 2016. Construction begins in 2017 and is expected to last until the end of 2020, with the project opening in 2021. The four-year construction period means that first-year benefits are discounted by five years (i.e., one year to construction start plus four years construction period).

Exhibit 16: Project Data Inputted into Cal-B/C Corridor Project Information Page

1A **PROJECT DATA**

Type of Project	Hypothetical Interchange Project
Project Location (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural)	1
Project Timing	
Current Year	2016
Year Construction Begins	2017
Year Project Opens	2021

The user then enters the number of model groups, safety groups, and years of analysis post-construction. There are 12 model groups representing the 12 major travel movements through the interchange. Safety data are provided for four safety groups which include mainline and ramps in two directions (northbound and southbound). The benefits are evaluated for a period of 20 years. The user should press the "Create Model" button to save the model before proceeding to Section 1C.

Exhibit 17: Model Structure Inputted into Cal-B/C Corridor Project Information Page

1B

MODEL STRUCTURE

		Values In This Model
Number of Model Groups	12	12
Number of Safety Groups	4	4
Years	20	20

The capital outlays anticipated for the project are entered directly into the model for a four-year construction period. This construction schedule assumes that costs are expended 20 percent in the first year, 30 percent each in the next two years, and 20 percent in the final year. As in the Cal-B/C Sketch model, Cal-B/C Corridor assumes project benefits begin after construction ends.

Exhibit 18: Project Costs Inputted into Cal-B/C Corridor Project Information Page

1C

PROJECT COSTS (enter costs in thousands of dollars)

Col. no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
	DIRECT PROJECT COSTS								
	INITIAL COSTS			SUBSEQUENT COSTS			Transit Agency Cost Savings	TOTAL COSTS (in dollars)	
Year	Project Support	R / W	Construction	Maint./ Op.	Rehab.	Mitigation		Constant Dollars	Present Value
Construction Period									
2017			$61,496					$61,495,600	$59,130,385
2018			$92,243					92,243,400	85,284,209
2019			$92,243					92,243,400	82,004,047
2020			$61,496					61,495,600	52,566,697
2021								0	0
2022								0	0
2023								0	0
2024								0	0
Project Open									
2021								$0	$0
2022								0	0
2023								0	0
2024								0	0
2025								0	0
2026								0	0
2027								0	0
2028								0	0
2029								0	0
2030								0	0
2031								0	0
2032								0	0
2033								0	0
2034								0	0
2035								0	0
2036								0	0
2037								0	0
2038								0	0
2039								0	0
2040								0	0
Total	$0	$0	$307,478	$0	$0	$0	$0	$307,478,000	$278,985,337

STEP 2: Input Traffic Simulation Data and Safety Data into Model Inputs Worksheet

The detailed model data from the simulation model are entered into the Cal-B/C Corridor *Model Inputs* worksheet as shown in Exhibit 19 through Exhibit 24. There are 12 highway model groups defined by a combination of travel movements and peak periods. These are identified in the box shown in Exhibit 19. The AVO for all model groups is assumed to be the standard 1.15 persons per vehicle used in the Cal-B/C framework for peak period travel. The percent box is not entered in this box because the percentage is expected to vary between the two future years.

The years from the simulation model correspond to 2021 (Year 1) and 2044 (Year 24) of the project lifecycle. These are identified in the box shown in Exhibit 19, so Cal-B/C Corridor can correctly interpolate the VMT and VHT data. Cal-B/C Corridor estimates benefits for a 20-year lifecycle, so the final year of analysis corresponds to values interpolated to four years before the final simulation model forecast.

Exhibit 19: Definition of Model Groups Entered into Cal-B/C Corridor Model Inputs Page

2A

DEFINITIONS OF MODEL GROUPS AND YEARS

	Select Mode	Name	Description	Avg. Vehicle Occupancy (AVO)	Percent Trucks
Model Group 1	Highway	AM15SThru	AM I-15 SB Thru traffic	1.15	
Model Group 2	Highway	AM15S215S	AM I-15 SB to I-215 SB	1.15	
Model Group 3	Highway	AM15NThru	AM I-15 NB Thru traffic	1.15	
Model Group 4	Highway	AM15N215S	AM I-15 NB to I-215 SB	1.15	
Model Group 5	Highway	AM215N15N	AM I-215 NB to I-15 NB	1.15	
Model Group 6	Highway	AM215N15S	AM I-215 NB to I-15 SB	1.15	
Model Group 7	Highway	PM15SThru	PM I-15 SB Thru traffic	1.15	
Model Group 8	Highway	PM15S215S	PM I-15 SB to I-215 SB	1.15	
Model Group 9	Highway	PM15NThru	PM I-15 NB Thru traffic	1.15	
Model Group 10	Highway	PM15N215S	PM I-15 NB to I-215 SB	1.15	
Model Group 11	Highway	PM215N15N	PM I-215 NB to I-15 NB	1.15	
Model Group 12	Highway	PM215N15S	PM I-215 NB to I-15 SB	1.15	

Base Year	2021
Forecast Year	2044

The VMT and VHT data are entered in Sections 2C and 2D. Section 2B is not relevant in this example and thus the cells in this section are grayed out. These are shown in Exhibit 20 and Exhibit 21. The speed is calculated automatically from the VMT and VHT and the AVO is referenced from the box shown in Exhibit 19. The percent trucks data are entered independently for each forecast year, since they are expected to be different in the two years. Note that the years in the two exhibits change automatically to reflect the years entered in the red boxes in Exhibit 19 (i.e., 2021 and 2044). PMT and PHT cells are grayed out since these are not applicable to highway model groups. Number of trips and out-of-pocket costs are optional and are not used in this example.

Exhibit 20: Model Data for Year 2021 Entered into Cal-B/C Corridor Model Inputs Page

2C

MODEL DATA - YEAR 2021

		REQUIRED FOR TRANSIT Number of Trips (Trips) * **	Vehicle Miles Traveled (VMT) *	Vehicle Hours Traveled (VHT)	Passenger Miles Traveled (PMT)	Passenger Hours Traveled (PHT)	Out-of-Pocket Cost ($ per trip)	Speed	Average Vehicle Occupancy (AVO)	Percent Trucks
No Build										
1	AM15SThru		76,893	1,768				43.5	1.15	12.4%
2	AM15S215S		42,221	944				44.7	1.15	4.8%
3	AM15NThru		39,179	669				58.6	1.15	10.6%
4	AM15N215S		5,947	112				53.1	1.15	5.2%
5	AM215N15N		14,677	254				57.8	1.15	15.6%
6	AM215N15S		6,541	132				49.6	1.15	5.7%
7	PM15SThru		71,767	1,330				54.0	1.15	13.3%
8	PM15S215S		29,853	587				50.9	1.15	9.1%
9	PM15NThru		91,310	2,607				35.0	1.15	15.4%
10	PM15N215S		7,283	199				36.7	1.15	4.7%
11	PM215N15N		44,705	1,068				41.9	1.15	5.4%
12	PM215N15S		8,567	164				52.1	1.15	5.0%
	TOTAL	0	438,942	9,833	0	0				
Build										
1	AM15SThru		76,893	1,270				60.5	1.15	12.4%
2	AM15S215S		42,221	692				61.0	1.15	4.8%
3	AM15NThru		39,179	634				61.8	1.15	10.6%
4	AM15N215S		5,947	98				60.8	1.15	5.2%
5	AM215N15N		14,677	248				59.2	1.15	15.6%
6	AM215N15S		6,541	117				56.1	1.15	5.7%
7	PM15SThru		71,767	1,186				60.5	1.15	13.3%
8	PM15S215S		29,853	488				61.2	1.15	9.1%
9	PM15NThru		91,310	1,574				58.0	1.15	15.4%
10	PM15N215S		7,283	121				60.3	1.15	4.7%
11	PM215N15N		44,705	753				59.4	1.15	5.4%
12	PM215N15S		8,567	154				55.5	1.15	5.0%
	TOTAL	0	438,942	7,335	0	0				

Exhibit 21: Model Data for Year 2045 Entered into Cal-B/C Corridor Model Inputs Page

2D

MODEL DATA - YEAR 2044

		REQUIRED FOR TRANSIT Number of Trips (Trips) * **	Vehicle Miles Traveled (VMT) *	Vehicle Hours Traveled (VHT)	Passenger Miles Traveled (PMT)	Passenger Hours Traveled (PHT)	Out-of-Pocket Cost ($ per trip)	Speed	Average Vehicle Occupancy (AVO)	Percent Trucks
No Build										
1	AM15SThru		122,296	2,470				49.5	1.15	13.2%
2	AM15S215S		69,485	1,492				46.6	1.15	3.6%
3	AM15NThru		71,742	1,912				37.5	1.15	15.9%
4	AM15N215S		10,070	273				36.9	1.15	3.3%
5	AM215N15N		29,051	649				44.8	1.15	11.3%
6	AM215N15S		7,496	151				49.7	1.15	9.3%
7	PM15SThru		123,739	2,886				42.9	1.15	16.3%
8	PM15S215S		59,667	1,228				48.6	1.15	6.3%
9	PM15NThru		140,993	5,182				27.2	1.15	16.2%
10	PM15N215S		11,811	364				32.4	1.15	7.0%
11	PM215N15N		73,409	2,768				26.5	1.15	5.2%
12	PM215N15S		10,690	311				34.4	1.15	4.4%
	TOTAL	0	730,449	19,685	0	0				
Build										
1	AM15SThru		122,296	2,070				59.1	1.15	13.2%
2	AM15S215S		69,485	1,180				58.9	1.15	3.6%
3	AM15NThru		71,742	1,230				58.3	1.15	15.9%
4	AM15N215S		10,070	170				59.4	1.15	3.3%
5	AM215N15N		29,051	502				57.8	1.15	11.3%
6	AM215N15S		7,496	140				53.7	1.15	9.3%
7	PM15SThru		123,739	2,084				59.4	1.15	16.3%
8	PM15S215S		59,667	994				60.0	1.15	6.3%
9	PM15NThru		140,993	2,567				54.9	1.15	16.2%
10	PM15N215S		11,811	203				58.2	1.15	7.0%
11	PM215N15N		73,409	1,291				56.9	1.15	5.2%
12	PM215N15S		10,690	205				52.1	1.15	4.4%
	TOTAL	0	730,449	12,636	0	0				

There are four safety groups defined by a combination of roadway classification (mainline and ramps) and direction (northbound and southbound).These are identified in the box shown in Exhibit 22. Reduction factors that indicate the percentage by which accidents decrease from the No Build scenario to the Build scenario are also entered for each safety group. The safety base and forecast years are identical to the simulation model years identified in Section 2A and are not modified in this example. The years from the safety data correspond to 2021 (Year 1) and 2044 (Year 24) of the project lifecycle. These are identified in the box shown in Exhibit 22, so Cal-B/C Corridor can correctly interpolate the accident data. In this example, Cal-B/C Corridor estimates benefits for a 20-year lifecycle, so the final year of analysis corresponds to values interpolated to four years before the final simulation model forecast.

Exhibit 22: Definition of Safety Groups Entered into Cal-B/C Corridor Model Inputs Page

2E

DEFINITIONS OF SAFETY GROUPS AND YEARS

	Select Mode	Name	Description	Fatal Reduction Factor	Injury Reduction Factor	PDO Reduction Factor
Safety Group 1	Highway	ML NB	Mainline Northbound	30.0%	30.0%	30.0%
Safety Group 2	Highway	Ramps NB	Ramps Northbound	20.0%	20.0%	20.0%
Safety Group 3	Highway	ML SB	Mainline Southbound	25.0%	25.0%	25.0%
Safety Group 4	Highway	Ramps NB	Ramps Southbound	15.0%	15.0%	15.0%

Safety Base Year	2021
Safety Forecast Year	2044

For the base year, daily VMT and accident rates per million VMT are entered for each severity of accidents in the No Build scenario for all four safety groups. In the Build scenario, only daily VMT is entered. Accident rates are automatically calculated based on daily VMT (Build scenario) and the reduction factors entered in Section 2E. For the forecast year, daily VMT is entered in the No Build and Build scenarios. These are identified in the boxes shown in Exhibit 23 and Exhibit 24.

Exhibit 23: Safety Data for Year 2021 Entered into Cal-B/C Corridor Model Inputs Page

2F

SAFETY DATA - YEAR 2021

	Vehicle Miles Traveled (VMT)	Fatal Accident Rate Per MVM	Injury Accident Rate Per MVM	PDO Accident Rate Per MVM	Number of Fatal Accidents	Number of Injury Accidents	Number of PDO Accidents
No Build							
1 ML NB	153,630	0.015	0.02	0.03	0.0023	0.0029	0.0038
2 Ramps NB	65,841	0.007	0.03	0.05	0.0005	0.0020	0.0030
3 ML SB	175,577	0.019	0.02	0.04	0.0033	0.0040	0.0063
4 Ramps NB	43,894	0.009	0.04	0.06	0.0004	0.0018	0.0024
TOTAL	438,942				0.0065	0.0107	0.0155
Total VMT in model groups equals total VMT in safety groups							
Build							
1 ML NB	153,630	0.011	0.01	0.02	0.0016	0.0020	0.0027
2 Ramps NB	65,841	0.006	0.02	0.04	0.0004	0.0016	0.0024
3 ML SB	175,577	0.014	0.02	0.03	0.0025	0.0030	0.0047
4 Ramps NB	43,894	0.008	0.03	0.05	0.0003	0.0015	0.0021
TOTAL	438,942				0.0048	0.0081	0.0119
Total VMT in model groups equals total VMT in safety groups							

Exhibit 24: Safety Data for Year 2044 Entered into Cal-B/C Corridor Model Inputs Page

2G

SAFETY DATA - YEAR 2044

	Vehicle Miles Traveled (VMT)	Fatal Accident Rate Per MVM	Injury Accident Rate Per MVM	PDO Accident Rate Per MVM	Number of Fatal Accidents	Number of Injury Accidents	Number of PDO Accidents
No Build							
1 ML NB	255,657	0.015	0.02	0.03	0.0038	0.0049	0.0064
2 Ramps NB	109,567	0.007	0.03	0.05	0.0008	0.0033	0.0049
3 ML SB	292,180	0.019	0.02	0.04	0.0056	0.0067	0.0105
4 Ramps NB	73,045	0.009	0.04	0.06	0.0007	0.0029	0.0040
TOTAL	730,449				0.0108	0.0178	0.0259
Total VMT in traffic inputs equals total VMT in safety inputs							
Build							
1 ML NB	255,657	0.011	0.01	0.02	0.0027	0.0034	0.0045
2 Ramps NB	109,567	0.006	0.02	0.04	0.0006	0.0026	0.0039
3 ML SB	292,180	0.014	0.02	0.03	0.0042	0.0050	0.0079
4 Ramps NB	73,045	0.008	0.03	0.05	0.0006	0.0025	0.0034
TOTAL	730,449				0.0080	0.0136	0.0197
Total VMT in traffic inputs equals total VMT in safety inputs							

STEP 3: Review Final Results

Following completion of the first two steps, the user can review the benefit-cost analysis results in the *Results* worksheet. This worksheet allows the user to see the final results with key metrics such as the net present value and the benefit/cost ratio presented in the top left box.[4] The *Results* worksheet allows the user to determine whether to include or exclude the following benefits:

- Induced Travel Benefits
- Vehicle Operating Cost Savings (*Vehicle Operating Costs*)
- Accident Cost Savings (*Accident Costs*)
- Emission Cost Savings (*Vehicle Emissions*).

The results of this interchange example project are presented in Exhibit 25. This hypothetical project is expected to generate $140.5 million in discounted net public benefits and a benefit-cost ratio of 1.5. The majority of the benefits are generated from travel time savings, which is reflective of the projected 36.8 million person-hours of time saved as a result of the project. The project is also expected to prevent 17 fatalities, 47 injuries, and 190 property damage accidents.

[4] More detail results can be seen in the *Final Calculations* tab.

Exhibit 25: Results for Interchange Example

3

INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$279.0
Life-Cycle Benefits (mil. $)	$419.5
Net Present Value (mil. $)	$140.5
Benefit / Cost Ratio:	1.50
Rate of Return on Investment:	7.7%
Payback Period:	11 years

ITEMIZED BENEFITS (mil. $)	Total Over 20 Years	Average Annual
Travel Time Savings	$316.1	$15.8
Veh. Op. Cost Savings	-$1.1	-$0.1
Accident Cost Savings	$96.9	$4.8
Emission Cost Savings	$7.6	$0.4
TOTAL BENEFITS	$419.5	$21.0
Person-Hours of Time Saved	36,754,012	1,837,701
Fatalities Avoided	17	1
Injuries Avoided	47	2
PDO Avoided	190	10

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 CO_2e	Y	Default = Y

EMISSIONS REDUCTION	Tons		Value (mil. $)	
	Total Over 20 Years	Average Annual	Total Over 20 Years	Average Annual
CO Emissions Saved	600	30	$0.1	$0.0
CO_2 Emissions Saved	46,121	2,306	$1.2	$0.1
NO_X Emissions Saved	204	10	$7.1	$0.4
PM_{10} Emissions Saved	-2	0	-$0.8	-$0.0
$PM_{2.5}$ Emissions Save	-2	0		
SO_X Emissions Saved	0	0	$0.0	$0.0
VOC Emissions Saved	25	1	$0.1	$0.0

PROJECT EXAMPLE 2: LONG-RANGE PLAN EXAMPLE

This section provides a brief hypothetical example of using Cal-B/C Corridor to analyze projects as part of a long-range plan. The proposed plan includes both highway and transit investments. VMT and VHT results were extracted from a travel demand model for the Build and No Build conditions in a base year and a forecast year. These data can be entered into Cal-B/C Corridor, which monetizes the benefits and calculates the benefit-cost ratio.

The travel demand data are critical to the analysis since Cal-B/C Corridor does not have rules of the thumb to estimate project benefits. Unlike Cal-B/C Sketch, the corridor version of the model requires an external model to generate the VMT and VHT results prior to running the benefit-cost analysis.

STEP 1: Input Project Data into Project Information Worksheet

Exhibit 26 through Exhibit 28 show the data entered on the Cal-B/C Corridor *Project Information* worksheet to analyze long-range plan benefits. This analysis is unusual as there is no construction period and the capital expenditure costs are spread through the life of long-range plan. The investments start generating benefits from the first day of the plan (i.e., the opening date). The current year is 2018, and the long-range plan begins in 2020. The first-year benefits are discounted by two years.

Exhibit 26: Project Data Inputted into Cal-B/C Corridor Project Information Page

(1A) **PROJECT DATA**

Type of Project	Hypothetical Long-Range Plan
Project Location (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural)	2
Project Timing	
Current Year	2018
Year Construction Begins	2019
Year Project Opens	2020

The user needs to enter the number of model groups, safety groups, and years of analysis post-construction. This example has 144 model groups: 71 model groups for personal vehicles, 71 model groups for trucks, and two model groups for transit investments in the plan (light rail and bus). Safety data are provided for three safety groups which include highway, light rail, and bus. The benefits are evaluated for a 25-year period. The user should press the "Create Model" button to save the model before proceeding to Section 1C.

Exhibit 27: Model Structure Inputted into Cal-B/C Corridor Project Information Page

1B

MODEL STRUCTURE

		Values In This Model
Number of Model Groups	144	144
Number of Safety Groups	3	3
Years	25	25

The long-range plan starts in 2020 and all the costs are spread throughout the life of the plan. The model assumes that investment benefits begin when the plan starts. Note that costs in Section 1C need to be entered in thousands of dollars.

Exhibit 28: Project Costs Inputted into Cal-B/C Corridor Project Information Page

1C

PROJECT COSTS (enter costs in thousands of dollars)

Col. no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
	DIRECT PROJECT COSTS						Transit Agency Cost Savings	TOTAL COSTS (in dollars)	
	INITIAL COSTS			SUBSEQUENT COSTS					
Year	Project Support	R / W	Construction	Maint./ Op.	Rehab.	Mitigation		Constant Dollars	Present Value
Construction Period									
2019			$0					$0	$0
2020								0	0
2021								0	0
2022								0	0
2023								0	0
2024								0	0
2025								0	0
2026								0	0
Project Open									
2020				$2,821,000				$2,821,000,000	$2,608,173,077
2021				$2,812,000				2,812,000,000	2,499,857,761
2022				$3,067,000				3,067,000,000	2,621,684,454
2023				$2,941,000				2,941,000,000	2,417,287,621
2024				$2,397,000				2,397,000,000	1,894,383,918
2025				$4,315,000				4,315,000,000	3,279,045,364
2026				$5,884,000				5,884,000,000	4,299,381,166
2027				$7,565,000				7,565,000,000	5,315,068,655
2028				$7,251,000				7,251,000,000	4,898,515,788
2029				$7,627,000				7,627,000,000	4,954,353,765
2030				$8,789,000				8,789,000,000	5,489,583,469
2031				$8,809,000				8,809,000,000	5,290,457,125
2032				$7,745,000				7,745,000,000	4,472,544,516
2033				$7,384,000				7,384,000,000	4,100,073,088
2034				$7,473,000				7,473,000,000	3,989,895,797
2035				$7,172,000				7,172,000,000	3,681,912,919
2036				$6,927,000				6,927,000,000	3,419,361,994
2037				$6,372,000				6,372,000,000	3,024,421,526
2038				$6,219,000				6,219,000,000	2,838,270,418
2039				$9,845,000				9,845,000,000	4,320,316,813
2040				$5,260,000				5,260,000,000	2,219,485,334
2041				$5,087,000				5,087,000,000	2,063,929,858
2042				$5,044,000				5,044,000,000	1,967,772,717
2043				$5,113,000				5,113,000,000	1,917,972,210
2044				$11,796,000				11,796,000,000	4,254,690,192
Total	$0	$0	$0	$155,715,000	$0	$0	$0	$155,715,000,000	$87,838,439,544

STEP 2: Input Traffic Simulation Data and Safety Data into Model Inputs Worksheet

The detailed model data from the travel demand model are entered into the Cal-B/C Corridor *Model Inputs* worksheet as shown in Exhibit 29 through Exhibit 35. The model has 144 model groups defined by speed bins and mode type. These are identified in Exhibit 29. Note that certain rows are hidden in the screenshots to fit the tables in one exhibit. The AVO for personal vehicles is assumed to be 1.45 persons, while trucks have an AVO of 1.00. For the personal vehicle model groups, percent truck is zero. The truck model groups have percent trucks of 100 percent. The AVO and percent truck information is not needed for transit, therefore, those cells are grayed out for the transit groups. The example uses the travel demand results for 2020 and 2040. The default values for base year and forecast year in red cells stay unchanged. Cal-B/C Corridor can then interpolate the VMT, VHT, PMT, and PHT data for a 25-year lifecycle.

Exhibit 29: Definition of Model Groups Entered into Cal-B/C Corridor Model Inputs Page

2A

DEFINITIONS OF MODEL GROUPS AND YEARS

	Select Mode	Name	Description	Avg. Vehicle Occupancy (AVO)	Percent Trucks
Model Group 1	Highway	A1	Auto mph1	1.45	0.0%
Model Group 2	Highway	A2	Auto mph2	1.45	0.0%
Model Group 3	Highway	A3	Auto mph3	1.45	0.0%
Model Group 4	Highway	A4	Auto mph4	1.45	0.0%
Model Group 5	Highway	A5	Auto mph5	1.45	0.0%
Model Group 6	Highway	A6	Auto mph6	1.45	0.0%
Model Group 7	Highway	A7	Auto mph7	1.45	0.0%
Model Group 8	Highway	A8	Auto mph8	1.45	0.0%
Model Group 9	Highway	A9	Auto mph9	1.45	0.0%
Model Group 10	Highway	A10	Auto mph10	1.45	0.0%
Model Group 11	Highway	A11	Auto mph11	1.45	0.0%
Model Group 12	Highway	A12	Auto mph12	1.45	0.0%
Model Group 13	Highway	A13	Auto mph13	1.45	0.0%
Model Group 14	Highway	A14	Auto mph14	1.45	0.0%
Model Group 15	Highway	A15	Auto mph15	1.45	0.0%
Model Group 16	Highway	A16	Auto mph16	1.45	0.0%
Model Group 17	Highway	A17	Auto mph17	1.45	0.0%
Model Group 18	Highway	A18	Auto mph18	1.45	0.0%
Model Group 19	Highway	A19	Auto mph19	1.45	0.0%
Model Group 20	Highway	A20	Auto mph20	1.45	0.0%
Model Group 21	Highway	A21	Auto mph21	1.45	0.0%
Model Group 22	Highway	A22	Auto mph22	1.45	0.0%
Model Group 23	Highway	A23	Auto mph23	1.45	0.0%
Model Group 24	Highway	A24	Auto mph24	1.45	0.0%
Model Group 25	Highway	A25	Auto mph25	1.45	0.0%
Model Group 26	Highway	A26	Auto mph26	1.45	0.0%
Model Group 27	Highway	A27	Auto mph27	1.45	0.0%
Model Group 28	Highway	A28	Auto mph28	1.45	0.0%
Model Group 29	Highway	A29	Auto mph29	1.45	0.0%
Model Group 30	Highway	A30	Auto mph30	1.45	0.0%
Model Group 31	Highway	A31	Auto mph31	1.45	0.0%
Model Group 32	Highway	A32	Auto mph32	1.45	0.0%
Model Group 33	Highway	A33	Auto mph33	1.45	0.0%
Model Group 34	Highway	A34	Auto mph34	1.45	0.0%
Model Group 35	Highway	A35	Auto mph35	1.45	0.0%
Model Group 36	Highway	A36	Auto mph36	1.45	0.0%
Model Group 37	Highway	A37	Auto mph37	1.45	0.0%
Model Group 38	Highway	A38	Auto mph38	1.45	0.0%
Model Group 39	Highway	A39	Auto mph39	1.45	0.0%
Model Group 40	Highway	A40	Auto mph40	1.45	0.0%
Model Group 41	Highway	A41	Auto mph41	1.45	0.0%
Model Group 42	Highway	A42	Auto mph42	1.45	0.0%
Model Group 43	Highway	A43	Auto mph43	1.45	0.0%
Model Group 44	Highway	A44	Auto mph44	1.45	0.0%
Model Group 45	Highway	A45	Auto mph45	1.45	0.0%
Model Group 46	Highway	A46	Auto mph46	1.45	0.0%
Model Group 47	Highway	A47	Auto mph47	1.45	0.0%
Model Group 48	Highway	A48	Auto mph48	1.45	0.0%
Model Group 49	Highway	A49	Auto mph49	1.45	0.0%
Model Group 50	Highway	A50	Auto mph50	1.45	0.0%
Model Group 51	Highway	A51	Auto mph51	1.45	0.0%
Model Group 52	Highway	A52	Auto mph52	1.45	0.0%
Model Group 53	Highway	A53	Auto mph53	1.45	0.0%
Model Group 54	Highway	A54	Auto mph54	1.45	0.0%
Model Group 55	Highway	A55	Auto mph55	1.45	0.0%
Model Group 56	Highway	A56	Auto mph56	1.45	0.0%
Model Group 57	Highway	A57	Auto mph57	1.45	0.0%
Model Group 58	Highway	A58	Auto mph58	1.45	0.0%
Model Group 59	Highway	A59	Auto mph59	1.45	0.0%
Model Group 60	Highway	A60	Auto mph60	1.45	0.0%

Model Group 61	Highway	A61	Auto mph61	1.45	0.0%
Model Group 62	Highway	A62	Auto mph62	1.45	0.0%
Model Group 63	Highway	A63	Auto mph63	1.45	0.0%
Model Group 64	Highway	A64	Auto mph64	1.45	0.0%
Model Group 65	Highway	A65	Auto mph65	1.45	0.0%
Model Group 66	Highway	A66	Auto mph66	1.45	0.0%
Model Group 67	Highway	A67	Auto mph67	1.45	0.0%
Model Group 68	Highway	A68	Auto mph68	1.45	0.0%
Model Group 69	Highway	A69	Auto mph69	1.45	0.0%
Model Group 70	Highway	A70	Auto mph70	1.45	0.0%
Model Group 71	Highway	A71	Auto mph71	1.45	0.0%
Model Group 72	Highway	T1	Truck mph1	1.00	100.0%
Model Group 73	Highway	T2	Truck mph2	1.00	100.0%
Model Group 74	Highway	T3	Truck mph3	1.00	100.0%
Model Group 75	Highway	T4	Truck mph4	1.00	100.0%
Model Group 76	Highway	T5	Truck mph5	1.00	100.0%
Model Group 77	Highway	T6	Truck mph6	1.00	100.0%
Model Group 78	Highway	T7	Truck mph7	1.00	100.0%
Model Group 79	Highway	T8	Truck mph8	1.00	100.0%
Model Group 80	Highway	T9	Truck mph9	1.00	100.0%
Model Group 81	Highway	T10	Truck mph10	1.00	100.0%
Model Group 82	Highway	T11	Truck mph11	1.00	100.0%
Model Group 83	Highway	T12	Truck mph12	1.00	100.0%
Model Group 84	Highway	T13	Truck mph13	1.00	100.0%
Model Group 85	Highway	T14	Truck mph14	1.00	100.0%
Model Group 86	Highway	T15	Truck mph15	1.00	100.0%
Model Group 87	Highway	T16	Truck mph16	1.00	100.0%
Model Group 88	Highway	T17	Truck mph17	1.00	100.0%
Model Group 89	Highway	T18	Truck mph18	1.00	100.0%
Model Group 90	Highway	T19	Truck mph19	1.00	100.0%
Model Group 91	Highway	T20	Truck mph20	1.00	100.0%
Model Group 92	Highway	T21	Truck mph21	1.00	100.0%
Model Group 93	Highway	T22	Truck mph22	1.00	100.0%
Model Group 94	Highway	T23	Truck mph23	1.00	100.0%
Model Group 95	Highway	T24	Truck mph24	1.00	100.0%
Model Group 96	Highway	T25	Truck mph25	1.00	100.0%
Model Group 97	Highway	T26	Truck mph26	1.00	100.0%
Model Group 98	Highway	T27	Truck mph27	1.00	100.0%
Model Group 99	Highway	T28	Truck mph28	1.00	100.0%
Model Group 100	Highway	T29	Truck mph29	1.00	100.0%
Model Group 101	Highway	T30	Truck mph30	1.00	100.0%
Model Group 102	Highway	T31	Truck mph31	1.00	100.0%
Model Group 103	Highway	T32	Truck mph32	1.00	100.0%
Model Group 104	Highway	T33	Truck mph33	1.00	100.0%
Model Group 105	Highway	T34	Truck mph34	1.00	100.0%
Model Group 106	Highway	T35	Truck mph35	1.00	100.0%
Model Group 107	Highway	T36	Truck mph36	1.00	100.0%
Model Group 108	Highway	T37	Truck mph37	1.00	100.0%
Model Group 109	Highway	T38	Truck mph38	1.00	100.0%
Model Group 110	Highway	T39	Truck mph39	1.00	100.0%
Model Group 111	Highway	T40	Truck mph40	1.00	100.0%
Model Group 112	Highway	T41	Truck mph41	1.00	100.0%
Model Group 113	Highway	T42	Truck mph42	1.00	100.0%
Model Group 114	Highway	T43	Truck mph43	1.00	100.0%
Model Group 115	Highway	T44	Truck mph44	1.00	100.0%
Model Group 116	Highway	T45	Truck mph45	1.00	100.0%
Model Group 117	Highway	T46	Truck mph46	1.00	100.0%
Model Group 118	Highway	T47	Truck mph47	1.00	100.0%
Model Group 119	Highway	T48	Truck mph48	1.00	100.0%
Model Group 120	Highway	T49	Truck mph49	1.00	100.0%
Model Group 121	Highway	T50	Truck mph50	1.00	100.0%
Model Group 122	Highway	T51	Truck mph51	1.00	100.0%
Model Group 123	Highway	T52	Truck mph52	1.00	100.0%
Model Group 124	Highway	T53	Truck mph53	1.00	100.0%
Model Group 125	Highway	T54	Truck mph54	1.00	100.0%
Model Group 126	Highway	T55	Truck mph55	1.00	100.0%
Model Group 127	Highway	T56	Truck mph56	1.00	100.0%
Model Group 128	Highway	T57	Truck mph57	1.00	100.0%
Model Group 129	Highway	T58	Truck mph58	1.00	100.0%
Model Group 130	Highway	T59	Truck mph59	1.00	100.0%
Model Group 131	Highway	T60	Truck mph60	1.00	100.0%
Model Group 132	Highway	T61	Truck mph61	1.00	100.0%
Model Group 133	Highway	T62	Truck mph62	1.00	100.0%
Model Group 134	Highway	T63	Truck mph63	1.00	100.0%
Model Group 135	Highway	T64	Truck mph64	1.00	100.0%
Model Group 136	Highway	T65	Truck mph65	1.00	100.0%
Model Group 137	Highway	T66	Truck mph66	1.00	100.0%
Model Group 138	Highway	T67	Truck mph67	1.00	100.0%
Model Group 139	Highway	T68	Truck mph68	1.00	100.0%
Model Group 140	Highway	T69	Truck mph69	1.00	100.0%
Model Group 141	Highway	T70	Truck mph70	1.00	100.0%
Model Group 142	Highway	T71	Truck mph71	1.00	100.0%
Model Group 143	Light Rail	Rail	Rail		
Model Group 144	Bus	Bus	Bus		

Base Year	2020
Forecast Year	2040

The daily VMT, daily VHT, daily PMT, and daily PHT data are entered in Sections 2C and 2D. Section 2B is not needed because this example has transit in the No Build and Build scenarios, and thus, this section is grayed out. These are shown in Exhibit 30 and Exhibit 31, which spread over the next several pages. The speed is calculated automatically from the VMT, VHT, PMT, and PHT data. Note that the years in the two exhibits change automatically to reflect the years in the red boxes in Exhibit 29.

Highway and transit model groups need different sets of inputs for Cal-B/C Corridor model. Highway model groups only need VMT and VHT, and if available, the number of trips. Transit model groups need PMT, PHT, VMT, and number of trips data. The number of trips is required for transit projects. This allows for consumer surplus calculations to work. Out-of-pocket costs are optional and not entered in this example.

Exhibit 30: Model Data for Year 2020 Entered into Cal-B/C Corridor Model Inputs Page

2C

MODEL DATA - YEAR 2020

	REQUIRED FOR TRANSIT Number of Trips (Trips) * **	Vehicle Miles Traveled (VMT) *	Vehicle Hours Traveled (VHT)	Passenger Miles Traveled (PMT)	Passenger Hours Traveled (PHT)	Out-of-Pocket Cost ($ per trip)	Speed	Average Vehicle Occupancy (AVO)	Percent Trucks
No Build									
1 A1	180	1,490	2,140				0.7	1.45	0.0%
2 A2	650	5,470	3,670				1.5	1.45	0.0%
3 A3	990	8,350	3,440				2.4	1.45	0.0%
4 A4	2,970	25,150	6,790				3.7	1.45	0.0%
5 A5	25,550	216,300	43,640				5.0	1.45	0.0%
6 A6	50,810	430,250	82,810				5.2	1.45	0.0%
7 A7	65,270	552,670	81,160				6.8	1.45	0.0%
8 A8	130,470	1,104,730	153,380				7.2	1.45	0.0%
9 A9	73,420	621,700	73,890				8.4	1.45	0.0%
10 A10	87,570	741,510	77,450				9.6	1.45	0.0%
11 A11	110,810	938,260	89,120				10.5	1.45	0.0%
12 A12	124,580	1,054,870	91,490				11.5	1.45	0.0%
13 A13	143,780	1,217,430	97,660				12.5	1.45	0.0%
14 A14	151,500	1,282,780	95,100				13.5	1.45	0.0%
15 A15	203,550	1,723,490	118,730				14.5	1.45	0.0%
16 A16	173,780	1,471,470	95,070				15.5	1.45	0.0%
17 A17	233,640	1,978,330	119,780				16.5	1.45	0.0%
18 A18	297,570	2,519,660	144,050				17.5	1.45	0.0%
19 A19	315,100	2,668,030	144,100				18.5	1.45	0.0%
20 A20	796,330	6,742,800	341,530				19.7	1.45	0.0%
21 A21	654,150	5,538,940	272,960				20.3	1.45	0.0%
22 A22	436,400	3,695,110	171,830				21.5	1.45	0.0%
23 A23	518,340	4,389,000	194,910				22.5	1.45	0.0%
24 A24	609,260	5,158,850	219,300				23.5	1.45	0.0%
25 A25	2,205,660	18,676,090	751,930				24.8	1.45	0.0%
26 A26	2,072,220	17,546,210	695,810				25.2	1.45	0.0%
27 A27	1,081,410	9,156,670	344,940				26.5	1.45	0.0%
28 A28	1,111,110	9,408,160	341,950				27.5	1.45	0.0%
29 A29	1,443,270	12,220,680	428,120				28.5	1.45	0.0%
30 A30	1,752,940	14,842,700	501,200				29.6	1.45	0.0%
31 A31	1,422,550	12,045,250	395,610				30.4	1.45	0.0%
32 A32	1,600,680	13,553,470	429,360				31.6	1.45	0.0%
33 A33	1,427,130	12,084,010	371,770				32.5	1.45	0.0%
34 A34	1,738,550	14,720,920	439,810				33.5	1.45	0.0%
35 A35	1,422,410	12,044,030	348,510				34.6	1.45	0.0%
36 A36	1,376,100	11,651,870	328,800				35.4	1.45	0.0%
37 A37	1,049,140	8,883,460	243,160				36.5	1.45	0.0%
38 A38	1,066,290	9,028,650	240,530				37.5	1.45	0.0%
39 A39	1,176,770	9,964,090	259,220				38.4	1.45	0.0%
40 A40	959,440	8,123,890	205,180				39.6	1.45	0.0%
41 A41	697,730	5,907,920	145,880				40.5	1.45	0.0%
42 A42	964,560	8,167,260	196,800				41.5	1.45	0.0%
43 A43	642,620	5,441,260	127,960				42.5	1.45	0.0%
44 A44	643,520	5,448,860	125,120				43.5	1.45	0.0%
45 A45	1,011,990	8,568,850	192,210				44.6	1.45	0.0%
46 A46	781,930	6,620,870	145,500				45.5	1.45	0.0%
47 A47	954,510	8,082,120	173,680				46.5	1.45	0.0%
48 A48	769,090	6,512,190	136,940				47.6	1.45	0.0%
49 A49	721,180	6,106,490	125,870				48.5	1.45	0.0%
50 A50	920,850	7,797,140	157,180				49.6	1.45	0.0%
51 A51	841,760	7,127,500	141,070				50.5	1.45	0.0%
52 A52	593,540	5,025,730	97,560				51.5	1.45	0.0%
53 A53	609,860	5,163,850	98,330				52.5	1.45	0.0%
54 A54	650,630	5,509,090	102,940				53.5	1.45	0.0%
55 A55	1,028,900	8,712,010	159,390				54.7	1.45	0.0%
56 A56	586,460	4,965,710	89,530				55.5	1.45	0.0%
57 A57	555,170	4,700,830	83,190				56.5	1.45	0.0%
58 A58	562,760	4,765,040	82,860				57.5	1.45	0.0%
59 A59	503,100	4,259,940	72,840				58.5	1.45	0.0%
60 A60	655,450	5,549,920	93,210				59.5	1.45	0.0%

62 A62	512,710	4,341,280	70,590				61.5	1.45	0.0%
63 A63	509,860	4,317,180	69,070				62.5	1.45	0.0%
64 A64	525,390	4,448,630	70,060				63.5	1.45	0.0%
65 A65	594,640	5,035,000	77,950				64.6	1.45	0.0%
66 A66	553,490	4,686,540	71,530				65.5	1.45	0.0%
67 A67	590,170	4,997,190	75,140				66.5	1.45	0.0%
68 A68	618,340	5,235,710	77,560				67.5	1.45	0.0%
69 A69	748,130	6,334,640	92,460				68.5	1.45	0.0%
70 A70	3,073,160	26,021,520	373,420				69.7	1.45	0.0%
71 A71	2,242,280	18,986,130	257,530				73.7	1.45	0.0%
72 T1	10	70	100				0.7	1.00	100.0%
73 T2	30	230	140				1.6	1.00	100.0%
74 T3	30	260	110				2.4	1.00	100.0%
75 T4	150	1,260	340				3.7	1.00	100.0%
76 T5	620	5,280	1,070				4.9	1.00	100.0%
77 T6	1,090	9,210	1,770				5.2	1.00	100.0%
78 T7	1,710	14,500	2,110				6.9	1.00	100.0%
79 T8	3,750	31,790	4,430				7.2	1.00	100.0%
80 T9	2,730	23,100	2,780				8.3	1.00	100.0%
81 T10	2,340	19,840	2,070				9.6	1.00	100.0%
82 T11	3,920	33,210	3,160				10.5	1.00	100.0%
83 T12	4,380	37,120	3,230				11.5	1.00	100.0%
84 T13	4,890	41,390	3,330				12.4	1.00	100.0%
85 T14	4,340	36,750	2,720				13.5	1.00	100.0%
86 T15	8,790	74,460	5,160				14.4	1.00	100.0%
87 T16	7,680	65,050	4,200				15.5	1.00	100.0%
88 T17	9,230	78,180	4,720				16.6	1.00	100.0%
89 T18	11,410	96,590	5,520				17.5	1.00	100.0%
90 T19	12,660	107,160	5,780				18.5	1.00	100.0%
91 T20	31,040	262,810	13,290				19.8	1.00	100.0%
92 T21	26,660	225,710	11,130				20.3	1.00	100.0%
93 T22	15,910	134,730	6,260				21.5	1.00	100.0%
94 T23	18,110	153,330	6,810				22.5	1.00	100.0%
95 T24	22,750	192,640	8,190				23.5	1.00	100.0%
96 T25	61,790	523,180	21,090				24.8	1.00	100.0%
97 T26	62,890	532,550	21,080				25.3	1.00	100.0%
98 T27	38,220	323,610	12,200				26.5	1.00	100.0%
99 T28	42,470	359,610	13,070				27.5	1.00	100.0%
100 T29	46,630	394,840	13,820				28.6	1.00	100.0%
101 T30	61,740	522,730	17,660				29.6	1.00	100.0%
102 T31	53,120	449,810	14,770				30.5	1.00	100.0%
103 T32	52,910	448,000	14,190				31.6	1.00	100.0%
104 T33	50,960	431,500	13,280				32.5	1.00	100.0%
105 T34	64,560	546,670	16,320				33.5	1.00	100.0%
106 T35	57,970	490,830	14,190				34.6	1.00	100.0%
107 T36	57,930	490,500	13,840				35.4	1.00	100.0%
108 T37	50,260	425,560	11,640				36.6	1.00	100.0%
109 T38	42,990	364,030	9,710				37.5	1.00	100.0%
110 T39	53,910	456,460	11,860				38.5	1.00	100.0%
111 T40	59,600	504,640	12,720				39.7	1.00	100.0%
112 T41	34,370	291,050	7,190				40.5	1.00	100.0%
113 T42	50,290	425,840	10,260				41.5	1.00	100.0%
114 T43	53,620	454,060	10,670				42.6	1.00	100.0%
115 T44	56,940	482,140	11,080				43.5	1.00	100.0%
116 T45	74,390	629,900	14,130				44.6	1.00	100.0%
117 T46	50,510	427,700	9,390				45.5	1.00	100.0%
118 T47	73,990	626,500	13,470				46.5	1.00	100.0%
119 T48	52,930	448,140	9,430				47.5	1.00	100.0%
120 T49	64,300	544,410	11,220				48.5	1.00	100.0%
121 T50	70,490	596,880	12,040				49.6	1.00	100.0%
122 T51	67,280	569,720	11,280				50.5	1.00	100.0%
123 T52	58,450	494,950	9,610				51.5	1.00	100.0%
124 T53	63,320	536,170	10,220				52.5	1.00	100.0%
125 T54	60,780	514,620	9,620				53.5	1.00	100.0%
126 T55	94,750	802,290	14,680				54.7	1.00	100.0%
127 T56	62,730	531,170	9,570				55.5	1.00	100.0%
128 T57	60,410	511,510	9,050				56.5	1.00	100.0%
129 T58	65,740	556,660	9,680				57.5	1.00	100.0%
130 T59	60,400	511,420	8,750				58.4	1.00	100.0%
131 T60	62,190	526,590	8,840				59.6	1.00	100.0%
132 T61	53,480	452,860	7,480				60.5	1.00	100.0%
133 T62	56,080	474,880	7,720				61.5	1.00	100.0%
134 T63	58,790	497,790	7,970				62.5	1.00	100.0%
135 T64	64,680	547,710	8,630				63.5	1.00	100.0%
136 T65	106,440	901,260	13,960				64.6	1.00	100.0%
137 T66	82,640	699,700	10,680				65.5	1.00	100.0%
138 T67	109,550	927,570	13,940				66.5	1.00	100.0%
139 T68	574,370	4,863,380	71,910				67.6	1.00	100.0%
140 T69	38,220	323,590	4,730				68.4	1.00	100.0%
141 T70	43,760	370,530	5,330				69.5	1.00	100.0%
142 T71	819,410	6,938,200	96,010				72.3	1.00	100.0%
143 Rail	417,810	36,540		4,170,309	131,602		31.7	0.00	0.0%
144 Bus	1,484,970	482,500		12,768,893	693,234		18.4	0.00	0.0%
TOTAL	59,465,670	487,923,580	13,690,140	16,939,202	824,836				

Build

1	A1	200	1,710	2,700				0.6	1.45	0.0%
2	A2	440	3,710	2,430				1.5	1.45	0.0%
3	A3	780	6,540	2,600				2.5	1.45	0.0%
4	A4	760	6,370	1,810				3.5	1.45	0.0%
5	A5	17,430	146,500	29,600				4.9	1.45	0.0%
6	A6	40,240	338,180	65,210				5.2	1.45	0.0%
7	A7	39,700	333,680	49,770				6.7	1.45	0.0%
8	A8	111,130	934,080	128,560				7.3	1.45	0.0%
9	A9	65,570	551,130	65,070				8.5	1.45	0.0%
10	A10	64,390	541,210	56,600				9.6	1.45	0.0%
11	A11	73,000	613,580	58,160				10.5	1.45	0.0%
12	A12	84,540	710,540	61,920				11.5	1.45	0.0%
13	A13	134,220	1,128,180	90,310				12.5	1.45	0.0%
14	A14	140,750	1,183,040	87,660				13.5	1.45	0.0%
15	A15	154,820	1,301,320	89,470				14.5	1.45	0.0%
16	A16	158,740	1,334,270	86,180				15.5	1.45	0.0%
17	A17	168,310	1,414,670	85,810				16.5	1.45	0.0%
18	A18	226,390	1,902,810	108,530				17.5	1.45	0.0%
19	A19	291,080	2,446,620	132,150				18.5	1.45	0.0%
20	A20	737,170	6,196,030	313,240				19.8	1.45	0.0%
21	A21	582,320	4,894,520	241,380				20.3	1.45	0.0%
22	A22	375,330	3,154,750	146,540				21.5	1.45	0.0%
23	A23	433,340	3,642,290	161,750				22.5	1.45	0.0%
24	A24	511,940	4,302,930	182,790				23.5	1.45	0.0%
25	A25	2,100,630	17,656,160	710,460				24.9	1.45	0.0%
26	A26	1,978,300	16,627,990	659,930				25.2	1.45	0.0%
27	A27	938,660	7,889,640	297,170				26.5	1.45	0.0%
28	A28	993,430	8,349,970	303,390				27.5	1.45	0.0%
29	A29	1,310,550	11,015,380	385,780				28.6	1.45	0.0%
30	A30	1,693,510	14,234,220	480,730				29.6	1.45	0.0%
31	A31	1,353,540	11,376,760	373,530				30.5	1.45	0.0%
32	A32	1,599,780	13,446,440	426,060				31.6	1.45	0.0%
33	A33	1,403,810	11,799,290	363,030				32.5	1.45	0.0%
34	A34	1,672,010	14,053,510	419,880				33.5	1.45	0.0%
35	A35	1,477,410	12,417,900	359,190				34.6	1.45	0.0%
36	A36	1,418,790	11,925,140	336,520				35.4	1.45	0.0%
37	A37	1,087,970	9,144,570	250,310				36.5	1.45	0.0%
38	A38	1,024,140	8,608,040	229,360				37.5	1.45	0.0%
39	A39	1,235,030	10,380,620	270,020				38.4	1.45	0.0%
40	A40	952,420	8,005,270	202,120				39.6	1.45	0.0%
41	A41	715,570	6,014,520	148,490				40.5	1.45	0.0%
42	A42	968,770	8,142,710	196,180				41.5	1.45	0.0%
43	A43	638,690	5,368,260	126,240				42.5	1.45	0.0%
44	A44	602,930	5,067,750	116,410				43.5	1.45	0.0%
45	A45	918,180	7,717,500	173,000				44.6	1.45	0.0%
46	A46	755,480	6,349,930	139,590				45.5	1.45	0.0%
47	A47	941,130	7,910,340	169,950				46.5	1.45	0.0%
48	A48	661,010	5,555,930	116,880				47.5	1.45	0.0%
49	A49	767,890	6,454,280	132,990				48.5	1.45	0.0%
50	A50	898,140	7,549,030	152,220				49.6	1.45	0.0%
51	A51	844,540	7,098,540	140,390				50.6	1.45	0.0%
52	A52	537,860	4,520,780	87,720				51.5	1.45	0.0%
53	A53	538,350	4,524,960	86,160				52.5	1.45	0.0%
54	A54	616,650	5,183,020	96,890				53.5	1.45	0.0%
55	A55	1,162,260	9,769,010	178,630				54.7	1.45	0.0%
56	A56	687,470	5,778,270	104,140				55.5	1.45	0.0%
57	A57	620,100	5,212,020	92,280				56.5	1.45	0.0%
58	A58	604,420	5,080,250	88,360				57.5	1.45	0.0%
59	A59	567,430	4,769,320	81,550				58.5	1.45	0.0%
60	A60	660,110	5,548,340	93,200				59.5	1.45	0.0%
61	A61	559,350	4,701,470	77,730				60.5	1.45	0.0%
62	A62	541,440	4,550,910	74,010				61.5	1.45	0.0%
63	A63	585,770	4,923,530	78,800				62.5	1.45	0.0%
64	A64	614,230	5,162,670	81,290				63.5	1.45	0.0%
65	A65	698,170	5,868,230	90,880				64.6	1.45	0.0%
66	A66	589,590	4,955,570	75,670				65.5	1.45	0.0%
67	A67	604,770	5,083,210	76,430				66.5	1.45	0.0%
68	A68	737,010	6,194,710	91,780				67.5	1.45	0.0%
69	A69	817,400	6,870,410	100,240				68.5	1.45	0.0%
70	A70	3,251,020	27,325,410	391,990				69.7	1.45	0.0%
71	A71	2,351,200	19,762,230	268,280				73.7	1.45	0.0%
72	T1	10	40	70				0.6	1.00	100.0%
73	T2	10	100	60				1.7	1.00	100.0%
74	T3	30	210	90				2.3	1.00	100.0%
75	T4	30	250	70				3.6	1.00	100.0%
76	T5	220	1,880	380				4.9	1.00	100.0%
77	T6	860	7,190	1,360				5.3	1.00	100.0%
78	T7	1,180	9,930	1,460				6.8	1.00	100.0%
79	T8	3,700	31,120	4,240				7.3	1.00	100.0%
80	T9	1,640	13,810	1,630				8.5	1.00	100.0%
81	T10	1,340	11,260	1,180				9.5	1.00	100.0%
82	T11	2,070	17,360	1,640				10.6	1.00	100.0%
83	T12	2,620	22,020	1,910				11.5	1.00	100.0%
84	T13	4,670	39,270	3,170				12.4	1.00	100.0%
85	T14	5,030	42,250	3,110				13.6	1.00	100.0%
86	T15	6,520	54,820	3,790				14.5	1.00	100.0%
87	T16	5,930	49,810	3,220				15.5	1.00	100.0%
88	T17	5,770	48,480	2,950				16.4	1.00	100.0%
89	T18	9,220	77,480	4,410				17.6	1.00	100.0%
90	T19	10,020	84,220	4,550				18.5	1.00	100.0%
91	T20	29,160	245,050	12,380				19.8	1.00	100.0%
92	T21	22,530	189,340	9,350				20.3	1.00	100.0%
93	T22	13,750	115,550	5,380				21.5	1.00	100.0%
94	T23	14,460	121,550	5,390				22.6	1.00	100.0%
95	T24	16,830	141,440	6,000				23.6	1.00	100.0%
96	T25	58,600	492,560	19,840				24.8	1.00	100.0%
97	T26	56,160	472,070	18,720				25.2	1.00	100.0%
98	T27	31,090	261,320	9,850				26.5	1.00	100.0%
99	T28	36,120	303,630	11,040				27.5	1.00	100.0%
100	T29	45,000	378,270	13,250				28.5	1.00	100.0%

101	T30	61,050	513,130	17,320				29.6	1.00	100.0%
102	T31	52,000	437,030	14,350				30.5	1.00	100.0%
103	T32	50,430	423,880	13,430				31.6	1.00	100.0%
104	T33	48,730	409,590	12,610				32.5	1.00	100.0%
105	T34	61,430	516,350	15,410				33.5	1.00	100.0%
106	T35	61,300	515,210	14,890				34.6	1.00	100.0%
107	T36	54,210	455,640	12,860				35.4	1.00	100.0%
108	T37	43,240	363,470	9,940				36.6	1.00	100.0%
109	T38	40,410	339,620	9,060				37.5	1.00	100.0%
110	T39	53,990	453,830	11,790				38.5	1.00	100.0%
111	T40	58,640	492,920	12,420				39.7	1.00	100.0%
112	T41	31,910	268,220	6,620				40.5	1.00	100.0%
113	T42	45,450	381,990	9,200				41.5	1.00	100.0%
114	T43	39,750	334,110	7,850				42.6	1.00	100.0%
115	T44	51,550	433,260	9,960				43.5	1.00	100.0%
116	T45	52,130	438,120	9,840				44.5	1.00	100.0%
117	T46	49,360	414,890	9,110				45.5	1.00	100.0%
118	T47	60,830	511,260	10,980				46.6	1.00	100.0%
119	T48	51,240	430,680	9,060				47.5	1.00	100.0%
120	T49	60,230	506,260	10,430				48.5	1.00	100.0%
121	T50	67,040	563,450	11,370				49.6	1.00	100.0%
122	T51	61,380	515,900	10,210				50.5	1.00	100.0%
123	T52	56,540	475,250	9,230				51.5	1.00	100.0%
124	T53	55,350	465,190	8,860				52.5	1.00	100.0%
125	T54	64,620	543,110	10,150				53.5	1.00	100.0%
126	T55	103,700	871,650	15,950				54.6	1.00	100.0%
127	T56	68,980	579,800	10,450				55.5	1.00	100.0%
128	T57	62,460	524,950	9,290				56.5	1.00	100.0%
129	T58	77,280	649,530	11,290				57.5	1.00	100.0%
130	T59	65,160	547,660	9,370				58.4	1.00	100.0%
131	T60	67,440	566,810	9,520				59.5	1.00	100.0%
132	T61	62,240	523,110	8,640				60.5	1.00	100.0%
133	T62	63,980	537,780	8,740				61.5	1.00	100.0%
134	T63	73,690	619,370	9,910				62.5	1.00	100.0%
135	T64	66,550	559,390	8,810				63.5	1.00	100.0%
136	T65	105,350	885,520	13,700				64.6	1.00	100.0%
137	T66	101,680	854,640	13,050				65.5	1.00	100.0%
138	T67	122,080	1,026,080	15,420				66.5	1.00	100.0%
139	T68	655,390	5,508,670	81,400				67.7	1.00	100.0%
140	T69	46,310	389,220	5,680				68.5	1.00	100.0%
141	T70	46,740	392,850	5,650				69.5	1.00	100.0%
142	T71	831,440	6,988,420	96,700				72.3	1.00	100.0%
143	Rail	504,880	57,790		4,502,452	125,267		35.9	0.00	0.0%
144	Bus	1,493,120	534,910		13,435,432	712,503		18.9	0.00	0.0%
	TOTAL	59,045,350	480,085,460	13,007,100	17,937,884	837,770				

Exhibit 31: Model Data for Year 2040 Entered into Cal-B/C Corridor Model Inputs Page

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MODEL DATA - YEAR 2040

		REQUIRED FOR TRANSIT Number of Trips (Trips) * **	Vehicle Miles Traveled (VMT) *	Vehicle Hours Traveled (VHT)	Passenger Miles Traveled (PMT)	Passenger Hours Traveled (PHT)	Out-of-Pocket Cost ($ per trip)	Speed	Average Vehicle Occupancy (AVO)	Percent Trucks
No Build										
1	A1	250	2,060	3,350				0.6	1.45	0.0%
2	A2	1,220	9,950	6,720				1.5	1.45	0.0%
3	A3	1,010	8,240	3,370				2.4	1.45	0.0%
4	A4	4,080	33,290	9,720				3.4	1.45	0.0%
5	A5	46,790	381,920	76,810				5.0	1.45	0.0%
6	A6	78,630	641,890	124,400				5.2	1.45	0.0%
7	A7	129,100	1,053,840	153,410				6.9	1.45	0.0%
8	A8	214,440	1,750,490	242,730				7.2	1.45	0.0%
9	A9	93,980	767,170	89,860				8.5	1.45	0.0%
10	A10	140,420	1,146,270	120,630				9.5	1.45	0.0%
11	A11	141,550	1,155,470	109,680				10.5	1.45	0.0%
12	A12	210,290	1,716,590	149,400				11.5	1.45	0.0%
13	A13	165,450	1,350,570	107,950				12.5	1.45	0.0%
14	A14	212,880	1,737,770	128,620				13.5	1.45	0.0%
15	A15	212,810	1,737,200	119,540				14.5	1.45	0.0%
16	A16	214,320	1,749,510	112,800				15.5	1.45	0.0%
17	A17	304,360	2,484,500	150,730				16.5	1.45	0.0%
18	A18	316,860	2,586,550	147,960				17.5	1.45	0.0%
19	A19	386,430	3,154,440	170,600				18.5	1.45	0.0%
20	A20	871,520	7,114,210	360,450				19.7	1.45	0.0%
21	A21	687,540	5,612,400	276,320				20.3	1.45	0.0%
22	A22	496,590	4,053,620	188,450				21.5	1.45	0.0%
23	A23	593,710	4,846,450	215,170				22.5	1.45	0.0%
24	A24	694,850	5,672,080	241,230				23.5	1.45	0.0%
25	A25	2,468,170	20,147,630	811,190				24.8	1.45	0.0%
26	A26	2,328,360	19,006,330	754,010				25.2	1.45	0.0%
27	A27	1,124,130	9,176,250	345,510				26.6	1.45	0.0%
28	A28	1,203,270	9,822,290	356,770				27.5	1.45	0.0%
29	A29	1,517,310	12,385,790	433,930				28.5	1.45	0.0%
30	A30	1,917,930	15,656,050	528,570				29.6	1.45	0.0%
31	A31	1,513,840	12,357,460	405,930				30.4	1.45	0.0%
32	A32	1,725,220	14,082,940	446,390				31.5	1.45	0.0%
33	A33	1,534,770	12,528,290	385,480				32.5	1.45	0.0%
34	A34	1,879,040	15,338,570	458,160				33.5	1.45	0.0%
35	A35	1,541,650	12,584,420	364,110				34.6	1.45	0.0%
36	A36	1,520,300	12,410,180	350,210				35.4	1.45	0.0%
37	A37	1,156,640	9,441,630	258,510				36.5	1.45	0.0%
38	A38	1,098,010	8,963,030	238,820				37.5	1.45	0.0%
39	A39	1,331,400	10,868,210	282,580				38.5	1.45	0.0%
40	A40	1,091,720	8,911,730	225,210				39.6	1.45	0.0%
41	A41	802,580	6,551,450	161,740				40.5	1.45	0.0%
42	A42	988,210	8,066,720	194,390				41.5	1.45	0.0%
43	A43	702,850	5,737,330	134,970				42.5	1.45	0.0%
44	A44	680,730	5,556,800	127,580				43.6	1.45	0.0%
45	A45	1,166,110	9,518,920	213,550				44.6	1.45	0.0%
46	A46	793,020	6,473,420	142,270				45.5	1.45	0.0%
47	A47	1,040,000	8,489,500	182,470				46.5	1.45	0.0%
48	A48	776,610	6,339,480	133,330				47.5	1.45	0.0%
49	A49	793,550	6,477,760	133,500				48.5	1.45	0.0%
50	A50	1,024,440	8,362,460	168,670				49.6	1.45	0.0%
51	A51	860,210	7,021,890	138,910				50.5	1.45	0.0%
52	A52	596,940	4,872,830	94,650				51.5	1.45	0.0%
53	A53	707,910	5,778,640	110,020				52.5	1.45	0.0%
54	A54	632,310	5,161,500	96,480				53.5	1.45	0.0%
55	A55	1,153,070	9,412,530	172,280				54.6	1.45	0.0%
56	A56	627,130	5,119,280	92,260				55.5	1.45	0.0%
57	A57	678,940	5,542,170	98,070				56.5	1.45	0.0%
58	A58	617,280	5,038,870	87,590				57.5	1.45	0.0%
59	A59	565,700	4,617,770	78,980				58.5	1.45	0.0%
60	A60	631,290	5,153,180	86,560				59.5	1.45	0.0%
61	A61	522,490	4,265,060	70,490				60.5	1.45	0.0%
62	A62	561,910	4,586,860	74,580				61.5	1.45	0.0%
63	A63	548,400	4,476,540	71,630				62.5	1.45	0.0%
64	A64	583,730	4,765,010	75,010				63.5	1.45	0.0%
65	A65	652,360	5,325,170	82,560				64.5	1.45	0.0%
66	A66	536,970	4,383,310	66,910				65.5	1.45	0.0%
67	A67	540,590	4,412,830	66,330				66.5	1.45	0.0%
68	A68	607,160	4,956,220	73,440				67.5	1.45	0.0%
69	A69	837,510	6,836,580	99,760				68.5	1.45	0.0%
70	A70	2,797,510	22,836,050	327,770				69.7	1.45	0.0%
71	A71	1,878,180	15,331,520	209,290				73.3	1.45	0.0%
72	T1	10	100	150				0.7	1.00	100.0%
73	T2	90	710	470				1.5	1.00	100.0%
74	T3	50	440	180				2.4	1.00	100.0%
75	T4	210	1,720	510				3.4	1.00	100.0%
76	T5	1,490	12,180	2,450				5.0	1.00	100.0%
77	T6	2,230	18,240	3,520				5.2	1.00	100.0%
78	T7	8,900	72,610	10,460				6.9	1.00	100.0%
79	T8	13,020	106,310	14,800				7.2	1.00	100.0%
80	T9	5,240	42,750	5,010				8.5	1.00	100.0%
81	T10	10,630	86,810	9,140				9.5	1.00	100.0%
82	T11	9,070	74,020	7,020				10.5	1.00	100.0%
83	T12	20,530	167,600	14,630				11.5	1.00	100.0%
84	T13	10,530	85,930	6,850				12.5	1.00	100.0%
85	T14	13,430	109,660	8,100				13.5	1.00	100.0%
86	T15	12,220	99,780	6,880				14.5	1.00	100.0%
87	T16	12,460	101,720	6,550				15.5	1.00	100.0%
88	T17	20,290	165,650	10,030				16.5	1.00	100.0%
89	T18	23,460	191,540	10,910				17.6	1.00	100.0%
90	T19	24,700	201,650	10,880				18.5	1.00	100.0%
91	T20	47,220	385,420	19,540				19.7	1.00	100.0%
92	T21	42,740	348,880	17,180				20.3	1.00	100.0%
93	T22	26,340	215,010	10,010				21.5	1.00	100.0%
94	T23	34,820	284,250	12,640				22.5	1.00	100.0%
95	T24	36,570	298,510	12,700				23.5	1.00	100.0%
96	T25	87,490	714,200	28,800				24.8	1.00	100.0%
97	T26	85,840	700,740	27,710				25.3	1.00	100.0%
98	T27	52,290	426,870	16,090				26.5	1.00	100.0%
99	T28	58,280	475,760	17,270				27.5	1.00	100.0%
100	T29	63,770	520,520	18,240				28.5	1.00	100.0%

101	T30	93,540	763,590	25,800				29.6	1.00	100.0%
102	T31	73,000	595,930	19,570				30.5	1.00	100.0%
103	T32	75,560	616,780	19,550				31.5	1.00	100.0%
104	T33	80,200	654,670	20,140				32.5	1.00	100.0%
105	T34	91,050	743,250	22,190				33.5	1.00	100.0%
106	T35	95,460	779,230	22,540				34.6	1.00	100.0%
107	T36	83,400	680,820	19,190				35.5	1.00	100.0%
108	T37	71,770	585,900	16,040				36.5	1.00	100.0%
109	T38	63,050	514,670	13,720				37.5	1.00	100.0%
110	T39	97,700	797,500	20,720				38.5	1.00	100.0%
111	T40	110,640	903,150	22,790				39.6	1.00	100.0%
112	T41	56,950	464,920	11,480				40.5	1.00	100.0%
113	T42	89,280	728,790	17,580				41.5	1.00	100.0%
114	T43	85,000	693,850	16,300				42.6	1.00	100.0%
115	T44	102,730	838,600	19,300				43.5	1.00	100.0%
116	T45	126,260	1,030,650	23,130				44.6	1.00	100.0%
117	T46	99,800	814,700	17,890				45.5	1.00	100.0%
118	T47	115,130	939,820	20,200				46.5	1.00	100.0%
119	T48	96,590	788,420	16,580				47.6	1.00	100.0%
120	T49	111,120	907,080	18,700				48.5	1.00	100.0%
121	T50	132,720	1,083,430	21,850				49.6	1.00	100.0%
122	T51	108,350	884,460	17,510				50.5	1.00	100.0%
123	T52	93,780	765,540	14,870				51.5	1.00	100.0%
124	T53	104,070	849,500	16,170				52.5	1.00	100.0%
125	T54	116,080	947,590	17,720				53.5	1.00	100.0%
126	T55	164,020	1,338,870	24,500				54.6	1.00	100.0%
127	T56	122,040	996,200	17,950				55.5	1.00	100.0%
128	T57	106,160	866,590	15,340				56.5	1.00	100.0%
129	T58	109,650	895,110	15,560				57.5	1.00	100.0%
130	T59	118,620	968,260	16,560				58.5	1.00	100.0%
131	T60	116,620	951,930	15,990				59.5	1.00	100.0%
132	T61	111,430	909,600	15,030				60.5	1.00	100.0%
133	T62	95,770	781,770	12,720				61.5	1.00	100.0%
134	T63	118,320	965,810	15,470				62.4	1.00	100.0%
135	T64	115,540	943,120	14,850				63.5	1.00	100.0%
136	T65	156,050	1,273,860	19,720				64.6	1.00	100.0%
137	T66	162,490	1,326,370	20,250				65.5	1.00	100.0%
138	T67	228,300	1,863,640	28,010				66.5	1.00	100.0%
139	T68	854,190	6,972,710	103,160				67.6	1.00	100.0%
140	T69	101,780	830,800	12,140				68.4	1.00	100.0%
141	T70	115,360	941,660	13,520				69.6	1.00	100.0%
142	T71	1,168,250	9,536,440	132,250				72.1	1.00	100.0%
143	Rail	496,470	44,550		5,333,881	165,689		32.2	0.00	0.0%
144	Bus	1,768,260	575,680		16,268,559	887,297		18.3	0.00	0.0%
	TOTAL	66,403,000	524,180,320	15,094,590	21,602,440	1,052,986				

Build

1 A1	380	3,130	4,870				0.6	1.45	0.0%
2 A2	650	5,260	3,920				1.3	1.45	0.0%
3 A3	530	4,280	1,580				2.7	1.45	0.0%
4 A4	600	4,900	1,420				3.5	1.45	0.0%
5 A5	16,190	131,790	26,620				5.0	1.45	0.0%
6 A6	33,870	275,640	52,910				5.2	1.45	0.0%
7 A7	27,190	221,290	33,200				6.7	1.45	0.0%
8 A8	71,990	585,920	81,190				7.2	1.45	0.0%
9 A9	49,970	406,720	47,720				8.5	1.45	0.0%
10 A10	49,700	404,520	42,630				9.5	1.45	0.0%
11 A11	57,740	469,960	44,820				10.5	1.45	0.0%
12 A12	79,500	647,100	56,090				11.5	1.45	0.0%
13 A13	99,360	808,730	64,300				12.6	1.45	0.0%
14 A14	102,880	837,400	62,060				13.5	1.45	0.0%
15 A15	129,100	1,050,790	71,870				14.6	1.45	0.0%
16 A16	127,230	1,035,560	67,020				15.5	1.45	0.0%
17 A17	132,430	1,077,860	65,250				16.5	1.45	0.0%
18 A18	194,930	1,586,610	90,590				17.5	1.45	0.0%
19 A19	204,780	1,666,800	89,930				18.5	1.45	0.0%
20 A20	674,140	5,487,090	276,930				19.8	1.45	0.0%
21 A21	502,010	4,086,070	201,940				20.2	1.45	0.0%
22 A22	298,510	2,429,720	113,040				21.5	1.45	0.0%
23 A23	333,020	2,710,620	120,340				22.5	1.45	0.0%
24 A24	409,350	3,331,900	141,700				23.5	1.45	0.0%
25 A25	2,140,790	17,424,700	700,400				24.9	1.45	0.0%
26 A26	1,949,120	15,864,650	630,380				25.2	1.45	0.0%
27 A27	797,780	6,493,450	244,460				26.6	1.45	0.0%
28 A28	890,500	7,248,150	263,320				27.5	1.45	0.0%
29 A29	1,199,600	9,763,990	341,730				28.6	1.45	0.0%
30 A30	1,662,050	13,528,120	456,250				29.7	1.45	0.0%
31 A31	1,219,630	9,927,040	326,210				30.4	1.45	0.0%
32 A32	1,434,610	11,676,890	369,850				31.6	1.45	0.0%
33 A33	1,245,690	10,139,140	311,910				32.5	1.45	0.0%
34 A34	1,654,570	13,467,210	402,280				33.5	1.45	0.0%
35 A35	1,618,550	13,173,990	380,810				34.6	1.45	0.0%
36 A36	1,454,470	11,838,500	333,850				35.5	1.45	0.0%
37 A37	1,264,140	10,289,340	281,480				36.6	1.45	0.0%
38 A38	1,153,260	9,386,800	250,360				37.5	1.45	0.0%
39 A39	1,313,250	10,689,040	277,840				38.5	1.45	0.0%
40 A40	1,132,010	9,213,870	232,640				39.6	1.45	0.0%
41 A41	827,380	6,734,360	166,460				40.5	1.45	0.0%
42 A42	1,051,090	8,555,280	206,110				41.5	1.45	0.0%
43 A43	648,370	5,277,370	124,120				42.5	1.45	0.0%
44 A44	710,390	5,782,140	132,750				43.6	1.45	0.0%
45 A45	1,138,590	9,267,430	207,680				44.6	1.45	0.0%
46 A46	677,480	5,514,300	121,200				45.5	1.45	0.0%
47 A47	881,230	7,172,650	154,130				46.5	1.45	0.0%
48 A48	692,780	5,638,790	118,590				47.5	1.45	0.0%
49 A49	873,980	7,113,710	146,440				48.6	1.45	0.0%
50 A50	926,920	7,544,560	152,100				49.6	1.45	0.0%
51 A51	780,800	6,355,250	125,690				50.6	1.45	0.0%
52 A52	606,550	4,936,930	95,810				51.5	1.45	0.0%
53 A53	587,010	4,777,890	91,010				52.5	1.45	0.0%
54 A54	688,590	5,604,700	104,800				53.5	1.45	0.0%
55 A55	1,319,540	10,740,250	196,440				54.7	1.45	0.0%
56 A56	751,140	6,113,840	110,160				55.5	1.45	0.0%
57 A57	596,170	4,852,450	85,890				56.5	1.45	0.0%
58 A58	640,170	5,210,600	90,700				57.4	1.45	0.0%
59 A59	686,860	5,590,640	95,600				58.5	1.45	0.0%
60 A60	850,070	6,919,080	116,230				59.5	1.45	0.0%
61 A61	621,260	5,056,670	83,600				60.5	1.45	0.0%
62 A62	698,480	5,685,240	92,440				61.5	1.45	0.0%
63 A63	764,000	6,218,460	99,510				62.5	1.45	0.0%
64 A64	844,280	6,871,940	108,220				63.5	1.45	0.0%
65 A65	899,540	7,321,720	113,450				64.5	1.45	0.0%
66 A66	810,100	6,593,730	100,670				65.5	1.45	0.0%
67 A67	872,320	7,100,160	106,780				66.5	1.45	0.0%
68 A68	1,078,950	8,782,040	130,060				67.5	1.45	0.0%
69 A69	1,149,610	9,357,170	136,520				68.5	1.45	0.0%
70 A70	3,316,230	26,992,100	387,230				69.7	1.45	0.0%
71 A71	2,019,150	16,434,700	224,400				73.2	1.45	0.0%
72 T1	0	20	40				0.5	1.00	100.0%
73 T2	20	180	130				1.4	1.00	100.0%
74 T3	10	90	30				3.0	1.00	100.0%
75 T4	10	120	30				4.0	1.00	100.0%
76 T5	310	2,560	520				4.9	1.00	100.0%
77 T6	770	6,290	1,210				5.2	1.00	100.0%
78 T7	1,470	11,950	1,740				6.9	1.00	100.0%
79 T8	5,280	42,950	6,030				7.1	1.00	100.0%
80 T9	3,650	29,700	3,450				8.6	1.00	100.0%
81 T10	1,610	13,060	1,380				9.5	1.00	100.0%
82 T11	3,050	24,790	2,390				10.4	1.00	100.0%
83 T12	3,710	30,200	2,620				11.5	1.00	100.0%
84 T13	5,100	41,480	3,320				12.5	1.00	100.0%
85 T14	4,340	35,340	2,640				13.4	1.00	100.0%
86 T15	10,130	82,440	5,680				14.5	1.00	100.0%
87 T16	14,340	116,730	7,420				15.7	1.00	100.0%
88 T17	13,750	111,950	6,840				16.4	1.00	100.0%
89 T18	11,540	93,920	5,380				17.5	1.00	100.0%
90 T19	9,670	78,680	4,240				18.6	1.00	100.0%
91 T20	35,820	291,560	14,760				19.8	1.00	100.0%
92 T21	25,160	204,800	10,140				20.2	1.00	100.0%
93 T22	11,740	95,520	4,460				21.4	1.00	100.0%
94 T23	17,480	142,290	6,320				22.5	1.00	100.0%
95 T24	16,200	131,870	5,590				23.6	1.00	100.0%
96 T25	72,530	590,330	23,780				24.8	1.00	100.0%
97 T26	66,130	538,290	21,360				25.2	1.00	100.0%
98 T27	34,720	282,630	10,650				26.5	1.00	100.0%
99 T28	38,420	312,720	11,380				27.5	1.00	100.0%
100 T29	46,920	381,920	13,370				28.6	1.00	100.0%

101	T30	68,910	560,880	18,910				29.7	1.00	100.0%
102	T31	51,920	422,580	13,890				30.4	1.00	100.0%
103	T32	53,030	431,600	13,670				31.6	1.00	100.0%
104	T33	49,550	403,310	12,410				32.5	1.00	100.0%
105	T34	74,190	603,890	18,020				33.5	1.00	100.0%
106	T35	74,970	610,190	17,630				34.6	1.00	100.0%
107	T36	63,140	513,900	14,500				35.4	1.00	100.0%
108	T37	54,370	442,540	12,110				36.5	1.00	100.0%
109	T38	53,020	431,590	11,510				37.5	1.00	100.0%
110	T39	68,450	557,150	14,480				38.5	1.00	100.0%
111	T40	81,580	664,020	16,750				39.6	1.00	100.0%
112	T41	47,720	388,400	9,600				40.5	1.00	100.0%
113	T42	54,460	443,290	10,680				41.5	1.00	100.0%
114	T43	48,950	398,420	9,360				42.6	1.00	100.0%
115	T44	68,000	553,450	12,710				43.5	1.00	100.0%
116	T45	62,990	512,730	11,500				44.6	1.00	100.0%
117	T46	49,500	402,880	8,860				45.5	1.00	100.0%
118	T47	70,530	574,050	12,340				46.5	1.00	100.0%
119	T48	75,410	613,790	12,920				47.5	1.00	100.0%
120	T49	94,660	770,450	15,880				48.5	1.00	100.0%
121	T50	101,010	822,200	16,590				49.6	1.00	100.0%
122	T51	80,590	655,920	12,980				50.5	1.00	100.0%
123	T52	78,130	635,930	12,340				51.5	1.00	100.0%
124	T53	95,290	775,560	14,760				52.5	1.00	100.0%
125	T54	102,380	833,300	15,580				53.5	1.00	100.0%
126	T55	181,770	1,479,480	27,080				54.6	1.00	100.0%
127	T56	115,740	942,030	16,980				55.5	1.00	100.0%
128	T57	118,270	962,640	17,040				56.5	1.00	100.0%
129	T58	173,140	1,409,270	24,510				57.5	1.00	100.0%
130	T59	143,300	1,166,350	19,960				58.4	1.00	100.0%
131	T60	135,340	1,101,620	18,500				59.5	1.00	100.0%
132	T61	152,660	1,242,570	20,540				60.5	1.00	100.0%
133	T62	169,670	1,380,980	22,450				61.5	1.00	100.0%
134	T63	169,990	1,383,590	22,140				62.5	1.00	100.0%
135	T64	211,080	1,718,040	27,050				63.5	1.00	100.0%
136	T65	326,210	2,655,190	41,120				64.6	1.00	100.0%
137	T66	237,630	1,934,200	29,520				65.5	1.00	100.0%
138	T67	325,970	2,653,180	39,860				66.6	1.00	100.0%
139	T68	1,051,950	8,562,220	126,550				67.7	1.00	100.0%
140	T69	116,420	947,620	13,850				68.4	1.00	100.0%
141	T70	84,770	690,010	9,910				69.6	1.00	100.0%
142	T71	1,271,060	10,345,670	143,570				72.1	1.00	100.0%
143	Rail	790,370	99,120		5,712,399	180,447		31.7	0.00	0.0%
144	Bus	1,895,500	741,890		18,386,491	921,089		20.0	0.00	0.0%
	TOTAL	64,582,570	504,642,760	12,928,010	24,098,890	1,101,536				

For the long-range plan, the user has defined safety data for three groups by mode (i.e., highway, light rail and bus). These are identified in the box shown in Exhibit 32. The user does not have estimates for how the proposed investments improve safety for the individual modes, so zero percent is entered for reduction factors. However, Cal-B/C Corridor can calculate accident cost savings by examining the shift in modes and the reduction in VMT from the No Build to the Build. The base and forecast years remain the same.

Exhibit 32: Definition of Safety Groups Entered into Cal-B/C Corridor Model Inputs Page

2E

DEFINITIONS OF SAFETY GROUPS AND YEARS

	Select Mode	Name	Description	Fatal Reduction Factor	Injury Reduction Factor	PDO Reduction Factor
Safety Group 1	Highway	Highway	Highway Accidents	0.0%	0.0%	0.0%
Safety Group 2	Bus	Bus	Bus			
Safety Group 3	Light Rail	Rail	Rail			

Safety Base Year	2020
Safety Forecast Year	2040

The user has transit accident rates for the region covered by the plan (in events per million VMT). Since specific transit accident rates are available, the default values for non-highway accidents events are updated in the *Parameters* worksheet as shown in orange cells in Exhibit 33. In this case, the data was provided at the aggregate level for all transit modes, so the accident events information is the same for light rail and bus.

Exhibit 33: Project-Specific Accident Data

RATES FOR NON-HIGHWAY ACCIDENT EVENTS
(events/million veh-mi)

Event	Pass Train	Light Rail	Bus	Freight Rail
Fatality	0.0555	0.0986	0.0986	0.9917
Injury	0.2519	6.1057	6.1057	7.7862
All Accidents	0.2775	0.8932	0.8932	13.5424

For the base year, daily VMT is entered for three groups, and accident rates per million VMT are entered for the highway safety group only. The transit safety group calculations use updated accident data entered in the *Parameters* worksheet as shown in Exhibit 33. Since no reduction factors are entered in Section 2E, the accident rates do not change for the Build scenario, but the number of accidents do change as a reflection of the change in VMT. For the forecast year, daily VMT is entered in the No Build and Build scenarios. These are identified in the boxes shown in Exhibit 34 and Exhibit 35.

Exhibit 34: Safety Data for Year 2020 Entered into Cal-B/C Corridor Model Inputs Range

2F

SAFETY DATA - YEAR 2020

	Vehicle Miles Traveled (VMT)	Fatal Accident Rate Per MVM	Injury Accident Rate Per MVM	PDO Accident Rate Per MVM	Number of Fatal Accidents	Number of Injury Accidents	Number of PDO Accidents
No Build							
1 Highway	487,404,540	0.006	0.28	0.55	2.7965	134.3506	266.6337
2 Bus	482,500				0.0000	0.0000	0.0000
3 Rail	36,540				0.0000	0.0000	0.0000
TOTAL	487,923,580				2.7965	134.3506	266.6337
Total VMT in model groups equals total VMT in safety groups							
Build							
1 Highway	479,492,760	0.006	0.28	0.55	2.7512	132.1698	262.3056
2 Bus	534,910	0.000	0.00	0.00	0.0000	0.0000	0.0000
3 Rail	57,790	0.000	0.00	0.00	0.0000	0.0000	0.0000
TOTAL	480,085,460				2.7512	132.1698	262.3056
Total VMT in model groups equals total VMT in safety groups							

Exhibit 35: Safety Data for Year 2040 Entered into Cal-B/C Corridor Model Inputs Page

2G

SAFETY DATA - YEAR 2040

	Vehicle Miles Traveled (VMT)	Fatal Accident Rate Per MVM	Injury Accident Rate Per MVM	PDO Accident Rate Per MVM	Number of Fatal Accidents	Number of Injury Accidents	Number of PDO Accidents
No Build							
1 Highway	523,560,090	0.006	0.28	0.55	3.0040	144.3167	286.4125
2 Bus	575,680	0.000	0.00	0.00	0.0000	0.0000	0.0000
3 Rail	44,550	0.000	0.00	0.00	0.0000	0.0000	0.0000
TOTAL	524,180,320				3.0040	144.3167	286.4125
Total VMT in traffic inputs equals total VMT in safety inputs							
Build							
1 Highway	503,801,750	0.006	0.28	0.55	2.8906	138.8705	275.6037
2 Bus	741,890	0.000	0.00	0.00	0.0000	0.0000	0.0000
3 Rail	99,120	0.000	0.00	0.00	0.0000	0.0000	0.0000
TOTAL	504,642,760				2.8906	138.8705	275.6037
Total VMT in traffic inputs equals total VMT in safety inputs							

STEP 3: Review Final Results

Following completion of the first two steps, the user can review the benefit-cost analysis results in the *Results* worksheet. This worksheet allows the user to see a summary of the final results, with key metrics such as the net present value and the benefit/cost ratio presented in the top left box.[5] The *Results* worksheet allows the user to determine whether to include or exclude the following benefits:

- Induced Travel Benefits
- Vehicle Operating Cost Savings (*Vehicle Operating Costs*)
- Accident Cost Savings (*Accident Costs*)
- Emission Cost Savings (*Vehicle Emissions*).

The results for the long-range plan investments are presented in Exhibit 36. This hypothetical plan is expected to generate $115.4 billion in discounted net public benefits with a benefit-cost ratio of 2.31. The majority of the benefits are generated from travel time savings, which are reflective of the projected 20 billion person-hours of time saved as a result of the investments. The investment plan is also expected to prevent 711 fatalities, 46,016 injuries, and 338,537 property damage accidents over the 25-year lifecycle of the analysis. Note that the payback period statistic for this example is meaningless because investments and benefits are occurring at the same time.

[5] More detail results can be seen in the *Final Calculations* tab.

Exhibit 36: Results for Long-Range Plan Example

3

INVESTMENT ANALYSIS

SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$87,838.4
Life-Cycle Benefits (mil. $)	$203,209.8
Net Present Value (mil. $)	$115,371.3
Benefit / Cost Ratio:	2.31
Rate of Return on Investment:	N/A
Payback Period:	1 year

ITEMIZED BENEFITS (mil. $)	Total Over 25 Years	Average Annual
Travel Time Savings	$157,446.2	$6,297.8
Veh. Op. Cost Savings	$36,246.7	$1,449.9
Accident Cost Savings	$6,525.8	$261.0
Emission Cost Savings	$2,991.1	$119.6
TOTAL BENEFITS	$203,209.8	$8,128.4
Person-Hours of Time Saved	20,122,438,674	804,897,547
Fatalities Avoided	711	28
Injuries Avoided	46,016	1,841
PDO Avoided	338,537	13,541

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 CO_2e	Y	Default = Y

EMISSIONS REDUCTION	Tons: Total Over 25 Years	Tons: Average Annual	Value (mil. $): Total Over 25 Years	Value (mil. $): Average Annual
CO Emissions Saved	238,609	9,544	$11.5	$0.5
CO_2 Emissions Saved	80,618,192	3,224,728	$2,294.5	$91.8
NO_X Emissions Saved	61,695	2,468	$597.9	$23.9
PM_{10} Emissions Saved	517	21	$42.6	$1.7
$PM_{2.5}$ Emissions Save	542	22		
SO_X Emissions Saved	759	30	$32.0	$1.3
VOC Emissions Saved	16,194	648	$12.5	$0.5

Appendix B: Technical Documentation

BACKGROUND AND SCOPE OF ANALYSIS

Similar to the other Cal-B/C models, Cal-B/C Corridor measures, in real-dollar terms, four primary categories of benefits that result from highway and transit projects:

- Travel time savings
- Vehicle operating cost savings
- Accident cost savings
- Emission cost savings.

BENEFIT ESTIMATION

This section discusses the data and formulas for computing each of the benefit categories. Where important and relevant, differences among user inputs, default parameters and any intermediate computations to determine key factors for computing benefit categories are discussed.

Travel Time Savings

Projects that reduce travel time through projects, operational improvements or transit are typically a core rationale for most roadway projects. Cal-B/C Corridor estimates delay reduction benefits for each mode and project type, as applicable, using standard valuation methods for any time savings over the life of the project. Time savings are computed as the difference in travel time for all travelers between No Build and Build scenarios. For passenger vehicles, the number of travelers accounts for the estimated average vehicle occupancy (AVO). The user inputs vehicle hours traveled or passenger hours traveled for each mode. The model calculates average person hours based on the AVO and monetizes travel time using the value of time. Annual benefits, based on time savings in the Build scenario, are the present value of a user defined project life that can range between two and fifty years.

Cal-B/C Corridor allows the number of travelers in the No Build and Build scenarios to differ if the user has project-specific information that suggests travelers will make new trips (i.e., induced demand) as a result of the project.

The value of time savings is assumed, as standard practice, to be derived from the median wage rate. Since the values of time for people in passenger vehicles and trucks differ, benefits are also computed separately for these vehicles. Travel time benefits are calculated for (a) existing users; and (b) new users. For new users, the benefit is calculated based on the travel time difference between the selected mode and the least cost alternative.[6]

[6] Note that complications can arise if the difference in travel time is negative (i.e., the travel time is smaller on the least cost alternative compared to the new mode). In this unusual case, the benefit is assumed to be zero. Since the new users must have shifted modes for reasons other than travel time savings. Assuming that users are rational in their decision making, the sum of these benefits must be positive. Accordingly, since this model may not capture all potential

Cal-B/C Corridor generally follows the U.S. DOT guidance for estimating the value of time for each mode. The value of time for trucks is estimated as 100 percent of the California average Transportation and Utilities wage rate plus benefits. The value of off-the-clock highway travel is calculated at 50 percent of the wage rate.[7] Also, U.S. DOT recommends using 50 percent of the wage rate for the value of in-vehicle travel time and 100 percent for walking and waiting time.[8]

Travel time savings can be calculated only for travelers that had travel times before the project was built (i.e., existing travelers). Travel time savings are computed for existing travelers as a change in travel time multiplied by the number of travelers in the No Build scenario. Induced travelers do not have time savings because they were not making trips prior to the project being built. However, they do receive a benefit for making a trip or they would not be making the trips. The model values this benefit using a standard economic technique—consumer surplus theory.

Consumer surplus is the area under the demand curve and above the equilibrium price. This area equals the amount that customers (travelers) would be willing to pay above what they must pay. The change in consumer surplus is frequently used in welfare economics to estimate the benefit that new customers (travelers) receive. Cal-B/C Corridor calculates the value of induced demand as 0.5 multiplied by the reduction in travel time, the change in out of pocket costs and the number of additional travelers. The model uses travel time as the price of travel since most travelers are not likely to consider accidents, emissions, or operating costs when making decisions.

Computations of the value of travel time savings are presented in three parts: scale of impact, impact factors, and impact value. In each case, the computations show the value of travel time and the value of time savings are the difference between No Build and Build conditions. Discussion is generalized for all modes (passenger vehicle, trucks, and all types of transit). If variables or calculations differ among modes or context, additional notes are provided.

Scale of Impact	Impact Factors	Impact Value per Unit
Numbers of travelers by mode and facility	Travel times, by mode and facility	Value of time Out of pocket costs

Scale of Impact: N^m

Where:

- N^{mode} = Number of person trips by mode

benefits (e.g., the value of reducing ones stress by not having to drive, the improved reliability of transit, etc.), the model conservatively estimates that the new transit riders do not receive a benefit, not a negative one.

[7] Due to the difficulty in measuring the value of stress due to congestion, Cal-B/C Corridor follows the U.S. DOT methodology and ignores any potential difference in the value of time per individual between periods.

[8] However, the value of the disutility associated with transit travel is likely to be lower than that for private vehicles, because transit users may have the ability to spend their time doing something else, such as reading, while riding transit. Rather than require users to estimate in-vehicle time and waiting time separately for transit, Cal-B/C Corridor simplifies the methodology and uses 50 percent for all transit travel time (in-vehicle and waiting).

For passenger vehicle travelers, the number of travelers adjusts the number of vehicles V^P by the AVO, average vehicle occupancy, as shown:

- $N^P = V^P \cdot AVO$

As discussed above, AVO is an important parameter in estimating benefits of projects that convert lanes to HOV, HOT, or change the minimum number of persons in a vehicle operating in a HOV lane.

In addition, to account for the value of new travelers, the model computes the number of modal diversion users (N^S). The number of modal diversion travelers is computed as the difference in trips by mode between No Build (N) and Build (B) scenarios (N_B^{mode} and N_{NB}^{mode}, respectively). For example, the number of mode shift transit travelers is computed as:

- $N^{T,S} = (N_B^T - N_{NB}^T)$

The model values modal shift and induced users under consumer surplus methodology. Model users can decide to include induced benefits since they are not always applicable.

Impact Factors: PHT^m

Where:

- PHT^m = Person hours traveled per trip by mode

Impact Value per Unit: VOT

Where

- VOT = Value of time, in dollars per hour, varies by mode.

Note that as mentioned above, the value of time savings for induced transit riders is assumed to be half that of existing travelers.

- $PCK^{m,s}$ = Out-of-pocket cost by mode (m) for modal diversion users (s)

Total Value of Travel Time Savings, by mode for existing users =

$$VTT_e^m = N^m \cdot (PHT_{NB}^m - PHT_B^m) \cdot VOT$$

Total Value of Travel Time Savings, by mode for new users =

$$VTT_n^m = 0.5 \cdot N^{m,s} \cdot ((PHT_{LC}^m - PHT_B^m) \cdot VOT + (PCK_{NB}^m - PCK_B^m))$$

Vehicle Operating Cost Savings

The methodology for computing operating costs in Cal-B/C Corridor is relatively simple and based upon the most recent, available data. The accuracy of a more complex model would likely be offset by the resources needed for gathering and estimating data. The overall separates fuel and non-fuel operating costs. An important feature in estimating the fuel component of VOC is the relationship between fuel consumption and speed. Since fuel rates are separated from other costs, fuel prices (minus taxes) can be updated without altering consumption rates.

The model computes fuel costs by looking up the appropriate fuel consumption rate per mile, for estimated speeds in the No Build and Build scenarios. Any difference in speed leads to differences in fuel consumption over the entire project length for each vehicle. Overall, separate fuel consumption factors would be expected for passenger vehicles and trucks.

Non-fuel cost estimates are based upon American Automobile Association (AAA) estimates plus depreciation. These costs are applied to the change in vehicle-miles traveled (VMT) for each year of the project. VMT is input by the user for a base year and a forecast year.

Transit vehicle operating costs are not included since costs are borne by transit operators as a component of operation and maintenance costs. Since operation and maintenance costs are a component of total project cost, these are captured in the "cost" part of benefit-cost analysis. Changes in transit vehicle operating costs are not counted as a benefit (i.e., cost savings) by the model. The model accounts only for savings on the consumer side, and not on the operator side.

However, transit projects that generate induced travelers from a parallel highway would gain from a lower VOC. The potential decrease in highway VOC, caused by a reduction in buses, is negligible and, therefore, is not incorporated into the highway model. VOC savings for remaining highway motorists are assumed to come from the reduction in other vehicle (non-bus) traffic.

Scale of Impact	Impact Factors	Impact Value per Unit
Vehicle miles traveled, by type	Fuel consumption rates, by vehicle speed and type Vehicle speed, by type	Fuel, non-fuel operating costs by vehicle type

Scale of Impact: VMT^t

Where:

- VMT^t = Annual vehicle miles traveled, by type (t)

Impact Factors: $Fuel^t$, S^t

Where:

- $Fuel^t$ = Fuel consumption rates, based on average vehicle speed, S^t, by vehicle type (t)
- S^t = Travel speed, calculated based on vehicle miles traveled and vehicle hours traveled, for a given roadway and in No Build and Build scenarios, by vehicle type (t)

Impact Value per Unit: VOC^t

Where

- VOC^t = Sum of fuel and non-fuel costs and fuel costs are a function of fuel consumption rates (which is a function of travel speed), depending on the vehicle type t

Total Value of Vehicle Operating Costs, by mode:

$$VVOC^t = VMT^t_{NB} \cdot VOC^t_{NB} - VMT^t_B \cdot VOC^t_B$$

Accident Cost Savings

Accident cost savings from transportation projects are computed by determining the difference in anticipated accident costs between the No Build and Build scenarios. Accident costs are associated with accident rates and costs per event over the lifetime of a project, which is between two and fifty years in Cal-B/C Corridor. Individual projects may improve or adversely impact vehicle accidents, so the net result may be positive or negative.

Cal-B/C Corridor uses data on costs per accident and accident rates from the best available sources. The user provides data on accident rates by type (fatal injury, and property damage only) for highway modes. The data entered by the user reflects current rates per million vehicle miles traveled and crash modification factors if accident rates are anticipated to change in the build case.

The project may also impact the occurrence of accidents on transit. Cal-B/C Corridor calculates transit accident costs as a function of vehicle-miles operated. The model uses default accident rates based on U.S. DOT national averages. Since these statistics are tabulated by event (i.e., number of fatalities, injuries, and accidents), Cal-B/C Corridor calculates the value of transit accidents per event rather than by accident severity. That is, for rail modes, train-miles must be converted to vehicle-miles using the average number of vehicles per train.

Since some transit improvements may enhance safety, Cal-B/C Corridor allows the user to reduce accident rates. The user is asked to input the percent reduction in accidents anticipated as a result of the project. Since Cal-B/C Corridor calculates accident costs as a function of vehicle-miles operated, a transit project that increases vehicle-miles operated (either by extending the system or adding service), but does not improve transit safety will result in a dis-benefit for transit accident costs. However, such a project is likely to result in a decrease in accident costs on another route or mode.

The estimation of intersection safety benefits is presented below in three parts: scale of impact, factors in assessing impact per unit, and value of impact. Data to compute these benefits are described in Appendix C. Additional information on accident cost methodology are contained in the Cal-B/C Resource Guide. Additional information on valuation parameters is provided in the Cal-B/C Parameters Guide.

Scale of Impact	Impact Factors	Impact Value per Unit
Vehicle Miles Traveled	Crash Reduction Factors Accident rates, by severity	Accident costs, by severity

Scale of Impact: VMT^t

Where:

- VMT^t = Annual vehicle miles traveled, by type (t)

Impact Factors: $ACC^t_{sev,NB} \cdot (1 - (1 - CRF^t_{sev}))$

Where:

- ACC^{t}_{sev} = Accident frequencies per mile and costs per accident, by severity (fatal, injury, property damage only)
- CRF^{t}_{sev} = Crash reduction factor, by severity and vehicle type (t)

Impact Value per Unit: $VACC_{sev}$
Where:

- $VACC_{sev}$ =Costs per accident, by severity (fatal, injury, property damage only)

Total Value of Accident Risk Reduction, by mode and severity:

$$VAR^{t}_{sev} = VMT^{t} \cdot ACC^{t}_{sev} \cdot (1 - (1 - CRF^{t}_{sev})) \cdot VACC^{t}_{sev}$$

Emission Cost Savings

Transportation investments have external consequences on people, whether they use the facility or not, and the natural environment. Cal-B/C Corridor focuses on the environmental impacts associated with result of travelers using the facility.[9] Changes related to travel speeds, vehicle trip-making, or diversion of trips all have implications for air pollution and greenhouse gas emissions.

The adverse health effects of vehicle emissions are probably the most significant environmental costs of travel. Enough is known about these effects to incorporate them readily into benefit-cost analyses. Vehicle emissions generally fall into two categories:

- Air Pollutant Emissions: Motor vehicles emit pollutants, such as carbon monoxide (CO), oxides of nitrogen (NOX), volatile organic compounds (VOC), particulate matter (PM), and oxides of sulfur (SOX).
- Greenhouse Gas Emissions (GHG): Fuel consumption releases gases that trap heat within the Earth's atmosphere, of which carbon dioxide is the most important.

The physical volumes of air-pollutants and greenhouse gas emissions resulting from travel are readily quantified since emission rates are well understood.[10] In addition, monetized costs of specific pollutants per unit of measure are well-established. It is important to note that a transportation project could yield benefits or dis-benefits since air pollutant emissions are based on travel volumes and speeds. Cal-B/C Corridor computes emissions benefits separately for each vehicle type and determines net benefits by comparing the value of emissions in the No Build and Build scenarios.

[9] Construction activity can affect the environment directly through equipment emissions and noise, or indirectly by causing increased traffic congestion and vehicle emissions during the construction period.

[10] Other environmental effects are less significant, less understood, or difficult to quantify and value. As a result, these effects tend to be excluded from benefit-cost models. Ignored effects include: noise, hazardous materials incidents, and upstream fuel effects.

Separate emission rates were developed for automobiles and trucks using the California Air Resources Board, EMFAC emissions model. The emission rates for automobiles and trucks are based upon composite emission rates across vehicle classes (as required), for several pollutants: CO, NOX, VOC, PM_{10}, and $PM_{2.5}$ from vehicle exhaust, and brake and tire wear. The emissions model provides default values for the percent of vehicles in each vehicle category (e.g., light-duty gas vehicles, light-duty diesel vehicles, light-duty gas trucks) for each year of analysis (the fleet mix assumptions change over time). Emission rates are expected to change over time as the vehicle fleet changes. Cal-B/C Corridor uses a simplified approach to address emission rate changes: current emissions rates are used for the first seven years of project benefits, and a twenty-year forecast is used for the remaining years, if applicable.[11] Cal-B/C Corridor uses separate values for starting and running emissions.

Investment in transit projects may result in net emission benefits or dis-benefits, depending on whether the emissions reduction from new transit riders who shift modes from highway vehicles is sufficient to offset any new emissions generated by the transit project.

For a transit project in an area with no existing transit service, No Build emissions are zero, and the change in emissions is equal to the project's emissions. In the case of a transit improvement project, it is necessary to examine the emission levels with and without the improvement in order to assess the incremental emissions associated with the improvement. The calculations vary with the emission characteristics and rates for different transit modes. For example:

- **Passenger Rail** (e.g., commuter rail or other diesel-electric locomotive powered train service): Cal-B/C Corridor uses rates were derived from locomotive emissions per brake horsepower hour, horsepower ratings, load factors, and average speeds using CARB estimates. These rates are expressed in grams per train-mile assuming a single locomotive train set, and can be converted with a unit conversion to tons per vehicle-mile and by dividing emission rates by the number of vehicles or cars per train.
- **Light Rail** (e.g., electric-power generated trains): Cal-B/C Corridor recognizes that the pollution from these vehicles is emitted from power plants that generate electricity used by the trains. Power plant emissions have been converted to emissions per LRT vehicle-mile, based upon LRT traction power, energy consumption, the mix of power generation methods in California, and their respective emissions per mega-watt hour. This methodology is based on work completed by the California Air Resources Board, the California Energy Commission, and the South Coast Air Quality Management District. Rates are expressed in tons per vehicle-mile as opposed to train-mile.
- **Bus**: Buses generally travel on roadways with other vehicles, and their average speeds reflect those of the surrounding traffic. In most cases, the bus speed is the same as that of prevailing traffic, to take into account congestion effects. However, the user must specify the passenger miles traveled and passenger hours traveled to generate for buses to calculate the bus speed. The calculated speed is used by the model to estimate the emissions.

[11] Each year that the parameters are updated changes the current and forecast year for the emissions rates.

Scale of Impact	Impact Factors	Value of Impact per Unit
Vehicle Miles Traveled, by type	Vehicle speed, by facility type	Valuation per unit of emissions, by pollutant Running and starting emissions rates per vehicle, by pollutant

Scale of Impact: VMT^t

Where:

- VMT^t = Annual vehicles miles traveled, by vehicle type (t)

Impact Factors: S^t

Where:

- S^t = Travel speed, as calculated based on vehicle miles traveled and vehicle hours traveled, for a given roadway and in No Build and Build scenarios, by vehicle type (t)

Impact Value per Unit: EC^t

Where:

- EC^t = Emissions cost equals the sum product of each pollutant's emissions (*$pollutant^t$*) rate per mile by vehicle type (t), and costs per pollutant ($VPP_{pollutant}$).[12] The equation is:

$$EC^t=(CO^t \cdot VPP_{CO}+ CO_2^t \cdot VPP_{CO_2}+NO_X^t \cdot VPP_{NO}+PM_{10}^t \cdot VPP_{PM_{10}}+SO_X^t \cdot VPP_{SO}+VOC^t \cdot VPP_{VOC})$$

Total Value of Emissions Reduction, by mode:

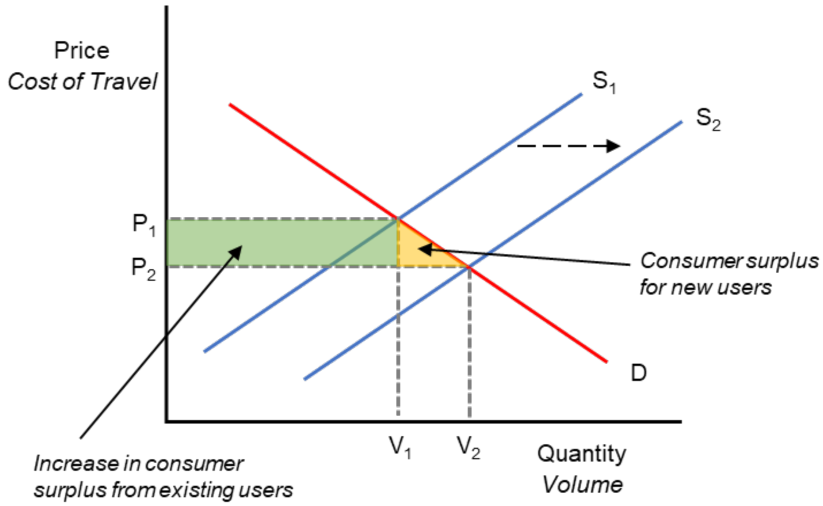
$$VER^t = VMT^t \cdot EC^t$$

CONSUMER SURPLUS

In economic analyses, an increase in consumer surplus is considered a benefit. When the market undergoes a change through increased supply, the price for the good lowers, and the new equilibrium introduces an increased level of demand for the good along the unchanged demand curve (see Exhibit 37). More people will choose to consume the good at the lower price to maximize their individual utility. The additional demand is referred to as induced demand. The change in the consumer surplus consists of the increase in consumer surplus for existing users and consumer surplus for new users. The same principles apply to a decrease in supply, resulting in an increase in price and a decrease in consumer surplus.

[12] Emissions rates are a function of vehicle speed, which is calculated based on user inputs for vehicle miles traveled and vehicle hours traveled.

Exhibit 37: Change in Consumer Surplus due to a Transportation Improvement Project Increasing Capacity



Consumer Surplus in Transportation

Methods for estimating consumer surplus depend on the definitions assumed for the market of interest. For example, in the context of transportation projects, we can describe the good as capacity on the roadway, or the option to travel on the roadway system. More specifically, we can define a trip from one origin to another destination on the roadway system as the consumable good. The limitation in supply derives from the capacity of the roadway. In this market, the aggregate price of the trip (i.e., the cost of travel) may also change depending on how many trips are taken. When the roadway's free-flow capacity is reached and exceeded, congestion increases, speeds decrease, and the cost of travel increases (in terms of opportunity costs on a person's time and vehicle operating expenditures).

A change in consumer surplus for a single market is straightforward to estimate based on the cost of travel before and after the market change, since the numbers of existing trips and induced trips are available. However, when the travel market consists of multiple roadways, routes, or origin-destination (O-D) pairs (i.e., the market is network- or system-wide), the number of existing trips that divert from between roads, routes, or O-D pairs, is difficult to derive with standard travel data, making the change in consumer surplus benefits for diverted existing trips difficult to estimate.

Two concepts of a travel demand "market" can be considered. First, if the market is one highway only, the impact of capacity changes on that highway on the levels of existing and induced trips driven before and after the change can be determined from available planning level or travel demand model data. The No Build volume represents the existing trips, and induced trips is the difference between trip volumes in the Build and No Build scenarios. Consumer surplus value can be estimated for these trip volumes to determine the difference in the costs of travel, and using the "rule of half" for induced demand (see Exhibit 37 for an illustration of the concept).

Alternatively, if the market is defined as a roadway network or system that is comprised of multiple highway segments or O-D pairs, the numbers of existing trips and truly induced trips for each segment or O-D pair before and after the capacity change is difficult to determine. In some contexts, O-D pairs are *substitutable,* in that it is possible for a capacity project to generate trip shifts between O-D pairs in response to a change in supply. In reality, and in a travel demand model, a change in supply from a transportation improvement project or program of projects may prompt changes in routes, origin-destinations, or modes, in addition to generating true induced demand, especially if the project(s) or other policies motivate changes in land use over time. Thus, existing trips could divert from one to another O-D pair in response to a highway capacity project.

If the market is defined as the roadway network, the existing trip levels for one roadway segment or O-D pair may not be the same between the No Build and Build scenarios, because some trips have diverted from or to other roadways or O-D pairs in the network. Similarly, the difference between trips in the No Build and Build scenarios for one segment or O-D pair cannot entirely be assigned as induced, as some may be existing trips diverted from another roadway or O-D pair. Estimating the change in consumer surplus for the existing trips diverted from another group (highway segment or O-D pair) is further hindered because the cost of travel for diverted trips before and after the project is unclear. While the travel demand data may capture some of these shifts, the data necessary to account for all shifts and the changes in price perceived by each shift is rarely, if ever, available.

Methods for Consumer Surplus Evaluation

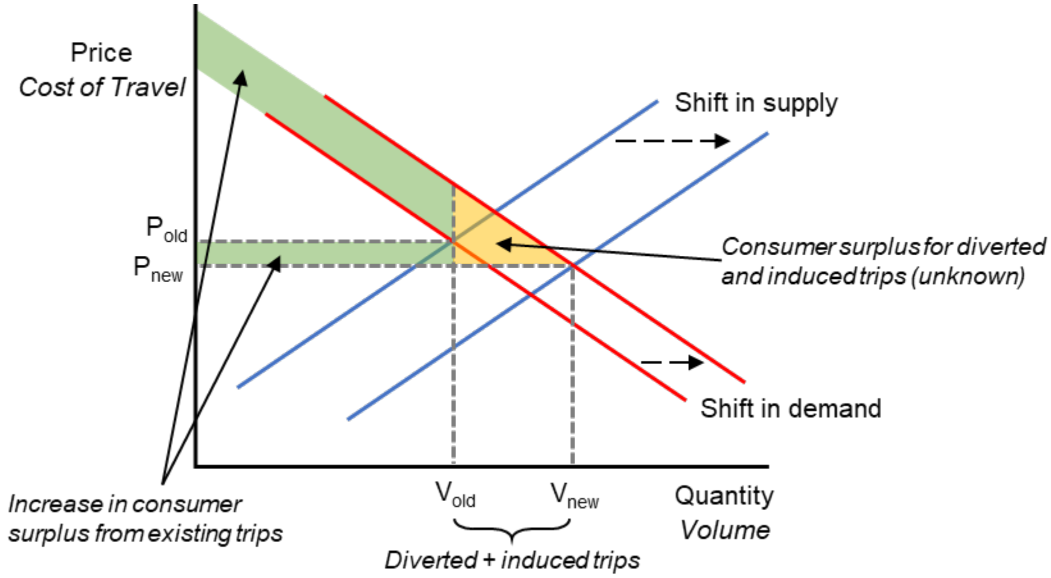
For travel data that characterizes activity between a series of specific O-D pairs, each O-D pair can be assumed to be an individual market or the market can be interpreted as the aggregated collection of O-D pairs (i.e., the roadway network as one market). Under the first approach, the value of an improvement can be approximated with consumer surplus methods applied to each O-D pair, as indicated by the change in trip characteristics between No Build and Build scenarios. But, when O-D pairs experience overall decreases in total numbers of trips in the Build scenario, due to diversion to other O-D markets, the benefits are estimated only for the travelers *remaining* in the market, which is the number of trips in the Build scenario. For O-D pairs that experience overall increases in the number of trips (because of diversion from other O-D markets and, potentially, induced trips) in the Build scenario, the *entire* difference in trips (including diversion from other O-D markets) is counted as the total induced demand. The benefits for these induced trips are estimated using the rule of half with the difference in the cost of travel, and standard benefits are estimated for the No Build number of trips. When O-D pairs are considered as separate markets and trip diversion occurs, this method produces less accurate results.

When O-D pairs are understood as individual markets, trip diversion can be represented as a shift in the demand curve for an individual O-D pair (to the left for a decrease in demand, or to the right for an increase in demand). Exhibit 38 shows the change in consumer surplus for a specific O-D pair in the case that a capacity improvement project (the shift in supply) generates a shift in demand from diverted trips and, potentially, induced trips.[13] The green polygons represent the increase in consumer surplus for existing No Build trips in this case. The difference in the old and new volumes is an unknown combination of diverted existing trips and induced trips, and the

[13] Supply and demand curves and shifts are merely illustrative and are not to scale.

change in price perceived by the diverted trips is unknown. When the rule of half method is applied to diverted trips, the resulting estimate of consumer surplus is less accurate.

Exhibit 38: Consumer Surplus in an O-D pair Market when Supply and Demand Curves Shift Right



Under the second assumption, in which the market is assumed to be the entire roadway network (the aggregated collection of O-D pairs), true induced demand can be derived from the difference between the No Build and Build scenarios in the aggregated numbers of trips across all O-D pairs. With an assumption about the distribution of induced demand across O-D pairs, such as assuming the distribution of trip increases across O-D pairs for induced trips, induced trips and diverted existing trips in the Build scenario can be derived for each O-D pair. Build scenario existing trip levels estimated for each O-D pair, which include diverted trips but exclude induced trips, can be compared against No Build scenario trip levels to estimate benefits for existing users. The change in travel costs perceived by diverted users is approximated by the change in travel costs in the O-D pair to which they diverted. Consumer surplus for induced demand then occurs either at the O-D pair level, using O-D specific differences in cost of travel, or at the aggregate level, using differences in weighted average travel cost. The latter is the more conservative assumption when the specific cost savings realized by induced trips is unknown.

Consumer Surplus in Cal-B/C Corridor

In a prior version of Cal-B/C Corridor, consumer surplus was estimated for each model group when trip data (in addition to VMT and VHT) are available. The approach works best when model groups can be assumed independent, with no trip diversion or shifts between model groups. These consumer surplus calculations can be used only for specific cases, and should not be included when model groups represented speed bins, or other categories that may experience shifts in vehicle trips.

With the addition of transit projects to the Cal-B/C Corridor, the consumer surplus approach was reevaluated to account for benefits attributed to potential trip shifts between and within modes and model groups. The new method allows for calculating consumer surplus with more types of model groups, enabling a greater specification of benefits from a transportation improvement project or package of improvements. The approach employed for estimating consumer surplus from induced demand in the updated Cal-B/C Corridor assumes that travel on the transportation network is a single "economic good" and can be represented by one aggregate market – the second consumer surplus approach described above.

Cal-B/C Corridor performs a series of calculations. First, the tool estimates the level of induced demand by mode and the distribution of induced and diverted trips across modes and model groups. Second, the tool calculates standard benefit categories for existing highway and transit trips using the No Build scenario trips and the derived existing trips (including diverted trips) in the Build scenario. Finally, the tool estimates the weighted average cost of travel for induced travel and calculates consumer surplus by mode for induced trips. Consumer surplus for induced travel is represented by travel time and out-of-pocket costs, as these are the direct costs that would likely enter an individual's trip decision.

In the *Model Inputs* worksheet, the user enters the "Average Profile for Diverted Trips/Induced Trips" for each transit model group, which represents typical No Build scenario conditions for travelers on or near the margin who will divert from highway to transit in the Build scenario, and No Build scenario conditions for induced trips. The profiles entered should reflect lower cost alternatives than the average traffic profiles implied from the rest of the model data, as these trips are not necessarily represented by the average travel profile for that model group. Travelers whose values of trips are near or the same as their realized trip costs for highway travel are most likely to divert, because their trip values are low enough that switches to transit modes is cost beneficial with a transit improvement project. Similarly, the least cost alternative represents the No Build price of travel that enters into the consumer surplus calculation for induced trips.

The *Consumer Surplus* worksheet contains summaries and calculations for the adjusted Build trip levels and consumer surplus calculations. Four tables (for four modes) summarize the model data for the base and forecast years by mode and extrapolate the data to each year of the analysis. In these tables, vehicle-hour and trip data are summed across all model groups, average vehicle occupancy and percent truck data are weighted by hours and averaged, and the out-of-pocket costs are weighted by trips and averaged. Exhibit 39 is a screenshot of this table for the model data for the bus mode, in which non-applicable data for this mode (average vehicle occupancy and percent trucks) are shaded gray.

Exhibit 39: Example of Aggregate Model Data in the Consumer Surplus Worksheet

Bus

Year	TOTAL VHT (veh-hours/yr)		AVERAGE VEH OCC (persons/vehicle)		TOTAL PERSON TRIPS (trips/yr)		PERCENT TRUCKS (%)		TOTAL PHT (per-hours/yr)		AVERAGE TRAVEL TIME (hours/trip)		OUT OF POCKET COST ($/trip)		TOTAL PERSON TRIPS (trips/yr)	CONSUMER SURPLUS BENEFIT ($/yr)
	No Build	Build	No Build	Build	No Build	Build	No Build	Build	No Build	Build	No Build	Build	No Build	Build	Adjusted (no induced) Build	New (Induced)
2020	0	0			0	0			0	0	0.00	0.00	$0.00	$0.00	0	$0
2040	0	0			0	0			0	0	0.00	0.00	$0.00	$0.00	0	$0
2020	0	0			0	0			0	0	0.00	0.00	0.00	0.00	0	$0
2021	0	0			0	0			0	0	0.00	0.00	0.00	0.00	0	$0
2022	0	0			0	0			0	0	0.00	0.00	0.00	0.00	0	$0
2023	0	0			0	0			0	0	0.00	0.00	0.00	0.00	0	$0
2024	0	0			0	0			0	0	0.00	0.00	0.00	0.00	0	$0
2025	0	0			0	0			0	0	0.00	0.00	0.00	0.00	0	$0

The summary of trips by mode sums trips across model groups, for the base and forecast years and for No Build and Build scenarios, and calculates induced demand by mode as shown in Exhibit 40.

Exhibit 40: Summary of Trips by Mode in the Consumer Surplus Worksheet

SUMMARY OF TRIPS BY MODE (across model groups)

Mode	TOTAL TRIPS* 2020 No Build	2020 Build	2020 Build - No Build**	2020 Induced Demand	2040 No Build	2040 Build	2040 Build - No Build**	2040 Induced Demand
Bus	0	0	0	0	0	0	0	0
Pass Train	0	0	0	0	0	0	0	0
Light Rail	0	0	0	0	0	0	0	0
Highway	0	0	0	0	0	0	0	0
TOTAL	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

The summary of the average profile for diverted trips and least cost alternative for induced trips averages the average profile data across model groups by mode, for the base and forecast years. Speeds are aggregated using the harmonic mean, and both speed and trip length are weighted by No Build trip levels. These tables are displayed in Exhibit 41.

Exhibit 41: Summary of Average Profiles by Mode in the Consumer Surplus Worksheet

AVERAGE PROFILE FOR DIVERTED TRIPS/INDUCED TRIPS BY MODE

For Trips Diverting from Highway to Transit

Mode	Average Speed in 2020 (mph)	Average Trip Length in 2020 (miles)	Average Speed in 2040 (mph)	Average Trip Length in 2040 (miles)
Bus	0.00	0.00	0.00	0.00
Pass Train	0.00	0.00	0.00	0.00
Light Rail	0.00	0.00	0.00	0.00
Highway	0.00	0.00	0.00	0.00

Least Cost Alternative (for Induced Trips)

Average Speed in 2020 (mph)	Average Trip Length in 2020 (miles)	Average Speed in 2040 (mph)	Average Trip Length in 2040 (miles)
0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00

The final tables reference model data and average profile data and calculate intermediate data points for each model group: trip increases from the No Build to the Build scenario, the share of the trip increase within each mode, and inverse average profile speeds, for the base and forecast years. The first table also identifies whether transit exists in the No Build scenario. The data in these tables, shown in Exhibit 42 and Exhibit 43 are used in calculations in other tables in the *Consumer Surplus* worksheet.

Exhibit 42: Intermediate Calculations by Model Group on Model Data in the Consumer Surplus Worksheet

MODEL DATA

		2020 Number of Trips (No Build)	2020 Increase in Number of Trips (Build vs. No Build)	2020 Share within mode	2020 Transit Does Not Exist in No Build	2040 Number of Trips (No Build)	2040 Increase in Number of Trips (Build vs. No Build)	2040 Share within mode	2040 Transit Does Not Exist in No Build
1 Not Used	0	0	0	0.0%	TRUE	0	0	0.0%	TRUE

Exhibit 43: Intermediate Calculations by Model Group on Average Profiles in the Consumer Surplus Worksheet

For Trips Diverting from Highway to Transit

Mode	Inverse of Average Speed in Year 2020 (mph)	Average Trip Length in Year 2020 (miles)	Inverse of Average Speed in Year 2040 (mph)	Average Trip Length in Year 2040 (miles)
0	0	0	0	0

Least Cost Alternative (for Induced Trips)

Inverse of Average Speed in Year 2020 (mph)	Average Trip Length in Year 2020 (miles)	Inverse of Average Speed in Year 2040 (mph)	Average Trip Length in Year 2040 (miles)
0	0	0	0

The summary of trips by mode estimates the induced trips at the aggregate level (for the entire market, across all modes) and distributes the induced trips proportionally to the trip increases between the No Build and Build scenarios by mode. This approach assumes that induced trips occur in model groups in which trip levels increased, in modes that experienced trip increases overall from the No Build to the Build scenarios.

The *Travel Time* worksheet calculates an "adjusted" Build trip levels by removing the estimated induced trips by model group, such that the remaining Build trip number represents existing and diverted users in the Build scenario. The adjusted Build trip level is equal to the original Build trip level for a given model group if the associated mode experiences diversion away from that mode in the Build scenario, or if there was no change to that mode's trips in the Build scenario (i.e., there is no induced demand to be removed from the Build trip level). The number of adjusted Build trips for a given model group can be less than the Build trips, but greater than No Build trips, when some positive trip diversion occurs in the Build scenario. No Build trips and adjusted Build trips are used to calculate travel time savings and out-of-pocket cost savings for existing users.

Cal-B/C Corridor calculates by mode the value of consumer surplus related to induced demand using the "rule of half" method for each mode for which data are entered. The calculations involve determining the difference in the weighted average cost of travel per trip, multiplied by the difference in the adjusted Build and Build trip levels (i.e., induced trips), and multiplied by one half. This approach assumes that induced trips realize the weighted average trip time and out-of-pocket cost improvements from the project by mode (across model groups). For highway modes, the travel time cost is weighted by truck and auto shares, and out-of-pocket cost per trip is averaged across model groups, weighted by number of trips. For transit modes, the least cost alternative input is used to calculate the No Build cost of travel in the case that the transit mode does not exist in the No Build scenario.

This methodology works whether model groups represent vehicle types, time periods, roadway segments, O-D pairs, or speed bins, because Cal-B/C Corridor handles the possibility of trips shifting between model groups after the project is built.