



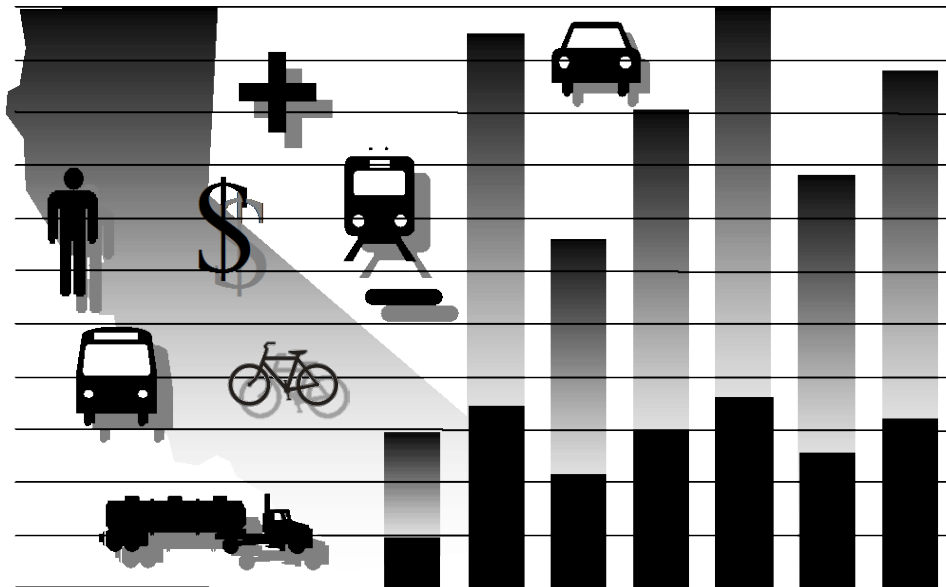
California  
Department  
Of  
Transportation



# California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C) 6.2

*User's Guide*

December 2017



*In Association with*  
*System Metrics Group, Inc.*



## TABLE OF CONTENTS

<b>1. USER REQUIREMENTS .....</b>	<b>2</b>
<b>2. OPERATING SYSTEM AND SOFTWARE REQUIREMENTS .....</b>	<b>2</b>
<b>3. MODEL OVERVIEW .....</b>	<b>3</b>
<b>4. WORKSHEET DETAILS AND PROJECT ANALYSIS .....</b>	<b>7</b>
4.1 PROJECT INFORMATION WORKSHEET .....	7
4.1A <i>Project Data</i> .....	8
4.1B <i>Highway Design and Traffic Data</i> .....	11
4.1C <i>Highway Accident Data</i> .....	17
4.1D <i>Rail and Transit Data</i> .....	20
4.1E <i>Project Cost Data</i> .....	22
4.1F <i>Bypass, Intersection, and Truck Only Lane Projects</i> .....	26
4.2 MODEL INPUTS WORKSHEET .....	27
4.3 RESULTS WORKSHEET .....	28
<b>APPENDIX A: PASSENGER RAIL IMPROVEMENT PROJECT EXAMPLE .....</b>	<b>A-1</b>
<b>APPENDIX B: TRUCK CLIMBING LANE EXAMPLE .....</b>	<b>B-1</b>
<b>APPENDIX C: TRUCK ONLY LANE EXAMPLE .....</b>	<b>C-1</b>



## LIST OF EXHIBITS

EXHIBIT 1: CAL-B/C FRAMEWORK .....	1
EXHIBIT 2: CAL-B/C GRAPHICAL USER INTERFACE.....	3
EXHIBIT 3: PROJECT INFORMATION WORKSHEET.....	7
EXHIBIT 4: PROJECT INFORMATION - 1A, PROJECT DATA.....	9
EXHIBIT 5: PROJECT INFORMATION - 1B, HIGHWAY DESIGN AND TRAFFIC DATA .....	15
EXHIBIT 6: PROJECT INFORMATION - 1C, HIGHWAY ACCIDENT DATA .....	18
EXHIBIT 7: PROJECT INFORMATION - 1D, RAIL AND TRANSIT DATA.....	20
EXHIBIT 8: PROJECT INFORMATION - 1E, PROJECT COSTS .....	23
EXHIBIT 9: PROJECT INFORMATION - BYPASS AND INTERSECTION ANALYSIS BUTTON.....	26
EXHIBIT 10: MODEL INPUTS SHEET.....	28
EXHIBIT 11: RESULTS WORKSHEET - FINAL MODEL OUTPUT .....	29
EXHIBIT A1: PROJECT INFORMATION WORKSHEET SECTION 1A.....	A-1
EXHIBIT A2: PROJECT INFORMATION WORKSHEET SECTION 1B.....	A-2
EXHIBIT A3: PROJECT INFORMATION WORKSHEET SECTION 1C.....	A-4
EXHIBIT A4: PROJECT INFORMATION WORKSHEET SECTION 1D.....	A-5
EXHIBIT A5: PROJECT INFORMATION WORKSHEET SECTION 1E.....	A-7
EXHIBIT A6: PROJECT INFORMATION WORKSHEET CORRECTING SECTION 1A .....	A-8
EXHIBIT A7: MODEL INPUTS WORKSHEET SECTION 2A .....	A-9
EXHIBIT A8: RESULTS WORKSHEET SECTION 3.....	A-10
EXHIBIT B1: PROJECT INFORMATION WORKSHEET SECTION 1A.....	B-1
EXHIBIT B2: PROJECT INFORMATION WORKSHEET SECTION 1B.....	B-2
EXHIBIT B3: PROJECT INFORMATION WORKSHEET SECTION 1C.....	B-4
EXHIBIT B4: PROJECT INFORMATION WORKSHEET SECTION 1E.....	B-5
EXHIBIT B5: RESULTS WORKSHEET SECTION 3.....	B-6



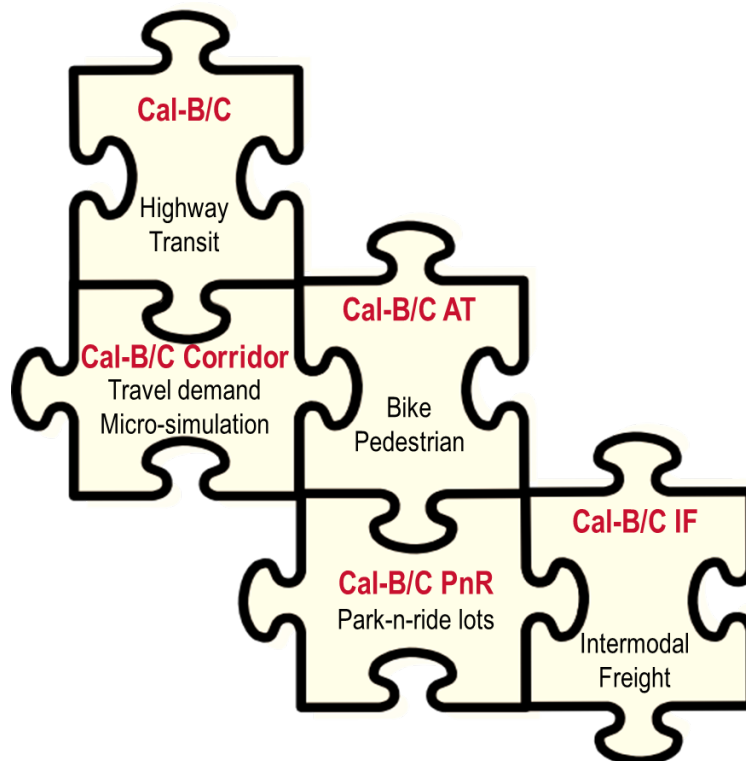
EXHIBIT C1: PROJECT INFORMATION WORKSHEET SECTION 1A.....	C-1
EXHIBIT C2: PROJECT INFORMATION WORKSHEET SECTION 1B.....	C-2
EXHIBIT C3: PROJECT INFORMATION WORKSHEET SECTION 1C .....	C-4
EXHIBIT C4: MODEL INPUTS WORKSHEET SECTION 2B .....	C-5
EXHIBIT C5: PROJECT INFORMATION WORKSHEET SECTION 1E.....	C-6
EXHIBIT C6: PROJECT INFORMATION WORKSHEET SECTION 1B.....	C-7
EXHIBIT C7: RESULTS WORKSHEET SECTION 3 .....	C-8

Welcome to the User's Guide for the *California Life-Cycle Benefit/Cost Analysis Model (Cal-B/C)* Version 6.2. The California Department of Transportation (Caltrans) uses Cal-B/C 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 is a spreadsheet-based, sketch planning tool that can prepare analyses of highway, transit, and passenger rail projects. Users input data defining the type, scope, and cost of projects. The model calculates life-cycle costs, net present values, benefit-cost ratios, internal rates of return, payback periods, annual benefits, and life-cycle benefits.

As part of a suite of Microsoft Excel spreadsheet-based tools, Cal-B/C can be used to conduct multi-modal analyses of highway, transit, bicycle, pedestrian, Intelligent Transportation System (ITS), operational improvement, and passenger rail projects. Exhibit 1 shows all five tools in the Cal-B/C suite, which together allow users to consider many different types of projects. Complementing the original Cal-B/C model, which focuses on highway and transit models, are two sketch planning models tailored to active transportation (AT) projects and park-and-ride (PnR) programs. In addition, a fourth model, called Cal-B/C Corridor, allows users to post-process travel demand and micro-simulation model data, while a fifth model is available to analyze intermodal freight (IF) improvements. All five tools in the Cal-B/C suite use consistent methods, rely on the same parameters, and produce comparable results.

**Exhibit 1: Cal-B/C Framework**



The rest of this User's Guide focuses on Cal-B/C. Cal-B/C AT and Cal-B/C PnR have their own User's Guides, while Volumes 3 and 4 of the User's Guide Technical Supplement provide information on Cal-B/C Corridor and Cal-B/C IF respectively. All five models have instructions pages built into their spreadsheets.

The latest version of Cal-B/C allows users to analyze freight and passenger benefits separately. This revision is part of Caltrans' commitment to improving good movement in California. The addition of Cal-B/C IF, which estimates benefits for freight modal diversions, network expansion, and terminal efficiency projects is another part of this commitment. There is also a special version of the model available that supports the analysis of project uncertainty using an Excel add-in called Risk Analyzer to conduct Monte Carlo simulation.

Cal-B/C 6.2 has several features to assess the benefits and costs of proposed projects in California. The current version includes:

- Separate reporting of freight and passenger benefits
- Updated economic measures
- Monte Carlo simulation support (in some models)
- New parameters for active transportation modes
- Updated travel data from 2010 Statewide Travel Survey.

This quick-start manual introduces you to important features of Cal-B/C 6.2 and leads you through the analysis of a hypothetical project. (Your copy of Cal-B/C may produce slightly different results from the examples due to updates in economic values.) The Technical Supplement to the User's Guide provides details of the methodologies and analytical framework for the model. Volume 1 of the supplement documents the basic framework and the original model, Volume 2 documents changes made through Version 3.2, and Volume 3 documents changes for Version 5.0, while the latest revisions are in Volume 4.

## 1. User Requirements

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

The user should also understand life-cycle benefit-cost analysis and be able to interpret the results in a transportation planning context. The reader should refer to the User's Guide Technical Supplement to learn more about the concepts used to develop Cal-B/C. The basic life-cycle benefit-cost framework is presented in Volume 1.

## 2. Operating System and Software Requirements

Cal-B/C is a Microsoft Excel 2007 workbook called *Cal-BC 62.xlt*. The file is approximately 1 MB in size and is provided in a template format to avoid accidental changes to the base model. The

user can open the file and Excel will automatically prompt the user to save the file to a new name. Although designed for a Windows environment, Cal-B/C should work on all computer platforms.

### 3. Model Overview

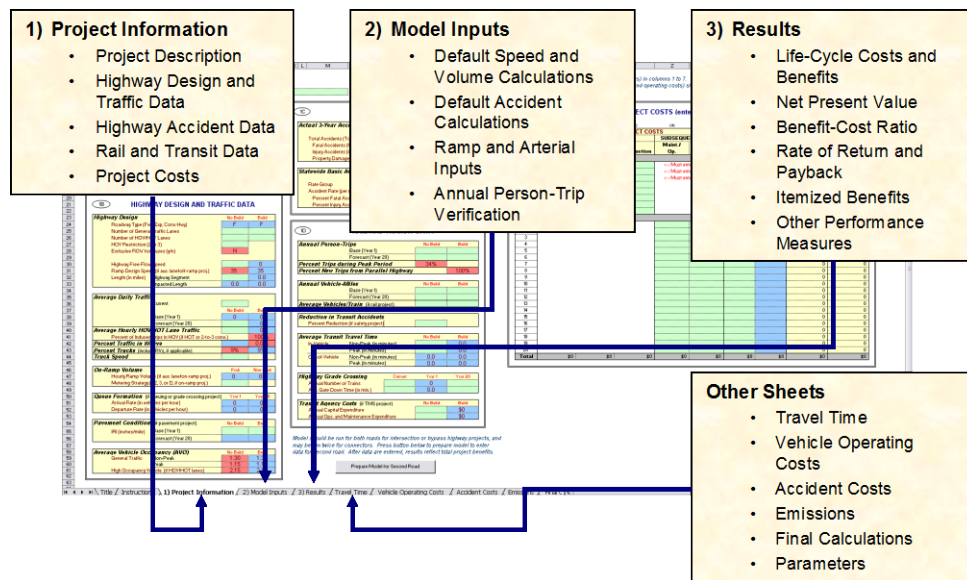
Cal-B/C is a Microsoft Excel spreadsheet that provides economic benefit-cost analysis for a range of capacity-expansion transportation projects. The model measures, in constant dollars, four categories of benefits that result from highway or transit projects:

- Travel time savings (reduced travel time and new trips)
- Vehicle operating cost savings (fuel and non-fuel operating cost reductions)
- Accident cost savings (safety benefits)
- Emission reductions (air quality and greenhouse gas benefits).

Each of these benefits are estimated for a peak (or congested) period and a non-peak (or uncongested period). The distinction is intended to capture the difference in congested and free-flow conditions on the highway as well as different operating characteristics for transit at peak times. Some travel demand models have fixed peak periods, which may not correspond to the congested period on the highway. Cal-B/C can accept these data in lieu of congested period data. Aggregate travel demand model or micro-simulation model results can also be evaluated using speed bin or segment level data in Cal-B/C Corridor.

The base Cal-B/C model consists of a cover page and ten sheets in an Excel workbook. Users generally refer to only the first four worksheets after the cover page (including one that provides instructions and reference materials) to conduct analyses. The six remaining worksheets perform calculations or store defaults and economic parameters. These pages are shown in Exhibit 2.

**Exhibit 2: Cal-B/C Graphical User Interface**



Cal-B/C requires few user inputs, but allows the user to enter many more inputs when available. Cells in the worksheets are color-coded. **Green** cells indicate required data (i.e., the user must input values for the model to work). **Red** cells provide default values, such as average vehicle occupancy, that the user can change if needed. **Blue** cells contain values calculated by the model, which can be changed if detailed data are available. Blue cells contain values that are likely to change from the base case.

The first worksheet after the cover page provides *Instructions*. The instructions include short descriptions of the steps in performing a basic analysis and hints on how to avoid potential pitfalls.

The *Project Information* sheet is the main data-entry worksheet. Users enter descriptive information about projects, expected traffic demand, accident rates, transit or rail data (for transit or rail projects only), and expected project construction and operating costs. The sheet also has a button linked to a macro that allows users to run analyses for bypass and intersection projects.

Caltrans provides Districts with “district input sheets” to use for submitting project information to Headquarters. These input sheets look similar (but are not identical) to the Cal-B/C project information sheet. For each project, a District is asked to submit relevant data using an input sheet tailored to the specific type of project.

The *Model Inputs* page in Cal-B/C contains information about the highway speed, volume, number of trips, and accident data used in calculating benefits. This sheet allows users to check the highway data that the model estimates from the project information sheet and to override the calculated values with project-specific information, if such information is available. Some users may have volume and speed projections from regional travel demand models or simulation models. Users can use peak and off-peak period volumes and speeds from these models to override the calculated values produced by Cal-B/C. Cal-B/C Corridor is also available to estimate benefits using model data. Cal-B/C calculates speeds using speed/volume relationships found in the 2010 Highway Capacity Manual.

The *Results* sheet presents the final investment measures as well as annualized and life-cycle benefits. The sheet allows users to include the effects of induced travel and vehicle emissions. Cal-B/C calculates induced travel benefits using consumer surplus theory. Cal-B/C summarizes analysis results on a per-project basis using several measures:

- Life-cycle costs (in millions of dollars)
- Life-cycle 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 per year)
- Project payback period (in years).

The model itemizes anticipated benefits (in millions of dollars) for the average year and over the full 20-year life-cycle. The model calculates benefits for:

- Travel time savings



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

The output also summarizes person-hours of time saved and itemizes the tons and value (in millions of dollars) of pollutants by type.

Cal-B/C estimates the value of CO<sub>2</sub> emissions using a standard value for tons of CO<sub>2</sub> equivalent. While the model is set up to estimate values only for CO<sub>2</sub>, other greenhouse gases could be valued using equivalency factors. The methodology is described in Volume 3 of the User's Guide Technical Supplement.

Experienced users can override default parameters in the *Parameters* other calculations worksheets to produce tailored results if detailed information is available for specific projects. The model requires inputs on only the three worksheets previously mentioned, but the parameters and detailed calculation sheets can be accessed to change default values as needed. In the *Results* worksheet, the user can select whether to include induced travel, vehicle operating cost, accident cost, and emissions benefits in the analysis. Emissions savings are reported even if they are not included in the benefit-cost evaluation.

The *Parameters* worksheet (the last sheet in Cal-B/C) contains all of the economic values and rate tables. Adjusting the economic update factor using the Gross Domestic Product (GDP) deflator changes the economic values contained in the model. This worksheet includes the following values:

### General Economic Values

- Year of current dollars for model
- 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

### Travel Time Values

- Automobile, truck, and transit
- Out-of-vehicle and 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, and PDO)
- Statewide highway accident rates (fatal, injury, PDO)

### Transit Accident Rates and 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<sub>2</sub>, NO<sub>x</sub>, PM<sub>10</sub>, SO<sub>x</sub>, and VOC
- Automobile, truck, and bus

### Rail Emissions Rates

- CO, NO<sub>x</sub>, PM<sub>10</sub>, and VOC
- Passenger train and light-rail

### Emissions Health Costs

- Urban Southern California, urban Northern California, and rural California
- CO, CO<sub>2</sub>e, NO<sub>x</sub>, PM<sub>10</sub>, SO<sub>x</sub>, and VOC
- Automobile, truck, and bus

### Other Values

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



# 4. Worksheet Details and Project Analysis

The following sections describe the three primary Cal-B/C worksheets and walk 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 how to enter data.

## 4.1 Project Information Worksheet

The *Project Information* sheet is the main data input sheet (Exhibit 3). For most projects, this will be the only sheet needed. The user should modify other sheets only if information is available that is more specific to the project than calculated by the model. The project information worksheet has five sections identified in Exhibit 3 and in the table below. There is also a button to prepare the model for analyzing a second road (bypass road or crossing road) in a bypass or intersection project, or a truck only lane in a truck only lane project.

Section Number	Name of Section	Location of Section in Worksheet (Top Left Cell: Bottom Right Cell)
1A	Project Data	B6:I18
1B	Highway Design and Traffic Data	B20:I62
1C	Highway Accident Data	K6:R22
1D	Rail and Transit Data	K24:R54
1E	Project Costs	U6:AF45
	Second Road Button	K56:R61

Exhibit 3: Project Information Worksheet

The screenshot shows the Project Information Worksheet with several sections highlighted by callout boxes:

- Section 1A: Project Data** (B6:I18): Includes fields for Project Name, Type of Project, Project Location, Length of Construction Period, and Length of Peak Period.
- Section 1B: Highway Design and Traffic Data** (B20:I62): Includes Highway Design (Roadway Type, Number of Lanes, HOV Restriction), Average Daily Traffic, Average Hourly HOV/HOT Lane Traffic, Percent Traffic in Hours, Percent Trucks, Queue Formation, Pavement Condition, and Average Vehicle Occupancy (AVO).
- Section 1C: Highway Accident Data** (K6:R22): Includes Statewide Basic Average Accident Rate, Annual Person-Trips, Percent Trips during Peak Period, Percent New Trips from Parallel Highway, Average Vehicle Miles, Reduction in Transit Accidents, and Average Transit Travel Time.
- Section 1D: Rail and Transit Data** (K24:R54): Includes Annual Person-Trips, Average Vehicles per Hour, and Reduction in Transit Accidents.
- Section 1E: Project Costs** (U6:AF45): A table for entering costs in thousands of dollars, categorized by Year, Project Support, Initial Costs, and Subsequent Costs (Construction, Maint./Op., Rehab., Mitigation). It also includes Transit Agency Cost Savings and Total Costs (Constant Dollars and Present Value).
- Button to analyze multiple roads for bypass and intersection projects** (K56:R61): A button labeled 'Prepare Model for Second Road'.

The worksheet also includes a 'Project Information Worksheet Tab' at the bottom and a 'Present Value = Future Value (in Constant Dollars) / (1 + Real Discount Rate)^Year' formula at the bottom right.



#### 4.1A Project Data

The user enters information about the project in the project data input section shown in Exhibit 3.

**TYPE OF PROJECT.** The model allows the user to identify several project types including:

Highway Capacity Expansion	Transit Capacity Expansion	Highway Operational Improvement	Transportation Management Systems (TMS)
General Highway	Passenger Rail	Auxiliary Lane	Ramp Metering
HOV or HOT Lane Addition	Light-Rail (LRT)	Freeway Connector	Ramp Metering Signal Coordination
Passing Lane	Bus	HOV Connector	Incident Management
Intersection	Highway-Rail Grade Crossing	HOV Drop Ramp	Traveler Information
Truck Only Lane Bypass		Off-Ramp Widening	Arterial Signal Management
Queuing*		On-Ramp Widening	Transit Vehicle Location (AVL)
		HOV-2 to HOV-3 Conversion	Transit Vehicle Signal Priority
Pavement		HOT Lane Conversion	Bus Rapid Transit (BRT)

\* The model has the ability to conduct a simple, deterministic queuing analysis for a highway bottleneck. This “project type” is expected to be used only for special cases.

The user selects the project type using a pull-down menu bar. The pull-down options become available when the user makes F10 the active cell. Making a cell “active” simply means putting the cursor in that cell. Once the cell is active a scroll bar becomes visible for the user to select one of the project types.

**PROJECT LOCATION** (i.e., Northern California Urban, Southern California Urban, or Rural). The model uses this information to estimate emission benefits using values appropriate for each region. It also selects the appropriate percentage from the demand for travel in peak period table. Although Cal-B/C 6.2 currently uses the same peak period percentages for the three regions, the model can accommodate different values if adopted in the future. The user identifies the project location by selecting a “1,” “2,” or “3,” as shown in Exhibit 4.

**LENGTH OF CONSTRUCTION PERIOD** indicates the number of years needed to construct the project and determines the project opening date, which is assumed to occur at the end of the construction period.

**ONE- OR TWO-WAY DATA** indicates whether the data provided in Section 1B is for travel in one direction or two directions. This input relates to the data entered, not the facility. Data for a single direction can be entered even if a project is proposed for a two-directional roadway.

Exhibit 4: Project Information - 1A, Project Data

The screenshot shows the 'PROJECT DATA' section of the Cal-B/C 6.2 Model. The callout box '1A' highlights the following input fields:

- Type of Project:** Select project type from list. Input: General Highway
- Project Location:** (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural). Input: 2
- Length of Construction Period:** Input: 3 years
- One- or Two-Way Data:** Input: 2 (enter 1 or 2)
- Length of Peak Period(s):** (up to 24 hrs). Input: 4 hours (Current)

LENGTH OF PEAK PERIOD(S) helps the model determine peak and non-peak volumes and speeds. Cal-B/C uses these values to estimate travel time benefits, fuel consumption, and emissions. The length of the peak period should be entered as the number of hours. For example, if the peak period is from 3:00 PM to 7:00 PM along the segment where the project is proposed, then the user would put “4” in this input cell to indicate 4 hours (see Exhibit 4). In earlier versions of Cal-B/C, users could choose peak periods lasting up to only 8 hours because the percent of traffic in any given peak hour was fixed. Cal-B/C 6.2 allows users to choose peak periods of any length. A lookup table takes into account the diminishing contribution of each hour to the amount of traffic occurring in the peak period. The table allows different standard values for the three project location regions and two road types. However, the values in the table are currently the same for each region and road type.

## Add a General Highway Lane Example

### PROJECT EXAMPLE STEP 1: Project Data

In this project example, which will be used throughout the User's Guide, we are going to "construct" two additional lanes on a 3.9-mile segment of freeway in Northern California. This project was selected because lane additions are common projects, and because this example highlights some basic issues that need to be addressed in benefit-cost analysis. Cal-B/C should not be viewed as a "black box." Using this tool requires making professional engineering judgments as well as the ability to interpret the outputs appropriately.

To begin the analysis, open the *Project Information* sheet (worksheet tab 1: Project Information). Exhibit 4 shows the *Project Data* section for our lane addition. Note that green-colored cells may require data. The red cells provide default values that the user can change.

- (1) **Descriptive Project Information.** The area at the very top of the worksheet provides space to enter the district where the project is being developed, a descriptive project name, the project EA number and the project priority number (PPNO). This information is not required, but it is useful to include for identification purposes when you return later to the project.
- (2) **Type of Project.** Make merged cells F10 through H10 the active selection by clicking on one of those cells. Use the scroll bar at the right to find the "General Highway" project type. This is a required selection for any project.
- (3) **Project Location.** This cell requires you to enter a "1" for urban areas in Southern California, a "2" for urban areas in Northern California, or a "3" for rural areas to determine emissions benefits for the project. Assume that our project is built in Northern California, and put a "2" in this cell. This cell tells the model which tables to reference in the Emissions worksheet.
- (4) **Length of Construction Period.** Enter the amount of time needed to construct the project. Assume that this lane addition project will be completed in 2.8 years. Cal-B/C uses this cell to determine the economic impacts. This number must be a whole number. A project that will take 2.8 years to construct should be entered as the number "3" representing three years. A project taking 2.4 years can be rounded down to two years or up to three years, at the user's discretion, but must be consistent with the cost data entered.

Note that the model evaluates project impacts only after the project is built. For example, a project that begins construction in 2017 and takes three years to complete will not cause any impacts until 2020 when the project opens. The Year 1 impacts occur immediately after the project opens. The Year 20 impacts occur in 2039 for this hypothetical project.

- (5) **One- or Two-Way Data.** Insert the number of directions that traffic flows along the corridor. The default value is "2", representing a project impacting traffic traveling both directions. This means that later we will need to add design and traffic data that reflects both directions.
- (6) **Length of Peak Period.** For our project, enter a "4" in this cell to indicate a four-hour peak period. This entry covers both the AM and PM peak periods and should represent typical daily conditions. The peak period helps convert average daily traffic volumes (described in Section 4.1B) into average peak and non-peak volumes and speeds. Speed is an important variable to determine travel time savings, fuel consumption, and emissions.



#### 4.1B Highway Design and Traffic Data

Section 1B, shown in Exhibit 5, is where the user inputs data about the highway components of a transportation project. Most transit-specific elements are added in Section 1D of the Project Information worksheet. In both sections, the user enters data for the “No Build” and “Build” situation. In early versions of Cal-B/C, the “No Build” was called “Existing” or “Without Project.” Likewise, the “Build” situation was called “New” or “With Project.” Cal-B/C 6.2 standardizes all terms to “No Build” and “Build” to reduce confusion.

The following data is entered into Section 1B of the worksheet:

**HIGHWAY DESIGN** includes basic information, such as lane configuration, design speed, and section length. The data entered in the highway design section should cover the no-build and build situations. Separate boxes are provided in most cases:

- *Roadway Type (i.e., Freeway, Expressway, or Conventional Highway)* – The user enters an “F” (freeway), “E” (expressway), or “C” (conventional highway) to indicate the type of roadway affected by the project. These inputs are case sensitive and should be entered in upper case.
- *Number of General Traffic Lanes* – The user provides the number of mainline traffic lanes along the roadway section for the existing condition and any future improvements. The number of mainline general traffic lanes is required for all highway-related project types including on-ramp and auxiliary lanes. Do not include short auxiliary lanes or ramp merge lanes in the count of general traffic lanes - this section is only for mainline lanes. (Note: Projects to construct long auxiliary lanes may be assessed as general traffic lane projects. In these cases, the auxiliary lanes should be included in this count.) Also, note that Cal-B/C does not allow the user to “phase in” the construction. For example, you cannot construct one lane by Year 1 and another by Year 7. Such a scenario must be analyzed as separate projects.
- *Number of HOV/HOT Lanes* – As with general traffic lanes, the user enters the number of HOV or HOT lanes, if they are present or being added. In the case of an HOV-to-HOT lane conversion project, the same number of lanes should be entered in the no-build and build cases.
- *HOV Restriction (2 or 3)* – If HOV or HOT lanes exist, the user must input the vehicle occupancy restriction for using the lanes. The HOV restriction is the minimum number of vehicle occupants in a vehicle. The model accepts only two values: a “2” for a two-person carpool restriction or a “3” when at least three or more people must be present in a carpool.
- *Exclusive ROW (Right-of-Way) for Buses* – This input is used if the highway section contains an exclusive ROW for buses, commonly known as a busway or bus lanes. In Cal-B/C an exclusive ROW for buses means that no vehicles other than buses can travel on the lane. This would exclude, for example, the El Monte Busway in the Los Angeles area where 3+ carpools also can travel on the lanes. The model accepts only an “N” for “No” or a “Y” for “Yes”. This input is used by Cal-B/C to evaluate the emissions impacts of busways.

- *Highway Free-Flow Speed* – Design speed for the highway section. The design speed is often the posted speed limit. The user inputs the existing free-flow speed, and the model assumes that the “Build” free-flow speed is the same. If the new speed is different from the existing speed, then the user can override the assumed speed by simply typing over the speed in the appropriate cell.
- *Ramp Design Speed (if auxiliary lane/off-ramp project)* - Used for on-ramp, off-ramp, and auxiliary lane projects. In the case of auxiliary lanes, this speed should be entered as the average speed experienced on the auxiliary lane while accelerating (in the case of an on-ramp), merging, or decelerating. As with the highway free-flow speed, the user can override the “Build” speed as appropriate.
- *Length (in miles)* – The length in miles of the section under analysis. There are two “lengths” that must be accounted for:
  - *Highway Segment* – the project design length.
  - *Impacted Length* – the distance upstream of the highway segment affected by improvements to the highway segment. In prior versions of Cal-B/C, this was called “Affected Length.” The model assumes an impacted length based on the project type based on the most recent research. If the project is an auxiliary lane or off-ramp project the assumed distance is 1,500 feet or 0.28 miles. Freeway connector or HOV operational improvement projects assume an affected length of 3,250 feet or 0.62 miles, while passing lane projects assumed a length of the highway segment length plus 3 miles. All other projects assume that the impacted length is as long as the project design length. As with other model estimates, the user can override the assumed value if better data are available.

**AVERAGE DAILY TRAFFIC (ADT)** contains the user inputs for highway general lane (i.e., mainline) volumes for the “Current” year, the first year after the project has been constructed or implemented (Year 1), and 20 years into the future. Note that the forecast year is the project opening date plus 20 years, not the current date plus 20 years.

The model uses straight-line interpolation to estimate the “Year 1” ADT from the “Current” ADT and the “Year 20” ADT. The values for the “Build” and “No Build” cases are estimated separately on the basis of the respective “Year 20” volumes. The user can override any of the estimates if better data are available.

The Results sheet has an option to include induced demand in the evaluation. If “Y” for “Yes” is selected, the model calculates the change in consumer surplus associated with the excess of traffic in the “Build” scenario compared to the “No Build” scenario. For transit projects, Cal-B/C assumes that highway demand is inelastic (i.e., no induced demand occurs).

**AVERAGE HOURLY HOV/HOT LANE TRAFFIC** requires that the user enter in current year average hourly HOV/HOT volumes for the segment in question, but only if there is an HOV or HOT lane present. This input has been modified in Cal-B/C 6.2 to accommodate HOT lane and HOV-2 to HOV-3 conversion projects. Both project types affect carpool formation and AVO, and can lead to induced demand. For these project types, the user should indicate how much of the new traffic



(if the build ADT is larger than the no-build ADT) occurs in the HOV/HOT lane by entering a percentage in the **Percent of Induced Trips in HOV** box.

**PERCENT TRAFFIC IN WEAVE** estimates the percent of traffic in the highway section that is impacted by an operational improvement for both the “No Build” and “Build” scenarios. In Cal-B/C, an operational improvement includes one of the following types: auxiliary lane, freeway or HOV connectors, HOV drop ramp, and on- or off-ramp widening. The model attempts to estimate how many general traffic lanes are affected by weaving. The table below shows the estimated percent of traffic affected by weaving for these types of projects:

Auxiliary Lane	2 lanes (100% if 1 lane)
On/Off-Ramp	3 lanes (100% if <3 lanes)
Freeway Connector	2.5%
HOV Connector/Drop-Ramps	4%

**PERCENT TRUCKS** (including recreational vehicles) is the percentage of trucks in the traffic flow (i.e., percent of ADT). Recreational vehicles should be included in this figure if they make up a sizeable portion of the traffic. The model assumes a statewide average of 9 percent truck traffic. The user can update this value if better data are available. Caltrans’ Traffic and Vehicle Data Systems in the Division of Traffic Operations publishes the *Annual Average Daily Truck Traffic on the California State Highway System*. This yearly report, often referred to as the “Truck Volumes Book,” provides truck estimates and counts for different locations around the state. Percent truck traffic should be estimated by comparing the vehicle-miles traveled by trucks and all traffic.

**TRUCK SPEED** is the average speed of slow-moving vehicles, such as trucks or recreational vehicles, on a grade when there are no passing lanes. An entry is required for passing lane projects, but this input is needed only for the “No Build” scenario. Cal-B/C calculates the automobile speed based on the volume/capacity relationships provided in the 2010 Highway Capacity Manual.

**ON-RAMP VOLUME** is used for auxiliary lane and on-ramp widening projects and is similar to the ADT input cells, except average hourly volumes are entered rather than daily volumes. An input is required for the average peak hour and non-peak hour. Cal-B/C uses this information to estimate the volume of traffic affected by weaving for auxiliary lanes, while it is used to evaluate the effectiveness of ramp metering for on-ramp widening projects. If the project is a ramp metering strategy without widening the on-ramp, then no entry needs to be made.

The user can override the default values in Cal-B/C. The model assumes a peak period volume of 1,350 vehicles per hour for auxiliary lanes and 800 vehicles per hour for on-ramps.

**METERING STRATEGY** is required for on-ramp widening projects in which there is ramp metering. The model requires a “1”, “2”, or “3” to indicate the number of vehicles allowed per green signal. A “D” indicates dual metering.

**QUEUE FORMATION** conveys the rate at which cars are entering and exiting any existing queue (in vehicles per hour). These numbers are applicable only to highway queuing or rail grade separation projects. For these projects, the user enters the vehicles per hour contributing to the queue in **Arrival Rate**. The arrival rate should be estimated only for the time that the queue grows. The model estimates queue dissipation automatically. More information on the methodology is available in the Technical Supplement to the User's Guide. The user enters the vehicles per hour leaving the queue in the **Departure Rate**.

**PAVEMENT CONDITION** for the Base Year (Year 1) for pavement rehabilitation projects. The user inputs the International Roughness Index (IRI) in the "No Build" and "Build" scenarios. Cal-B/C will calculate Year 20 values using standard parameters, but the user can override the IRI value if better information is available for Year 20.

**AVERAGE VEHICLE OCCUPANCY** displays default values from the 2010 Statewide Travel Survey and HOV monitoring data. Since many regional agencies have data that is more up-to-date, the user can override the default values.



Exhibit 5: Project Information - 1B, Highway Design and Traffic Data

1B HIGHWAY DESIGN AND TRAFFIC DATA		
<b>Highway Design</b>		
Roadway Type (Fwy, Exp, Conv Hwy)	No Build	Build
Number of General Traffic Lanes	F	F
Number of HOV/HOT Lanes		
HOV Restriction (2 or 3)		
Exclusive ROW for Buses (y/n)	N	
Highway Free-Flow Speed		0
Ramp Design Speed (if aux. lane/off-ramp proj.)	35	35
Length (in miles) Highway Segment		0.0
Impacted Length	0.0	0.0
<b>Average Daily Traffic</b>		
Current		
Base (Year 1)	0	0
Forecast (Year 20)		0
<b>Average Hourly HOV/HOT Lane Traffic</b>		
Percent of Induced Trips in HOV (if HOT or 2-to-3 conv.)		100%
<b>Percent Traffic in Weave</b>		
		0.0%
<b>Percent Trucks</b> (include RVs, if applicable)		
	9%	9%
<b>Truck Speed</b>		
<b>On-Ramp Volume</b>		
Hourly Ramp Volume (if aux. lane/on-ramp proj.)	Peak	Non-Peak
Metering Strategy (1, 2, 3, or D, if on-ramp proj.)	0	0
<b>Queue Formation</b> (if queuing or grade crossing project)		
Arrival Rate (in vehicles per hour)	Year 1	Year 20
Departure Rate (in vehicles per hour)	0	0
<b>Pavement Condition</b> (if pavement project)		
IRI (inches/mile) Base (Year 1)	No Build	Build
Forecast (Year 20)		
<b>Average Vehicle Occupancy (AVO)</b>		
General Traffic Non-Peak	No Build	Build
Peak	1.30	1.30
High Occupancy Vehicle (if HOV/HOT lanes)	1.15	1.15
	2.15	2.15

## PROJECT EXAMPLE STEP 2: Highway Design and Traffic Data

Now move to the *Highway Design and Traffic Data* section of the project information worksheet (Exhibit 5).

### (1) Highway Design.

- a. *Roadway Type (Fwy, Exp, Conv Hwy)* – Leave the default of F (freeway).
- b. *Number of General Traffic Lanes* - Assume that the mainline currently has eight lanes, and that our project will build two additional lanes, bringing the total for the “Build” scenario to ten.
- c. *Number of HOV/HOT Lanes* - Assume that the segment has 2 HOV lanes
- d. *HOV Restriction (2 or 3)* – Assume a 2-person HOV restriction.
- e. *Exclusive ROW for Buses (y/n)* – Assume that this segment has no bus lanes.
- f. *Highway Free-Flow Speed* - Set the free-flow speed to 65 mph. The blue cell with the “Build” free-flow speed will be set automatically to equal the “No-Build” free-flow speed. The blue color of the cell indicates that this value is estimated and that you may override this speed.
- g. *Ramp Design Speed* – Assume a default value of 35 mph.
- h. *Highway Segment* – The project length is 3.9 miles.
- i. *Impacted Length* – Assume that the impacted length equals the project length of 3.9 miles.

(2) **Average Daily Traffic.** Enter the existing average daily traffic into the cell labeled “Current.” Use a value of 234,000 vehicles per day for this exercise. Also, enter a value of 272,989 vehicles per day for the “Forecast (Year 20)” value in the “No Build” column. The model automatically calculates the “Base (Year 1)” value in the “No Build” column, which should be 239,317 vehicles per day.

Note: The *Results* sheet has an option to include induced demand in the evaluation. If “Y” for “Yes” is selected, the model calculates the change in consumer surplus associated with the excess traffic in the with “Build” scenario compared to the “No Build” scenario. For a transit project, Cal-B/C assumes that highway demand is inelastic (i.e., no induced demand occurs).

(3) **Average Hourly HOV/HOT Lane Traffic.** Update these cells if the project involves HOV or HOT lanes. As with the average daily traffic cells, the user should enter the number of HOV and HOT lanes for both the “No Build” and the “Build” scenarios. The model assumes that all lanes are constructed by Year 1. For our project, enter 2,400 vehicles per hour in both columns.

(4) **Percent Trucks.** Leave the default value of nine percent truck traffic.

(5) **Truck Speed.** This information is not needed for our project.

(6) **On-Ramp Volume.** Since this is not an auxiliary lane or on-ramp project, this information is not needed. Leave the default values of zero vehicles per hour.

(7) **Queue Formation.** Since this is not a queuing or grade crossing project, you can ignore this section.

(8) **Average Vehicle Occupancy (AVO).** This is the average number of people per vehicle on the highway. Let us use the model defaults of 1.30 for the non-peak AVO, 1.15 for the peak AVO, and 2.15 for HOV traffic. Notice that the AVO for HOVs is estimated automatically from the HOV restriction entered earlier.

#### 4.1C Highway Accident Data

This section calculates accident rates for the highway facility as shown in Exhibit 6. Accident rates are estimated for fatal, injury, and property damage only (PDO) accidents from actual count data from the last three years. In the latest version of Cal-B/C, this section is formatted to correspond to a “Table B” selective accident record retrieval from the Traffic Accident Surveillance and Analysis System (TASAS). The user enters the total number of accidents, the number of fatal accidents, and the number of injury accidents in the “Count” column. Cal-B/C automatically calculates the number of PDO accidents and the accident rates.

The “Rate” column, highlighted in gray, displays the accident rates calculated from the count data. An accident rate is simply the annualized count divided by millions of vehicle miles (average daily traffic x highway segment length x 365 days/1,000,000). Since this calculation is based upon the highway segment length for the project and the actual count data may not correspond directly, the user may choose to type over the rates in the gray cells with rates from a Table B.

For some specific project types, the inputs and calculations in these cells deviate from the standard evaluation. For intersection and ramp projects, the “Rate” column calculates the highway accident rate as the annualized count divided by millions of vehicles rather than vehicle miles. For rail grade crossing projects, Cal-B/C allows special inputs because the grade crossing accident data are collected separately from highway accident data. For rail grade separation projects, actual 10-year historical data can be obtained from the Federal Highway-Rail Crossing Accident database. Alternatively, the user can use data from the FRA Web Accident Prediction System (WBAPS). Cal-B/C can use either source to estimate rail grade separation safety benefits. Details are available in the Technical Supplement to the User’s Guide.

Cal-B/C provides statewide average rates as default values in case data specific to the facility are not available. This data comes from a special TASAS run titled “2013 Statewide Collision Total Check.” The default rates are particularly valuable for transit projects when roadway accident rates are not available.

Cal-B/C uses the change in accident rate group to estimate the safety benefits of roadway projects. The latest version of Cal-B/C allows the user to specify the appropriate rate groups for the no-build and build cases. This information is for record-keeping purposes only, and the model relies on average accident rate and percentages by accident type provided by the user. The latest information can be found in the annual collision reports, which provide rate group data in the “Basic Accident Rate Tables.” There are separate tables for three types of roadway: highways, intersections, and ramps. The tables report accident rate, percent fatal accidents (Pct Fat), and percent injury accidents (Pct Inj).



Exhibit 6: Project Information - 1C, Highway Accident Data

**1C HIGHWAY ACCIDENT DATA**

**Actual 3-Year Accident Data (from Table B)**

	Count (No.)	Rate
Total Accidents (Tot)	0.97	0.97
Fatal Accidents (Fat)	0.009	0.009
Injury Accidents (Inj)	0.31	0.31
Property Damage Only (PDO) Accidents	0.65	0.65

**Statewide Basic Average Accident Rate**

Rate Group	No Build	Build
Accident Rate (per million vehicle-miles)		
Percent Fatal Accidents (Pct Fat)		
Percent Injury Accidents (Pct Inj)		

### PROJECT EXAMPLE STEP 3: Highway Accident Data

Now move to the *Highway Accident Data* section (Section 1C) of the Project Information worksheet (Exhibit 6). Cal-B/C provides the statewide collision averages as the default values. However, assume that we have some highway accident data and projections available for our project.

- (1) For the **Actual 3-Year Accident Data (from Table B)** cells, assume there were 977 accidents on the highway corridor over the past three years. Of these, three were fatal accidents and 230 were injury accidents. Cal-B/C will calculate the number of PDO accidents automatically. In this example, Cal-B/C should show 744 property damage only accidents.
- (2) Insert statewide average accident rates per million vehicle-miles for road classifications similar to the existing and proposed facilities. This information can be found in the *2006 Accident Data on California State Highways*. In the annual report, there are a series of tables called the “Basic Average Accident Rate” tables, which provide statewide average rates for highways, intersections, and ramps.

This freeway type has a statewide average accident rate along for our section of 1.07. This same ramp type has a fatality percentage rate of 0.3 percent (should enter as 0.003) and a percent injury accidents of 31 percent. Enter these into Cal-B/C in the “No Build” columns of the Statewide Basic Average Accident Rate section. Enter 1.02 in the Accident Rate for the “Build” scenario, along with 0.3 percent fatal accidents (should enter as 0.003) and 29 percent injury accidents. The Rate Group labels are for information purposes only and not needed to calculate project benefits. We will leave the Rate Group cells empty for this example. The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates, by accident type, for new road classifications. The Model Inputs worksheet presents the results, which the user can edit.





### 4.1D Rail and Transit Data

This section of the project information sheet is used for transit and rail projects. For these projects, the user must enter seven additional data items:

- Annual person-trips
- Percent of person-trips occurring during the peak period
- Percent of new person-trips from the parallel highway
- Annual vehicle-miles
- Average vehicles per train (if rail project)
- Reduction in transit accidents due to the project (if safety project)
- Average transit travel time (including transfers and wait times).

For rail grade separation projects, Cal-B/C provides several additional inputs. If the project is a transit TMS project that is expect to lower agency costs, the user may also enter transit agency costs. Exhibit 7 shows the rail and transit data input section of the project information sheet.

Exhibit 7: Project Information - 1D, Rail and Transit Data

**1D RAIL AND TRANSIT DATA**

		No Build	Build
<b>Annual Person-Trips</b>			
Base (Year 1)			
Forecast (Year 20)			
<b>Percent Trips during Peak Period</b>		41%	
<b>Percent New Trips from Parallel Highway</b>			100%
<b>Annual Vehicle-Miles</b>			
Base (Year 1)			
Forecast (Year 20)			
<b>Average Vehicles/Train</b> (if rail project)			
<b>Reduction in Transit Accidents</b>			
Percent Reduction (if safety project)			
<b>Average Transit Travel Time</b>			
<b>In-Vehicle</b>	Non-Peak (in minutes)		0.0
	Peak (in minutes)		0.0
<b>Out-of-Vehicle</b>	Non-Peak (in minutes)	0.0	0.0
	Peak (in minutes)	0.0	0.0
<b>Highway Grade Crossing</b>			
	Current	Year 1	Year 20
Annual Number of Trains		0	
Avg. Gate Down Time (in min.)		0.0	
<b>Transit Agency Costs</b> (if TMS project)			
	No Build	Build	
Annual Capital Expenditure		\$0	
Annual Ops. and Maintenance Expenditure		\$0	



**ANNUAL PERSON TRIPS** refers to passenger trips during the first year after the project is built (Year 1) and twenty years later (Year 20) for the “No Build” and “Build Cases”. Note that the forecast year is the project completion date plus 20 years, and not the current date plus 20 years.

**PERCENT TRIPS DURING PEAK PERIOD.** The user provides an estimate of the ratio of peak period ridership to daily ridership. The definition of peak period should correspond to the number of hours listed in the project data section (Section 1A).

**PERCENT NEW TRIPS FROM PARALLEL HIGHWAY.** Improved transit may attract new trips from parallel highways. The default is set at 100 percent. In practice, the percentage of new transit trips from highways is typically between 50 and 80 percent.

**ANNUAL VEHICLE-MILES.** This is the number of vehicle-miles of transit or rail service operated on the line each year. The user should provide estimates for Year 1 and Year 20 in the “No Build” and “Build” cases. For passenger rail projects, the user should multiply the figures by the average number of rail cars per train consist.

**AVERAGE VEHICLES/TRAIN.** The user should enter the number of train cars used in an average train consist. This figure is used in conjunction with the annual vehicle-miles input to estimate emissions.

**REDUCTION IN TRANSIT ACCIDENTS.** This input provides the percent reduction in transit or rail accidents expected to occur due to a project. The user should enter a value only if the project specifically addresses safety concerns. Increases in transit accidents should be entered as a negative percentage.

**AVERAGE TRANSIT TRAVEL TIME.** Transit travel time has two components: in-vehicle time and out-of-vehicle time. In-vehicle time is the time spent in the bus or train traveling to the rider's destination. Out-of-vehicle time is the time spent walking or driving to the transit or rail stop. It also includes the time waiting for the bus or train to arrive. Research indicates that passengers value their time waiting at transit stops much more than they value their in-vehicle time. Cal-B/C requires that the user to enter peak and non-peak periods for the existing and new facilities.

For TMS projects, insert the average for all transit routes impacted. Cal-B/C assumes the “Build” scenario is the same as the “No Build” for most projects, except that signal priority and bus rapid transit projects reduce travel times.

**HIGHWAY GRADE CROSSING.** For Highway Grade Crossing projects, use these fields to enter the current, Year 1, and Year 20 counts for *Annual Number of Trains* and *Average Gate Down Time* (in minutes). Cal-B/C uses only the Year 1 and Year 20 counts. Year 1 estimates are often unavailable, so the model provides an input for current year to estimate the Year 1 data. The number of trains and average gate time are likely to differ for passenger and freight trains. Data should be collected separately for passenger and freight trains and aggregated prior to inputting in to the model.

**TRANSIT AGENCY COSTS.** For TMS projects, Cal-B/C requires the user to input annual capital, operating, and maintenance expenditures for routes impacted by project. The model calculates

cost reductions for the new expenditures due to transit TMS. Cal-B/C estimates agency cost savings and records them as negative costs.

#### 4.1E Project Cost Data

The user enters project construction, operating, mitigation, 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. 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 as shown in Exhibit 8. These inputs have been changed in Cal-B/C 6.2 to be consistent with Caltrans Programming documentation. While costs were entered in dollars in earlier versions, the user should enter them in thousands of dollars in the latest version of Cal-B/C. All costs should be entered in 2016 dollars for consistency with the benefit calculations.

The first column indicates the project year during construction and after project opening. In earlier versions of Cal-B/C, the first construction year was called “Year 0.” This has been renamed “Year 1” in the latest version. Cal-B/C can handle up to eight years of construction. The user should enter costs for as many years as were indicated in the Project Data section (Section 1A). The user should also enter subsequent incremental costs (i.e., maintenance, operations, and rehabilitation costs due to the project) for a 20-year period after the project opens. The numbering in the “Year” column restarts at 1 after the project opens.

Following the construction period, the project opens and there are twenty (20) years during the project operating period. Year 1 (Base Year) described in the previous sections is represented by the “1” under the “Project Opens” header. Year 20 (Forecast Year) is represented by the last row on this data entry form. For each row in the section (i.e., each row in the spreadsheet), the user enters the anticipated costs for the year in current year dollars. The model automatically calculates the sum and present value.



Exhibit 8: Project Information - 1E, Project Costs

**PROJECT DATA**

Type of Project:

Project Location:

Length of Construction Period:  years

Length of Travel Period:  years

**HIGHWAY ACCIDENT DATA**

Actual 3-Year Accident Data Table

Statistical Data: Average Accident Rate

**PROJECT COSTS (enter costs in thousands of dollars)**

Year	DIRECT PROJECT COSTS			SUBSEQUENT COSTS			Transit Agency Cost Savings	TOTAL COSTS (in dollars)	
	Project Support	R/W	Construction	Maint./Op.	Rehab.	Mitigation		Constant Dollars	Present Value
<b>Construction Period</b>									
1								\$0	\$0
2								0	0
3								0	0
4								0	0
5								0	0
6								0	0
7								0	0
8								0	0
<b>Project Open</b>									
1								\$0	\$0
2								0	0
3								0	0
4								0	0
5								0	0
6								0	0
7								0	0
8								0	0
9								0	0
10								0	0
11								0	0
12								0	0
13								0	0
14								0	0
15								0	0
16								0	0
17								0	0
18								0	0
19								0	0
20								0	0
<b>Total</b>	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0

**DIRECT PROJECT COSTS (IN THOUSANDS OF DOLLARS)**

- *Initial Costs* include:
  - Project support (e.g., engineering design and management costs),
  - Right-of-way acquisition costs, and
  - Construction costs.

Each project should incur no initial project costs after the project opens. Cal-B/C assumes that all construction funding has been spent by the opening day of the project. The user cannot exceed the number of construction years entered in Section 1A of the project information worksheet. If the user does not enter the construction costs correctly, the model prompts the user for the correct information under subsequent costs. This is illustrated in Exhibit 8.

- *Subsequent Costs* are costs incurred after the project is constructed and open for service. These costs include:
  - Maintenance and operating costs
  - Rehabilitation costs (e.g., pavement overlay, vehicle, track, or station refurbishment).

The user enters estimated future incremental maintenance, operating and rehabilitation costs in constant 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 transit noise. The user enters these costs in constant dollars during construction and for 20 years after construction had been completed.

**TRANSIT AGENCY COST SAVINGS (IN THOUSANDS OF DOLLARS).** The model calculates this column automatically. This cost element represents the cost savings to a transit agency due to efficiency improvements. For example, signal prioritization projects speed up bus services, which may reduce operating hours and result in lower labor and other operating costs.

**TOTAL COSTS (IN DOLLARS).** The remaining two columns are calculated by the model automatically. These two columns include the project cost in constant dollars and the net present value for each year. Note that the model multiplies the values in the previous columns by 1000, so these values are in dollars (not thousands of dollars). Each column is summarized at the bottom of the section. The following formula is used to calculate the net present value:

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

#### PROJECT EXAMPLE STEP 4: Project Cost Data

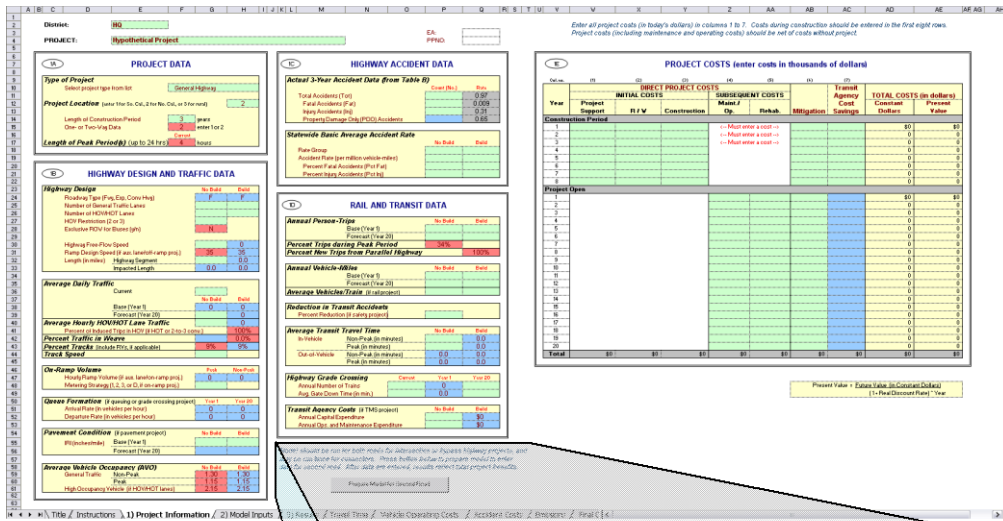
This is the final data entry required to perform a basic analysis. Users with project-specific information can change any parameter within the model. Please refer to the technical supplement for a more detailed discussion of the model assumptions. Let us continue with our analysis.

- (1) Enter the **Initial Project Costs**. Input cost data for each year that you indicated in the “Length of Construction Period” cell in the “Project Data” (Section 1A) of this worksheet. For this example, since you entered a construction period of three years, you must enter three years of data. Enter \$13,820 in construction costs for Year 1, and \$45,200 in both Years 2 and 3. (Note that these numbers are in thousands, so our example has project costs of over \$100 million). If you fail to enter cost data for the appropriate number of years the worksheet will issue a warning message.
- (2) Now look at the years after the project is constructed and open for service. In our project, we could allocate funding to operate and maintain the project. However, since this is a lane addition over a short distance, we will assume that the incremental costs to maintain and operate the additional lane are minimal.
- (3) Before reviewing the results of the model, please review the work done to this point. In the project cost section, you should have a total project cost of \$104,220,000 in constant 2016 dollars. After discounting, this corresponds to a present value of \$99,071,479.

### 4.1F Bypass, Intersection, and Truck Only Lane Projects

Since two roads are involved, bypass and intersection projects require the user to enter two sets of highway data. The model calculates benefits for the first road before the user enters information about the second road. To estimate benefits for the second road, the user clicks the button shown in Exhibit 9. A macro clears the Project Information worksheet so it is ready for the user to input information on the second road. The detailed calculations for the first road are lost, so it is good practice to save a copy of the analysis before entering information for the second road. Cal-B/C uses this same capability for analyzing truck only lanes. The truck only lane are treated as the second road. An example of analyzing truck only lanes is provided in Appendix C.

**Exhibit 9: Project Information - Bypass and Intersection Analysis Button**



Model should be run for both roads for intersection or bypass highway projects, and may be run twice for connectors. Press button below to prepare model to enter data for second road. After data are entered, results reflect total project benefits.

Prepare Model for Second Road

Button resets model to accept data for second road

The macro in the latest version of Cal-B/C prompts the user to save the model and automatically starts a new copy of the model before moving any data. The user should use this button for bypass and intersection projects. If the user clicks this button for any other type of project, the user must re-open the model and start the analysis again.

For intersection projects, the macro clears the highway information box, so traffic and highway geometric data can be entered for the other (intersecting) road. For bypass projects, the model erases the highway information under the “No Build” project column and calculates the “Build” column traffic on the bypass road as the “No Build” traffic minus the traffic on the existing roads.

The user needs to enter only the highway geometric information (e.g., number of lanes, etc.). For bypass projects, the model automatically changes the colors of the green and blue boxes in the highway design and traffic data section (Section 1B) so the user knows what data to enter. For both types of projects, the model retains accident data for the second road, but the user can change this if data specific to second road are available.

For truck only lanes, the model assumes that all trucks use the truck only lanes, so the “Build” traffic is estimated as the “No Build” traffic multiplied by 1 minus the percent trucks. The macro clears the “No Build” column, since the truck only lane does not currently exist and estimates the “Build” traffic as the trucks only.

After entering data for the first road, the user should check the speeds and volumes in the Model Inputs sheet. The user should return to the Project Information sheet to click the button. The model cannot calculate induced demand for bypass projects.

## 4.2 Model Inputs Worksheet

The model inputs worksheet (Exhibit 10) allows the user to review and replace several values for the benefit-cost analysis. More in-depth data are available for many projects, such as the output of a regional travel demand model or micro-simulation results for a TMS project. If these data are available, the user should override the Cal-B/C calculations. The model provides three sections in the model inputs worksheet for doing this:

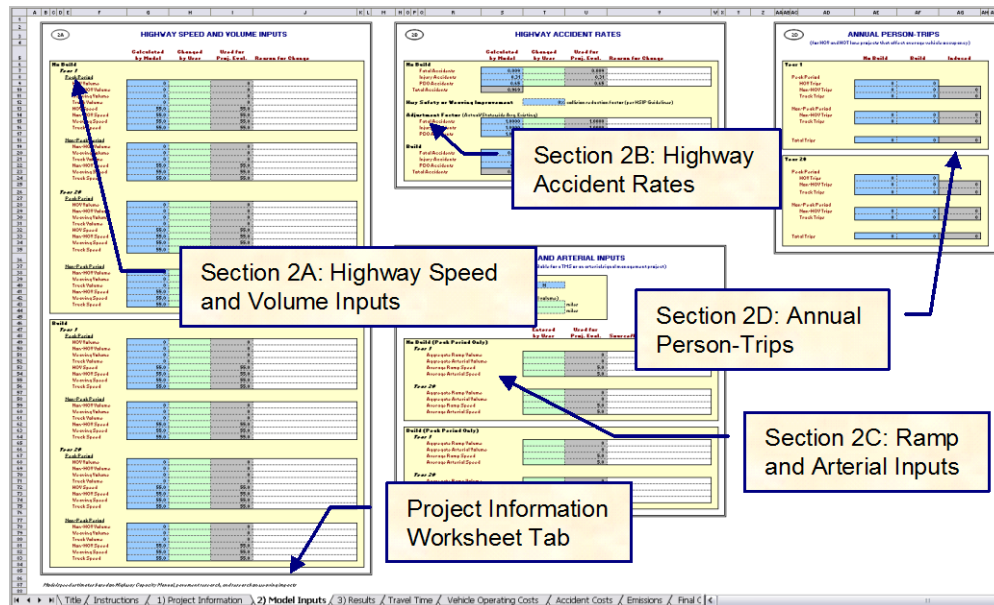
- 2A Highway Speed and Volume Inputs
  - Peak and non-peak periods
  - HOV, non-HOV, weaving, and truck volumes
  - HOV, non-HOV, weaving, and truck speeds
- 2B Highway Accident Rates and adjustment factors
  - Fatal accidents
  - Injury accidents
  - Property damage only (PDO) accidents
- 2C Ramp and Arterial Inputs
  - Aggregate ramp or arterial
  - Injury accidents
  - Property damage only (PDO) accidents.

The sheet shows the model estimate and provides space for the user to change the value without disrupting the model defaults. There is also space to input an explanation for the change.

A fourth section (2D) provides annual person-trip data estimated in the model for HOV conversion and HOT lane projects. This information is provided for review purposes only. The user should adjust the ADT and AVO data if the annual person-trip estimates are not as expected



Exhibit 10: Model Inputs Sheet



For example, Cal-B/C forecasts “Build” accident rates by calculating the ratio of current accident rates to the statewide average found in the annual collision report. If a particular stretch of highway has accident rates above the statewide average, the model will forecast “Build” accident rates to be above the average.

If the project is designed to lower accident rates to the statewide average, the user must manually override the value calculated by the model by changing the accident adjustment factor. The model assumes (through the adjustment factor) that the differential remains the same for the “Build” facility. The user can change this factor to 1.0 to result in accident rates at the statewide averages for the facility type. The user can control this calculation separately for fatal, injury, and PDO accidents.

In the latest version of Cal-B/C, calculations using the highway safety or weaving improvement percentage are consistent with the collision reduction factors found in the Caltrans Highway Safety Improvement Program (HSIP) Guidelines. The user can use the factors found in the guidelines to estimate the benefits of safety projects.

### 4.3 Results Worksheet

The final worksheet covered in this User's Guide is the *Results Worksheet*. This is where Cal-B/C outputs the results of the benefit-cost assessment. Exhibit 11 shows an example of this output.





**Exhibit 11: Results Worksheet - Final Model Output**

District: 8  
PROJECT: Hypothetical Project, General Highway Improvement  
EA:   
PPNO:   
3

### INVESTMENT ANALYSIS SUMMARY RESULTS

<b>Life-Cycle Costs (mil. \$)</b>	\$99.1				
<b>Life-Cycle Benefits (mil. \$)</b>	\$314.9				
<b>Net Present Value (mil. \$)</b>	\$215.8				
<b>Benefit / Cost Ratio:</b>	3.2				
<b>Rate of Return on Investment:</b>	15.4%				
<b>Payback Period:</b>	8 years				

	Passenger Benefits	Freight Benefits	Total Over 20 Years	Average Annual
<b>ITEMIZED BENEFITS (mil. \$)</b>				
Travel Time Savings	\$227.5	\$51.4	\$278.9	\$13.9
Veh. Op. Cost Savings	\$7.4	\$0.0	\$7.5	\$0.4
Accident Cost Savings	\$22.1	\$2.2	\$24.3	\$1.2
Emission Cost Savings	\$1.2	\$3.0	\$4.2	\$0.2
<b>TOTAL BENEFITS</b>	<b>\$258.2</b>	<b>\$56.6</b>	<b>\$314.9</b>	<b>\$15.7</b>
<b>Person-Hours of Time Saved</b>			32,469,377	1,623,469

**Should benefit-cost results include:**

1) Induced Travel? (y/n)	<input checked="" type="checkbox"/> Y <small>Default = Y</small>
2) Vehicle Operating Costs? (y/n)	<input checked="" type="checkbox"/> Y <small>Default = Y</small>
3) Accident Costs? (y/n)	<input checked="" type="checkbox"/> Y <small>Default = Y</small>
4) Vehicle Emissions? (y/n) <small>includes value for CO<sub>2</sub>e</small>	<input checked="" type="checkbox"/> Y <small>Default = Y</small>

	Tons		Value (mil. \$)	
	Total Over 20 Years	Average Annual	Total Over 20 Years	Average Annual
<b>EMISSIONS REDUCTION</b>				
CO Emissions Saved	461	23	\$0.0	\$0.0
CO <sub>2</sub> Emissions Saved	81,856	4,093	\$2.2	\$0.1
NO <sub>x</sub> Emissions Saved	194	10	\$2.1	\$0.1
PM <sub>10</sub> Emissions Saved	0	0	-\$0.1	-\$0.0
PM <sub>2.5</sub> Emissions Saved	0	0		
SO <sub>x</sub> Emissions Saved	1	0	\$0.0	\$0.0
VOC Emissions Saved	25	1	\$0.0	\$0.0

Navigation: Title | Instructions | 1) Project Information | 2) Model Inputs | 3) Results | Travel Time | Vehicle Operating Costs | Accident Costs | Emissions | Final Calculations | PARAMETERS

At the bottom of the Results worksheet, the user can control which benefits are included. All four user benefits, except for travel time benefits can be selectively included or excluded. The travel time benefits are always included since they typically comprise the majority of project benefits. The default setting for all benefits is “Y,” which means that the benefits are included in the benefit-cost analysis. The exclusion of emissions will eliminate benefits from the benefit-cost calculation, but the itemized emissions are still reported separately. Any change to a toggle setting for a bypass, intersection, or truck only lane project should be made before the button is pushed to prepare the model for the other road. Including or excluding benefits affects the current road only.

Cal-B/C provides several summary results, which highlight different aspects of the project:

- **Life-Cycle Costs** are the present values of all net project costs, including initial and subsequent costs in real current dollars.
- **Life-Cycle Benefits** are the sum of the present value benefits for the project.
- **Net Present Value** equals the life-cycle benefits minus the life-cycle costs. The value of benefits exceeds the value of costs for a project with a positive net present value.
- **Benefit/Cost Ratio** shows the benefits relative to the costs of a project. A project with a benefit-cost ratio greater than one has a positive economic value.
- **Rate of Return on Investment** is the discount rate at which benefits and costs are equal. For a project with a rate of return greater than the discount rate, the benefits are

greater than costs and the project has a positive economic value. The user can use rate of return to compare projects with different costs and different benefit flows over different time periods. This is particularly useful for project staging.

- **Payback Period** is the number of years it takes for the net benefits (life-cycle benefits minus life-cycle costs) to equal the initial construction costs. For a project with a payback period longer than the life-cycle of the project, initial construction costs are not recovered. The payback period varies inversely with the benefit-cost ratio. A shorter payback period yields a higher benefit-cost ratio.

The model calculates these results over the standard 20-year project life-cycle. Cal-B/C itemizes each of the four user benefits for both person trips and freight trips and displays the annualized and life-cycle user benefits. The annualized benefit is calculated as the life-cycle benefit divided by twenty.

Below the itemized project benefits, Cal-B/C displays:

- **Person-Hours of Time Saved** shows the reduction in person-hours of travel time due to the project. A positive value indicates a net benefit.
- **Emissions Reduction** shows the itemized change in emissions for CO, CO<sub>2</sub>, NO<sub>x</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>x</sub>, and VOC. A positive value indicates a reduction in emissions, while a negative value indicates an increase in emissions. The change in emissions are reported in tons and millions of dollars. PM<sub>2.5</sub> is reported only in tons because a generally accepted economic value was not available at the time of the model update.

#### **PROJECT EXAMPLE: Complete**

The project input has been completed, we have double-checked our data, and we are ready to review the results. Having completed the data entry means that we have completed the *Project Information* worksheet and the *Model Inputs* worksheet. The results are shown in the investment analysis summary (Exhibit 11).

You are now ready to use Cal-B/C to model highway, rail or transit improvement projects. For more information about how Cal-B/C estimates particular impacts, please see the Technical Supplement to the User's Guide.

# APPENDIX A: Passenger Rail Improvement Project Example

Open the *Project Information* sheet to begin an analysis. Exhibit A1 shows the *Project Data* section for a passenger rail improvement project. Green cells are cells that require data input. The red cells provide default values that the user can change.

Exhibit A1: Project Information Worksheet Section 1A

1A PROJECT DATA	
<b>Type of Project</b> Select project type from list	Enter data in both sections 1B & 1E Passenger Rail
<b>Project Location</b> (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural)	1
Length of Construction Period	2 years
One- or Two-Way Data	2 enter 1 or 2
<b>Length of Peak Period(s)</b> (up to 24 hrs)	Current 5 hours

- 1) **Type of Project.** Select the “Passenger Rail” project type.
- 2) **Project Location.** This cell requires you to enter a “1” for Southern California urban areas, a “2” for Northern California urban areas, or a “3” for rural areas in order to determine emissions benefits for the project. Assume that our project is being built in Southern California and put a “1” in this cell. This cell tells the model which emissions tables to reference.
- 3) **Length of Construction Period.** Enter the amount of time needed to construct the project. Assume that our rail project will be completed in two years. The model evaluates project impacts only after the project is built. For example, a project begun in 2017 that takes five years to complete would not cause any impacts until 2022 when the project opens. The Year 1 impacts occur in 2022. The Year 20 impacts would occur in 2041 for this hypothetical project. Cal-B/C uses this cell to determine the economic impacts. The entry must be a whole number. For example, a project that will take 8 months to construct should be entered as “1”, representing one year. A project taking 2 years and 5 months can be rounded down to 2 years or up to three years, at the user’s discretion, but the entry in this cell must be consistent with the cost data entered.
- 4) **One- or Two-Way Data.** Enter the number of directions across which traffic flows along this corridor. In this case, leave the default value of “2”.
- 5) **Length of Peak Period(s).** For our project, enter a “5” in this cell to represent a five-hour daily peak travel period (including both the AM and PM peak periods). The peak period length helps convert average daily traffic volumes into average peak and non-peak volumes and



speeds. Speed is an important variable to determine travel time savings, fuel consumption, and emissions.

Now move to the *Highway Design and Traffic Data* section of the project information worksheet (Exhibit A2).

**Exhibit A2: Project Information Worksheet Section 1B**

1B HIGHWAY DESIGN AND TRAFFIC DATA		
<b>Highway Design</b>		
	No Build	Build
Roadway Type (Fwy, Exp, Conv Hwy)	F	F
Number of General Traffic Lanes	6	6
Number of HOV/HOT Lanes		
HOV Restriction (2 or 3)		
Exclusive ROW for Buses (y/n)	N	
Highway Free-Flow Speed	55	55
Ramp Design Speed (if aux. lane/off-ramp proj.)	35	35
Length (in miles) Highway Segment	50.0	50.0
Impacted Length	50.0	50.0
<b>Average Daily Traffic</b>		
Current	130,000	
	No Build	Build
Base (Year 1)	143,124	143,124
Forecast (Year 20)	267,800	267,800
<b>Average Hourly HOV/HOT Lane Traffic</b>		
Percent of Induced Trips in HOV (if HOT or 2-to-3 conv.)		100%
<b>Percent Traffic in Weave</b>		
		0.0%
<b>Percent Trucks</b> (include RVs, if applicable)		
	9%	9%
<b>Truck Speed</b>		
<b>On-Ramp Volume</b>		
	Peak	Non-Peak
Hourly Ramp Volume (if aux. lane/on-ramp proj.)	0	0
Metering Strategy (1, 2, 3, or D, if on-ramp proj.)		
<b>Queue Formation</b> (if queuing or grade crossing project)		
	Year 1	Year 20
Arrival Rate (in vehicles per hour)	0	0
Departure Rate (in vehicles per hour)	0	0
<b>Pavement Condition</b> (if pavement project)		
	No Build	Build
IRI (inches/mile) Base (Year 1)		
Forecast (Year 20)		
<b>Average Vehicle Occupancy (AVO)</b>		
	No Build	Build
General Traffic Non-Peak	1.30	1.23
Peak	1.15	1.08
High Occupancy Vehicle (if HOV/HOT lanes)	2.15	2.15

- 6) **Highway Design.** Assume that the highway parallel to the rail project has six (6) general traffic lanes and no HOV lanes in both directions (i.e., three lanes per direction). Set the free-flow speed to 55 mph. Make sure that the “Build” number of lanes is the same as the “No Build”. Otherwise, the model will not produce the correct results for this rail project. (A lane addition project requires that the “Build” number of lanes be greater than the “No Build” number.) The model does not allow the user to “phase in” the construction. For example,

you cannot construct one lane by Year 1 and another by Year 7. Such a scenario must be analyzed as separate projects.

The blue cell for the “Build” free-flow speed will be set automatically to the “No Build” free-flow speed. The blue cell indicates that you may override this speed if you determine that the free-flow speed in “Build” is different from the “No Build” free-flow speed.

The *Length* cells determine the distance that the project will influence. In our example, assume that the project is an interregional rail project along a 50-mile corridor. The *Impacted Length* applies only to passing lane and operational improvement projects. This is because adding a truck climbing or passing lane improves traffic flow not only on the segment where the lane is located, but also upstream of the new lane.

- 7) **Average Daily Traffic.** Enter the existing average daily traffic into the cell labeled “Current.” Use a value of 130,000 for this exercise. Also, enter a value of 267,800 vehicles per day for the forecast year. Note: The forecast year is the project opening date plus 20 years, NOT the current date plus 20 years.

The model calculates the “Base (Year 1)” value in the “No Build” column. The model uses straight-line interpolation to estimate the Year 1 volume from the current year volume and the Year 20 volume. If you have more accurate data for Year 1, you can override the values calculated by the model.

Notice that the “No Build” and “Build” scenario volumes are the same for the passenger rail project. The model requires the user to assume a constant volume for highway demand, unless demand on the highway is expected to increase due to the rail project. We take the shift from highway to rail into account when we input the transit information. The model will correctly calculate the benefits associated with mode shifts to rail although it is not apparent on this input screen.

Note: the *Results* sheet has an option to include induced demand in the evaluation. If “Y” for “Yes” is selected, the model calculates the change in consumer surplus associated with the extra traffic in the “Build” scenario compared to the “No Build” scenario. For a transit project, Cal-B/C assumes that highway demand is inelastic (i.e., no induced demand occurs).

- 8) **Average Hourly HOV/HOT Lane Traffic.** Update these cells only if there are HOV or HOT lanes along the corridor. As with the average daily traffic cells, these cells require the “No Build” number of HOV/HOT lanes and the future number of HOV/HOT lanes when the project is completed. The model assumes that all lanes are constructed by Year 1.
- 9) **Percent Trucks.** Enter the percent truck composition of the traffic stream. The model assumes a nine percent truck composition for both the “No Build” and “Build” project scenarios.
- 10) **Truck Speed.** We do not need this information for our passenger rail project. For passing lane projects, trucks travel this speed on a grade when there is no passing lane. Cal-B/C calculates the automobile speed based on the volume and capacity of the roadway using

volume/capacity relationships provided in the 2010 Highway Capacity Manual. Trucks may have a much slower speed on grades where a passing lane project is to be constructed. Leave this cell empty for our project.

- 11) **Average Vehicle Occupancy (AVO).** This is the average number of people per vehicle on the highway. Let us use the model default of 1.30 for the non-peak AVO and 1.15 for the peak AVO in the “No Build” scenario. Assume a slight reduction in AVO to 1.23 for the off-peak and 1.08 for the peak as travelers use more transit in the “Build” scenario.

The model has the statewide averages already entered in Exhibit A3. Assume, however, that we have some highway accident data and projections available for our project.

**Exhibit A3: Project Information Worksheet Section 1C**

1C <b>HIGHWAY ACCIDENT DATA</b>		
<b>Actual 3-Year Accident Data (from Table B)</b>		
	Count (No.)	Rate
Total Accidents (Tot)	6310	0.89
Fatal Accidents (Fat)	71	0.010
Injury Accidents (Inj)	1872	0.26
Property Damage Only (PDO) Accidents	4367	0.61
<b>Statewide Basic Average Accident Rate</b>		
	No Build	Build
Rate Group		
Accident Rate (per million vehicle-miles)	0.80	0.80
Percent Fatal Accidents (Pct Fat)	2%	2%
Percent Injury Accidents (Pct Inj)	32%	32%

- 12) In the **Actual 3-Year Accident Data (from Table B)** cells, assume there were 6,310 accidents on the parallel highway corridor over the past three years: 71 fatal accidents, 1,872 injury accidents, and 4,367 PDO accidents. This may seem like a lot of accidents, but remember that this is the three-year total over a 50-mile corridor.

- 13) Insert statewide average accident rates per million vehicle-miles for road classifications similar to the existing and proposed facilities. Include Base Rate and ADT factors, where applicable. Also, insert statewide percent of accidents that are fatal and injury accidents for road classifications similar to “No Build” and “Build” facilities. The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates, by accident type, for new road classifications. The Model Inputs worksheet presents results that the user can edit.

For our project, assume that overall accident rates will remain the same (at 0.80 accidents per million vehicle-miles). Also assume the percentage of fatal accidents will remain the same at 2 percent and the percent injury accidents will hold constant at 32 percent.



The rail and transit data (Section 1D), as shown in Exhibit A4, is where we do most of our data entry for the rail project. Assume that we are implementing the project to improve train safety, travel times, and frequency of service. Such a project may require some right-of-way improvements, signaling improvements, and additional passenger train cars.

**Exhibit A4: Project Information Worksheet Section 1D**

1D RAIL AND TRANSIT DATA			
<b>Annual Person-Trips</b>			
		No Build	Build
Base (Year 1)		310,000	400,000
Forecast (Year 20)		460,000	600,000
<b>Percent Trips during Peak Period</b>		60%	
<b>Percent New Trips from Parallel Highway</b>			65%
<b>Annual Vehicle-Miles</b>			
		No Build	Build
Base (Year 1)		532,000	740,000
Forecast (Year 20)		532,000	740,000
<b>Average Vehicles/Train</b> (if rail project)		3	4
<b>Reduction in Transit Accidents</b>			
Percent Reduction (if safety project)		5%	
<b>Average Transit Travel Time</b>			
		No Build	Build
In-Vehicle	Non-Peak (in minutes)	50.0	50.0
	Peak (in minutes)	45.0	45.0
Out-of-Vehicle	Non-Peak (in minutes)	15.0	15.0
	Peak (in minutes)	10.0	10.0
<b>Highway Grade Crossing</b>			
	Current	Year 1	Year 20
Annual Number of Trains		0	
Avg. Gate Down Time (in min.)		0.0	
<b>Transit Agency Costs</b> (if TMS project)			
		No Build	Build
Annual Capital Expenditure			\$0
Annual Ops. and Maintenance Expenditure			\$0

- 14) **Annual Person-Trips.** While we entered current and Forecast (Year 20) average daily traffic for the parallel highway, we input Base (Year 1) and Forecast (Year 20) estimates for transit demand. Input the demand data as shown in Exhibit A4.
- 15) **Percent Trips during Peak Period.** This is where you estimate the ratio of peak period to daily ridership. In our example, assume that 60 percent of all transit trips on the line will occur during the five-hour peak period.
- 16) **Percent New Trips from Parallel Highway.** Typically, improved passenger rail services attract some new trips from the parallel highway. In practice, the percentage of new transit trips coming from highways falls somewhere between 50 percent and 80 percent. Let us assume that our new line will bring 65 percent of its new passengers from the highway in question.
- 17) **Annual Vehicle-Miles.** This is the number of vehicle-miles operated on the passenger rail line per year. Assume 532,000 revenue miles for Years 1 and 20 in the “No Build” scenario and 740,000 for the “Build” scenario.



- 18) **Average Vehicles per Train.** Enter the number of train cars that will be used on an average train consist during the day. In our example, we assume that each train will add an average of one car per train during the day increasing from three cars in the “No Build” scenario to four for our project. This means that some trains may have three cars, but others may have five or more per consist depending on the demand.
- 19) **Reduction in Transit Accidents.** If you are building a safety project, enter the percent reduction in transit accidents expected due to the project. Assume that this project includes grade-crossing improvements to increase vehicle and pedestrian safety, which leads to a five-percent reduction in train incidents.
- 20) **Average Transit Travel Time.** This is where you enter the average travel time required to make a trip on transit or rail. The transit travel time represents the total travel time by transit and includes the waiting time for the transit vehicle, transfer time, and the in-transit time. Enter the values as shown in Exhibit A4.
- 21) **Transit Agency Costs.** Since there is no Transportation Management System (TMS) component to this project, leave this section blank. For a TMS project, however, Cal-B/C requires that the user input annual capital, operating, and maintenance expenditures for routes impacted by the project. The model calculates cost reductions for the new expenditures due to transit TMS. Agency cost savings are estimated automatically as a negative cost.

Now we are at the final data entry step required to perform a basic analysis. Users with project-specific information can change any parameter within the model. Please refer to the technical supplement for a more detailed discussion of the model assumptions. Let us continue with our analysis. Exhibit A5 shows the data that we will enter for this project.





Exhibit A5: Project Information Worksheet Section 1E

1E PROJECT COSTS (enter costs in thousands of dollars)									
Col. no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
Year	DIRECT PROJECT COSTS			SUBSEQUENT COSTS		Mitigation	Transit Agency Cost Savings	TOTAL COSTS (in dollars)	
	Project Support	R / W	Construction	Maint./ Op.	Rehab.			Constant Dollars	Present Value
<b>Construction Period</b>									
1	\$500	\$4,000	\$6,000			250		\$10,750,000	\$10,750,000
2	400		12,750			500		13,650,000	13,125,000
3	200		12,750			800		13,750,000	12,712,648
4								0	0
5								0	0
6								0	0
7								0	0
8								0	0
<b>Project Open</b>									
1				\$175				\$175,000	\$161,797
2				175				175,000	155,574
3				175				175,000	149,591
4				175				175,000	143,837
5				175				175,000	138,305
6				175				175,000	132,986
7				175				175,000	127,871
8				175				175,000	122,953
9				175				175,000	118,224
10				175	2,000			2,175,000	1,412,839
11				175				175,000	109,304
12				175				175,000	105,100
13				175				175,000	101,058
14				175				175,000	97,171
15				175				175,000	93,434
16				175				175,000	89,840
17				175				175,000	86,385
18				175				175,000	83,062
19				175				175,000	79,868
20				175				175,000	76,796
<b>Total</b>	\$1,100	\$4,000	\$31,500	\$3,500	\$2,000	\$1,550	\$0	\$43,650,000	\$40,173,644

22) **Initial Project Costs.** Enter the project costs for Years 0 through 2 as shown in Exhibit A5. Note the error message received after entering the data for Year 2. It says, “Adjust Construction Period” (Look at the white space under the “Subsequent Cost” columns). Our construction dollars are being spent over three years, yet we indicated in Section 1A of the Project Information worksheet that construction would last only two years. Go back to the Project Information sheet and make the change as shown in Exhibit A6 below. Notice that the ADT estimated for Year 1 increases, since the additional construction year allows traffic to grow an additional year. Year 20 does not increase because this was a fixed user entry. You could change this entry as well if there were an error. For our example, we will not change the Year 20 traffic, because we simply made a mistake in typing in the number of construction years.

**Exhibit A6: Project Information Worksheet Correcting Section 1A**

1A

## PROJECT DATA

**Type of Project** Enter data in both sections 1B & 1E  
 Select project type from list Passenger Rail

**Project Location** (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural) 1

Length of Construction Period 3 years  
 One- or Two-Way Data 2 enter 1 or 2

Length of Peak Period(s) (up to 24 hrs) 5 hours  
Current

Change to  
"3" years

23) Now look at the years after the project is constructed and open for service. In our project, we will have to allocate funding to operate and maintain the project. These project maintenance and operating costs are the incremental costs required to operate the additional service, not the costs to operate the total service on the alignment. If we were to increase service on an existing rail line, we would subtract the cost required to operate the current route (i.e., the “No Build” scenario) from the cost to operate the “Build” scenario.

24) Before examining the results of the model, please review the work done to this point. In the project cost section, you should have a total project cost of \$43.7 million with a net present value of \$40.2 million.

We have completed the *Project Information Worksheet*, but assume for our example that we have additional volume information from a regional travel demand model. In particular, we have more detailed estimates of peak and off-peak volumes. In the Model Inputs sheet, the average daily volume is broken into peak and non-peak volumes as shown in Exhibit A7.



**Exhibit A7: Model Inputs Worksheet Section 2A**

2A		<b>HIGHWAY SPEED AND VOLUME INPUTS</b>			
		Calculated by Model	Changed by User	Used for Proj. Eval.	Reason for Change
<b>No Build</b>					
<b>Year 1</b>					
<u>Peak Period</u>					
HOV Volume	0			0	
Non-HOV Volume	52,488	41,267		41,267	
Weaving Volume	0			0	
Truck Volume	5,191	4,081		4,081	
HOV Speed	55.0			55.0	
Non-HOV Speed	54.3			54.3	
Weaving Speed	55.0			55.0	
Truck Speed	54.3			54.3	
<u>Non-Peak Period</u>					
Non-HOV Volume	77,755	91,425		91,425	
Weaving Volume	0			0	
Truck Volume	7,690	9,042		9,042	
Non-HOV Speed	55.0			55.0	
Weaving Speed	55.0			55.0	
Truck Speed	55.0			55.0	
<b>Year 20</b>					
<u>Peak Period</u>					
HOV Volume	0			0	
Non-HOV Volume	98,210	74,274		74,274	
Weaving Volume	0			0	
Truck Volume	9,713	7,346		7,346	
HOV Speed	55.0			55.0	
Non-HOV Speed	10.3			10.3	
Weaving Speed	55.0			55.0	
Truck Speed	10.3			10.3	
<u>Non-Peak Period</u>					
Non-HOV Volume	145,488	164,550		164,550	
Weaving Volume	0			0	
Truck Volume	14,389	16,274		16,274	
Non-HOV Speed	53.9			53.9	
Weaving Speed	55.0			55.0	
Truck Speed	53.9			53.9	
<b>Build</b>					
<b>Year 1</b>					
<u>Peak Period</u>					
HOV Volume	0			0	
Non-HOV Volume	52,404	41,185		41,185	
Weaving Volume	0			0	
Truck Volume	5,191	4,081		4,081	
HOV Speed	55.0			55.0	
Non-HOV Speed	54.4			54.4	
Weaving Speed	55.0			55.0	
Truck Speed	54.4			54.4	
<u>Non-Peak Period</u>					
Non-HOV Volume	77,706	91,376		91,376	
Weaving Volume	0			0	
Truck Volume	7,690	9,042		9,042	
Non-HOV Speed	55.0			55.0	
Weaving Speed	55.0			55.0	
Truck Speed	55.0			55.0	
<b>Year 20</b>					
<u>Peak Period</u>					
HOV Volume	0			0	
Non-HOV Volume	98,080	74,147		74,147	
Weaving Volume	0			0	
Truck Volume	9,713	7,346		7,346	
HOV Speed	55.0			55.0	
Non-HOV Speed	10.4			10.4	
Weaving Speed	55.0			55.0	
Truck Speed	10.4			10.4	
<u>Non-Peak Period</u>					
Non-HOV Volume	145,411	164,475		164,475	
Weaving Volume	0			0	
Truck Volume	14,389	16,274		16,274	
Non-HOV Speed	53.9			53.9	
Weaving Speed	55.0			55.0	
Truck Speed	53.9			53.9	



25) Fill in the Non-HOV and Truck Volume cells in the “Changed by User” column with the values shown in Exhibit A7.

Note: the total volume in the “Used for Proj. Eval.” field for each section should equal the total volume on the highway.

The project input has been completed, we have double-checked our data, and we are ready to review the results. Having completed the data entry means that we have completed the *Project Information* worksheet and the *Model Inputs* worksheet. The results are shown in the investment analysis summary (Exhibit A8).

**Exhibit A8: Results Worksheet Section 3**

3

### INVESTMENT ANALYSIS

#### SUMMARY RESULTS

<b>Life-Cycle Costs (mil. \$)</b> <input style="width: 80%;" type="text" value="\$40.0"/> <b>Life-Cycle Benefits (mil. \$)</b> <input style="width: 80%;" type="text" value="\$71.3"/> <b>Net Present Value (mil. \$)</b> <input style="width: 80%;" type="text" value="\$31.3"/>	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">ITEMIZED BENEFITS (mil. \$)</th> <th style="text-align: center;">Passenger Benefits</th> <th style="text-align: center;">Freight Benefits</th> <th style="text-align: center;">Total Over 20 Years</th> <th style="text-align: center;">Average Annual</th> </tr> </thead> <tbody> <tr> <td>Travel Time Savings</td> <td style="text-align: right;">\$38.0</td> <td style="text-align: right;">\$7.3</td> <td style="text-align: right;">\$45.3</td> <td style="text-align: right;">\$2.3</td> </tr> <tr> <td>Veh. Op. Cost Savings</td> <td style="text-align: right;">\$20.2</td> <td style="text-align: right;">\$1.6</td> <td style="text-align: right;">\$21.8</td> <td style="text-align: right;">\$1.1</td> </tr> <tr> <td>Accident Cost Savings</td> <td style="text-align: right;">\$4.3</td> <td style="text-align: right;">\$0.0</td> <td style="text-align: right;">\$4.3</td> <td style="text-align: right;">\$0.2</td> </tr> <tr> <td>Emission Cost Savings</td> <td style="text-align: right;">-\$3.3</td> <td style="text-align: right;">\$3.2</td> <td style="text-align: right;">-\$0.1</td> <td style="text-align: right;">-\$0.0</td> </tr> <tr> <td><b>TOTAL BENEFITS</b></td> <td style="text-align: right;"><b>\$59.2</b></td> <td style="text-align: right;"><b>\$12.1</b></td> <td style="text-align: right;"><b>\$71.3</b></td> <td style="text-align: right;"><b>\$3.6</b></td> </tr> </tbody> </table>	ITEMIZED BENEFITS (mil. \$)	Passenger Benefits	Freight Benefits	Total Over 20 Years	Average Annual	Travel Time Savings	\$38.0	\$7.3	\$45.3	\$2.3	Veh. Op. Cost Savings	\$20.2	\$1.6	\$21.8	\$1.1	Accident Cost Savings	\$4.3	\$0.0	\$4.3	\$0.2	Emission Cost Savings	-\$3.3	\$3.2	-\$0.1	-\$0.0	<b>TOTAL BENEFITS</b>	<b>\$59.2</b>	<b>\$12.1</b>	<b>\$71.3</b>	<b>\$3.6</b>
ITEMIZED BENEFITS (mil. \$)	Passenger Benefits	Freight Benefits	Total Over 20 Years	Average Annual																											
Travel Time Savings	\$38.0	\$7.3	\$45.3	\$2.3																											
Veh. Op. Cost Savings	\$20.2	\$1.6	\$21.8	\$1.1																											
Accident Cost Savings	\$4.3	\$0.0	\$4.3	\$0.2																											
Emission Cost Savings	-\$3.3	\$3.2	-\$0.1	-\$0.0																											
<b>TOTAL BENEFITS</b>	<b>\$59.2</b>	<b>\$12.1</b>	<b>\$71.3</b>	<b>\$3.6</b>																											
<b>Benefit / Cost Ratio:</b> <input style="width: 80%;" type="text" value="1.8"/>  <b>Rate of Return on Investment:</b> <input style="width: 80%;" type="text" value="8.0%"/>  <b>Payback Period:</b> <input style="width: 80%;" type="text" value="16 years"/>	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 70%;"><b>Person-Hours of Time Saved</b></td> <td style="width: 15%; text-align: right;"><input style="width: 80%;" type="text" value="6,489,664"/></td> <td style="width: 15%; text-align: right;"><input style="width: 80%;" type="text" value="324,483"/></td> </tr> </table>	<b>Person-Hours of Time Saved</b>	<input style="width: 80%;" type="text" value="6,489,664"/>	<input style="width: 80%;" type="text" value="324,483"/>																											
<b>Person-Hours of Time Saved</b>	<input style="width: 80%;" type="text" value="6,489,664"/>	<input style="width: 80%;" type="text" value="324,483"/>																													

<b>Should benefit-cost results include:</b>  1) Induced Travel? (y/n) <input style="width: 80%;" type="text" value="Y"/> <small style="color: red;">Default = Y</small> 2) Vehicle Operating Costs? (y/n) <input style="width: 80%;" type="text" value="Y"/> <small style="color: red;">Default = Y</small> 3) Accident Costs? (y/n) <input style="width: 80%;" type="text" value="Y"/> <small style="color: red;">Default = Y</small> 4) Vehicle Emissions? (y/n) <input style="width: 80%;" type="text" value="Y"/> <small style="color: red;">Default = Y</small> <small>includes value for CO<sub>2e</sub></small>	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th rowspan="2" style="text-align: left;">EMISSIONS REDUCTION</th> <th colspan="2" style="text-align: center;">Tons</th> <th colspan="2" style="text-align: center;">Value (mil. \$)</th> </tr> <tr> <th style="text-align: center;">Total Over 20 Years</th> <th style="text-align: center;">Average Annual</th> <th style="text-align: center;">Total Over 20 Years</th> <th style="text-align: center;">Average Annual</th> </tr> </thead> <tbody> <tr> <td>CO Emissions Saved</td> <td style="text-align: right;">139</td> <td style="text-align: right;">7</td> <td style="text-align: right;">\$0.0</td> <td style="text-align: right;">\$0.0</td> </tr> <tr> <td>CO<sub>2</sub> Emissions Saved</td> <td style="text-align: right;">69,914</td> <td style="text-align: right;">3,496</td> <td style="text-align: right;">\$1.8</td> <td style="text-align: right;">\$0.1</td> </tr> <tr> <td>NO<sub>x</sub> Emissions Saved</td> <td style="text-align: right;">47</td> <td style="text-align: right;">2</td> <td style="text-align: right;">\$0.4</td> <td style="text-align: right;">\$0.0</td> </tr> <tr> <td>PM<sub>10</sub> Emissions Saved</td> <td style="text-align: right;">-7</td> <td style="text-align: right;">0</td> <td style="text-align: right;">-\$2.5</td> <td style="text-align: right;">-\$0.1</td> </tr> <tr> <td>PM<sub>2.5</sub> Emissions Saved</td> <td style="text-align: right;">0</td> <td style="text-align: right;">0</td> <td></td> <td></td> </tr> <tr> <td>SO<sub>x</sub> Emissions Saved</td> <td style="text-align: right;">1</td> <td style="text-align: right;">0</td> <td style="text-align: right;">\$0.1</td> <td style="text-align: right;">\$0.0</td> </tr> <tr> <td>VOC Emissions Saved</td> <td style="text-align: right;">9</td> <td style="text-align: right;">0</td> <td style="text-align: right;">\$0.0</td> <td style="text-align: right;">\$0.0</td> </tr> </tbody> </table>	EMISSIONS REDUCTION	Tons		Value (mil. \$)		Total Over 20 Years	Average Annual	Total Over 20 Years	Average Annual	CO Emissions Saved	139	7	\$0.0	\$0.0	CO <sub>2</sub> Emissions Saved	69,914	3,496	\$1.8	\$0.1	NO <sub>x</sub> Emissions Saved	47	2	\$0.4	\$0.0	PM <sub>10</sub> Emissions Saved	-7	0	-\$2.5	-\$0.1	PM <sub>2.5</sub> Emissions Saved	0	0			SO <sub>x</sub> Emissions Saved	1	0	\$0.1	\$0.0	VOC Emissions Saved	9	0	\$0.0	\$0.0
EMISSIONS REDUCTION	Tons		Value (mil. \$)																																										
	Total Over 20 Years	Average Annual	Total Over 20 Years	Average Annual																																									
CO Emissions Saved	139	7	\$0.0	\$0.0																																									
CO <sub>2</sub> Emissions Saved	69,914	3,496	\$1.8	\$0.1																																									
NO <sub>x</sub> Emissions Saved	47	2	\$0.4	\$0.0																																									
PM <sub>10</sub> Emissions Saved	-7	0	-\$2.5	-\$0.1																																									
PM <sub>2.5</sub> Emissions Saved	0	0																																											
SO <sub>x</sub> Emissions Saved	1	0	\$0.1	\$0.0																																									
VOC Emissions Saved	9	0	\$0.0	\$0.0																																									

# APPENDIX B: Truck Climbing Lane Example

Open the *Project Information* sheet to begin an analysis. Exhibit B1 shows the *Project Data* section for a truck climbing lane improvement project. Green cells are cells that require data input. The red cells provide default values that the user can change.

Exhibit B1: Project Information Worksheet Section 1A

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

- 1) **Type of Project.** Select the “Passing Lane” project type.
- 2) **Project Location.** This cell requires you to enter a “1” for Southern California urban areas, a “2” for Northern California urban areas, or a “3” for rural areas in order to determine emissions benefits for the project. This project is being built in Southern California so put a “1” in this cell. This cell tells the model which emissions table to reference since emissions vary by location.
- 3) **Length of Construction Period.** Enter the amount of time needed to construct the project. Assume that the climbing lanes will be completed in one year. As described previously Cal-B/C evaluates project impacts only after project has been constructed and is open. Cal-B/C uses this cell to determine the economic benefits. The entry must be a whole number. For example, a project that will take 8 months to construct should be entered as “1”, representing one year. A project taking 2 years and 5 months can be rounded down to 2 years or up to three years at the user’s discretion, but the entry in this cell must be consistent with the cost data entered.
- 4) **One- or Two-Way Data.** Enter the number of directions across which traffic flows along this corridor. In this case, leave the default value of “2”.
- 5) **Length of Peak Period(s).** For our project, enter a “2” to represent a two-hour daily peak travel period (including both the AM and PM peak periods). The peak period length helps convert average daily traffic volumes into average peak and non-peak volumes and speeds. Speed is an important variable to determine travel time savings, fuel consumption, and emissions.



Now move to the *Highway Design and Traffic Data* section of the project information worksheet (Exhibit B2).

**Exhibit B2: Project Information Worksheet Section 1B**

1B		<b>HIGHWAY DESIGN AND TRAFFIC DATA</b>	
<b>Highway Design</b>			
		No Build	Build
Roadway Type (Fwy, Exp, Conv Hwy)		F	F
Number of General Traffic Lanes		3	4
Number of HOV/HOT Lanes			
HOV Restriction (2 or 3)			
Exclusive ROW for Buses (y/n)		N	
Highway Free-Flow Speed		65	65
Ramp Design Speed (if aux. lane/off-ramp proj.)		35	35
Length (in miles)	Highway Segment	6.7	6.7
	Impacted Length	9.7	9.7
<b>Average Daily Traffic</b>			
	Current	85,000	
		No Build	Build
	Base (Year 1)	86,750	86,750
	Forecast (Year 20)	120,000	120,000
<b>Average Hourly HOV/HOT Lane Traffic</b>			
		0	0
	Percent of Induced Trips in HOV (if HOT or 2-to-3 conv.)		100%
<b>Percent Traffic in Weave</b>			
			0.0%
<b>Percent Trucks</b> (include RVs, if applicable)			
		13%	13%
<b>Truck Speed</b>			
		55	
<b>On-Ramp Volume</b>			
		Peak	Non-Peak
	Hourly Ramp Volume (if aux. lane/on-ramp proj.)	0	0
	Metering Strategy (1, 2, 3, or D, if on-ramp proj.)		
<b>Queue Formation</b> (if queuing or grade crossing project)			
		Year 1	Year 20
	Arrival Rate (in vehicles per hour)	0	0
	Departure Rate (in vehicles per hour)	0	0
<b>Pavement Condition</b> (if pavement project)			
		No Build	Build
	IRI (inches/mile)		
	Base (Year 1)		
	Forecast (Year 20)		
<b>Average Vehicle Occupancy (AVO)</b>			
		No Build	Build
	General Traffic		
	Non-Peak	1.30	1.30
	Peak	1.15	1.15
	High Occupancy Vehicle (if HOV/HOT lanes)	2.15	2.15

6) **Highway Design.** Assume that the highway has three (3) general traffic lanes and no HOV or HOT lanes in the project direction. Set the free-flow speed to 65 mph. In this project, we are adding a truck climbing lanes, so enter a “4” into the “Build” number of lanes. Note that Cal B/C does not allow the user to “phase in” the construction. For example, you cannot

construct one lane by Year 1 and another by Year 7. Such a scenario must be analyzed as separate projects.

The blue cell for the “Build” free-flow speed will be set automatically to the “No Build” free-flow speed. The blue cell indicates that you may override this speed if you determine that the free-flow speed in “Build” is different from the “No Build” free-flow speed.

The *Length* cells determine the distance that the project will influence. This project calls for a new lane along a 6.7 stretch of highway. Note how the *Impacted Length* changes because of the project. Cal B/C assumes that passing lanes will have an impact three-miles upstream of the project. This is because adding a truck climbing or passing lane improves traffic flow not only on the segment where the lane is located, but also upstream of the new lane. The user can change this parameter, if needed.

- 7) **Average Daily Traffic.** Enter the existing average daily traffic into the cell labeled “Current.” Use a value of 85,000 for this exercise. Also, enter a value of 120,000 vehicles per day for the forecast year. Note: The forecast year is the project opening date plus 20 years, NOT the current date plus 20 years.

The model calculates the “Base (Year 1)” value in the “No Build” column. The model uses straight-line interpolation to estimate the Year 1 volume from the current year volume and the Year 20 volume. If you have more accurate data for Year 1, you can override the values calculated by the model.

Notice that the “No Build” and “Build” scenario volumes are the same for the project. The model requires the user to assume a constant volume for highway demand, unless demand on the highway is expected to increase due to the project. We take the shift from highway to transit into account when we input the transit information. The model will correctly calculate the benefits associated with mode shifts to although it is not apparent on this input screen.

Note: the *Results* sheet has an option to include induced demand in the evaluation. If “Y” for “Yes” is selected, the model calculates the change in consumer surplus associated with the extra traffic in the “Build” scenario compared to the “No Build” scenario.

- 8) **Average Hourly HOV/HOT Lane Traffic.** Update these cells only if there are HOV or HOT lanes along the corridor. As with the average daily traffic cells, these cells require the “No Build” number of HOV/HOT lanes and the future number of HOV/HOT lanes when the project is completed. The model assumes that all lanes are constructed by Year 1.
- 9) **Percent Trucks.** Enter the percent truck composition of the traffic stream. The model assumes a nine percent truck composition for both the “No Build” and “Build” project scenarios as a default. However, this is a very busy truck corridor so type a “13” in the red cell. Note that this cell is formatted as a percentage.
- 10) **Truck Speed.** For passing lane projects, trucks travel on grades at the speed entered when there is no passing lane. Cal-B/C calculates the automobile speed based on the volume and capacity of the roadway using volume/capacity relationships provided in the 2010 Highway





Capacity Manual. Trucks may have a much slower speed on grades where a passing lane project is constructed. Leave this cell empty for our project. For our example, the truck speed is 55 mph.

- 11) **Average Vehicle Occupancy (AVO).** This is the average number of people per vehicle on the highway. Let us use the model default of 1.30 for the non-peak AVO and 1.15 for the peak AVO in the “No Build” scenario. There should be no change in AVO since this is a truck project.

The model has the statewide averages already entered in Exhibit B3. Assume, however, that we have some highway accident data and projections available for our project.

**Exhibit B3: Project Information Worksheet Section 1C**

<b>HIGHWAY ACCIDENT DATA</b>		
<b>Actual 3-Year Accident Data (from Table B)</b>		
	<b>Count (No.)</b>	<b>Rate</b>
Total Accidents (Tot)	221	0.35
Fatal Accidents (Fat)	4	0.006
Injury Accidents (Inj)	49	0.08
Property Damage Only (PDO) Accidents	168	0.27
<b>Statewide Basic Average Accident Rate</b>		
	<b>No Build</b>	<b>Build</b>
Rate Group		
Accident Rate (per million vehicle-miles)	0.80	0.70
Percent Fatal Accidents (Pct Fat)	1.1%	1.1%
Percent Injury Accidents (Pct Inj)	29.0%	32.2%

- 12) In the **Actual 3-Year Accident Data (from Table B)** cells, assume there were 221 accidents on the parallel highway corridor over the past three years: 4 fatal accidents, 49 injury accidents, and 168 PDO accidents (Note: PDO accidents are calculated in the blue cell by taking the total accidents and subtracting fatal and injury accidents).

- 13) Insert statewide average accident rates per million vehicle-miles for road classifications similar to the existing and proposed facilities. Include Base Rate and ADT factors, where applicable. Also, insert statewide percent of accidents that are fatal and injury accidents for road classifications similar to “No Build” and “Build” facilities. The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates by accident type for new road classifications. The Model Inputs worksheet presents results that the user can edit.

For our project, assume that overall accident rates will decline from 0.80 to 0.70 between the “No Build” and the “Build” scenarios. Assume the percentage of fatal accidents will remain the same at 1.1 percent, but that the percent of injury accidents will increase from 29 to 32.2 percent.



Since this is a truck climbing lane project, the rail and transit data box (Section 1D) will not need to be updated.

Now we are at the final data entry step required to perform a basic analysis. Users with project-specific information can change any parameter within the model. Please refer to the technical supplement for a more detailed discussion of the model assumptions. Let us continue with our analysis. Exhibit A5 shows the project cost data that we will enter for this project.

14) Enter the **Initial Project Costs**. Enter the project costs for Years 1 as shown in Exhibit B4 on the next page.

**Exhibit B4: Project Information Worksheet Section 1E**

1E PROJECT COSTS (enter costs in thousands of dollars)									
Col. no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
Year	DIRECT PROJECT COSTS			SUBSEQUENT COSTS		Mitigation	Transit Agency Cost Savings	TOTAL COSTS (in dollars)	
	Project Support	R / W	Construction	Maint./ Op.	Rehab.			Constant Dollars	Present Value
<b>Construction Period</b>									
1			\$55,340					\$55,340,000	\$55,340,000
2								0	0
3								0	0
4								0	0
5								0	0
6								0	0
7								0	0
8								0	0
<b>Project Open</b>									
1								\$0	\$0
2								0	0
3								0	0
4								0	0
5								0	0
6								0	0
7								0	0
8								0	0
9								0	0
10								0	0
11								0	0
12								0	0
13								0	0
14								0	0
15								0	0
16								0	0
17								0	0
18								0	0
19								0	0
20								0	0
<b>Total</b>	\$0	\$0	\$55,340	\$0	\$0	\$0	\$0	\$55,340,000	\$55,340,000

15) Before examining the results of the model, please review the work done to this point. In the project cost section, you should have a total project cost of \$54.34 million.

We have completed the *Project Information Worksheet* and will not update the *Model Inputs* worksheet since we do not have better data available from a model. To see how to update a project with model data in the *Model Inputs* worksheet, please review the rail project shown in Appendix A.



The project input has been complete, we have double-checked our data, and we are ready to review the results. Having completed the data entry means that we have completed the *Project Information* worksheet and the *Model Inputs* worksheet. The results are shown in the investment analysis summary in Exhibit B5.

**Exhibit B5: Results Worksheet Section 3**

3

### INVESTMENT ANALYSIS

#### SUMMARY RESULTS

Life-Cycle Costs (mil. \$)	\$55.3	
Life-Cycle Benefits (mil. \$)	\$1,032.8	
Net Present Value (mil. \$)	\$977.4	
<b>Benefit / Cost Ratio:</b>		18.7
<b>Rate of Return on Investment:</b>		68.0%
<b>Payback Period:</b>		2 years

ITEMIZED BENEFITS (mil. \$)	Passenger Benefits	Freight Benefits	Total Over 20 Years	Average Annual
Travel Time Savings	\$616.1	\$155.3	\$771.4	\$38.6
Veh. Op. Cost Savings	\$25.5	\$12.7	\$38.2	\$1.9
Accident Cost Savings	\$168.5	\$25.2	\$193.7	\$9.7
Emission Cost Savings	\$4.0	\$25.5	\$29.5	\$1.5
<b>TOTAL BENEFITS</b>	<b>\$814.1</b>	<b>\$218.6</b>	<b>\$1,032.8</b>	<b>\$51.6</b>
<b>Person-Hours of Time Saved</b>			84,999,470	4,249,973

**Should benefit-cost results include:**

1) Induced Travel? (y/n)   
Default = Y

2) Vehicle Operating Costs? (y/n)   
Default = Y

3) Accident Costs? (y/n)   
Default = Y

4) Vehicle Emissions? (y/n)   
Default = Y  
includes value for CO<sub>2</sub>e

	Tons		Value (mil. \$)	
EMISSIONS REDUCTION	Total Over 20 Years	Average Annual	Total Over 20 Years	Average Annual
CO Emissions Saved	667	33	\$0.1	\$0.0
CO <sub>2</sub> Emissions Saved	206,330	10,316	\$5.6	\$0.3
NO <sub>x</sub> Emissions Saved	647	32	\$22.5	\$1.1
PM <sub>10</sub> Emissions Saved	3	0	\$0.9	\$0.0
PM <sub>2.5</sub> Emissions Saved	3	0		
SO <sub>x</sub> Emissions Saved	2	0	\$0.2	\$0.0
VOC Emissions Saved	66	3	\$0.2	\$0.0

hdrinc.com

201 California Street, Suite 1500, San Francisco, CA 94111-5002  
(415) 546-4200

B-6

# APPENDIX C: Truck Only Lane Example

Open the *Project Information* sheet to begin an analysis. Exhibit C1 shows the *Project Data* section for a truck only lane improvement project. Green cells are cells that require data input. The red cells provide default values that the user can change.

Exhibit C1: Project Information Worksheet Section 1A

1A		PROJECT DATA	
<b>Type of Project</b> Select project type from list	Remember to run macro for truck lane		
	Truck Only Lane		
<b>Project Location</b> (enter 1 for So. Cal., 2 for No. Cal., or 3 for rural)	1		
Length of Construction Period	4	years	
One- or Two-Way Data	1	enter 1 or 2	
	Current		
<b>Length of Peak Period(s)</b> (up to 24 hrs)	6	hours	

- 1) **Type of Project.** Select the “Truck Only Lane” project type.
- 2) **Project Location.** This cell requires you to enter a “1” for Southern California urban areas, a “2” for Northern California urban areas, or a “3” for rural areas in order to determine emissions benefits for the project. This project is being built in Southern California so put a “1” in this cell. This cell tells the model which emissions table to reference since emissions vary by location.
- 3) **Length of Construction Period.** Enter the amount of time needed to construct the project. Assume that the truck only lane will be completed in four years. As described previously, Cal-B/C evaluates project impacts only after project has been constructed and is open. Cal-B/C uses this cell to determine the economic benefits. The entry must be a whole number. For example, a project that will take 8 months to construct should be entered as “1”, representing one year. A project taking 2 years and 5 months can be rounded down to 2 years or up to three years at the user’s discretion, but the entry in this cell must be consistent with the cost data entered.
- 4) **One- or Two-Way Data.** Enter the number of directions across which traffic flows along this corridor. In this case, the project concerns only the northbound section of a highway, so enter a value of “1”.
- 5) **Length of Peak Period(s).** For our project, enter a “6” to represent a six-hour daily peak travel period (including both the AM and PM peak periods). The peak period length helps convert average daily traffic volumes into average peak and non-peak volumes and speeds.



Speed is an important variable to determine travel time savings, fuel consumption, and emissions.

Now move to the *Highway Design and Traffic Data* section of the project information worksheet (Exhibit C2).

**Exhibit C2: Project Information Worksheet Section 1B**

1B

**HIGHWAY DESIGN AND TRAFFIC DATA**

<b>Highway Design</b>		No Build	Build
Roadway Type (Fwy, Exp, Conv Hwy)		F	F
Number of General Traffic Lanes		4	4
Number of HOV/HOT Lanes			
HOV Restriction (2 or 3)			
Exclusive ROW for Buses (y/n)		N	
Highway Free-Flow Speed		65	65
Ramp Design Speed (if aux. lane/off-ramp proj.)		35	35
Length (in miles) Highway Segment		5.0	5.0
Impacted Length		5.0	5.0

<b>Average Daily Traffic</b>		No Build	Build
Current		105,000	
Base (Year 1)		108,600	94,482
Forecast (Year 20)		125,700	109,359
<b>Average Hourly HOV/HOT Lane Traffic</b>			0
Percent of Induced Trips in HOV (if HOT or 2-to-3 conv.)			100%
<b>Percent Traffic in Weave</b>			0.0%
<b>Percent Trucks</b> (include RVs, if applicable)		13%	0%
<b>Truck Speed</b>			

<b>On-Ramp Volume</b>		Peak	Non-Peak
Hourly Ramp Volume (if aux. lane/on-ramp proj.)		0	0
Metering Strategy (1, 2, 3, or D, if on-ramp proj.)			

<b>Queue Formation</b> (if queuing or grade crossing project)		Year 1	Year 20
Arrival Rate (in vehicles per hour)		0	0
Departure Rate (in vehicles per hour)		0	0

<b>Pavement Condition</b> (if pavement project)		No Build	Build
IRI (inches/mile) Base (Year 1)			
Forecast (Year 20)			

<b>Average Vehicle Occupancy (AVO)</b>		No Build	Build
General Traffic Non-Peak		1.30	1.30
Peak		1.15	1.15
High Occupancy Vehicle (if HOV/HOT lanes)		2.15	2.15

6) **Highway Design.** Assume that the highway has four (4) general traffic lanes and no HOV or HOT lanes in the project direction. Set the free-flow speed to 65 mph. In this project, we are

adding a separate truck only lane, but not any additional general traffic lanes, so the “Build” number of lanes is also “4”.

The blue cell for the “Build” free-flow speed will be set automatically to the “No Build” free-flow speed. The blue cell indicates that you may override this speed if you determine that the free-flow speed in “Build” is different from the “No Build” free-flow speed.

The *Length* cells determine the distance that the project will influence. This project calls for a truck only lane along a 5 mile stretch of highway. Note that the *Impacted Length* is the same as the *Length*, because Cal B/C does not assume that truck only lanes will have an impact upstream or downstream of the project. The user can change this parameter, but for now leave the default value.

- 7) **Average Daily Traffic.** Enter the existing average daily traffic into the cell labeled “Current.” Use a value of 105,000 for this exercise. Also, enter a value of 125,700 vehicles per day for the forecast year. Note: the forecast year is the project opening date plus 20 years, NOT the current date plus 20 years.

The model can calculate the “Base (Year 1)” value in the “No Build” column using straight-line interpolation to estimate the Year 1 volume from the current year volume and the Year 20 volume. For this exercise, we will use this interpolated value.

Notice that the “No Build” and “Build” scenario volumes are not the same for a project with truck only lanes. The model assumes that all truck traffic will divert from the general lanes to the new truck only lane, and the ADT values calculated for the “Build” scenario reflects only non-truck traffic using the existing lanes. The user can override these values if a different assumption is more accurate.

Note: the *Results* sheet has an option to include induced demand in the evaluation, but Cal-B/C is unable to calculate induced demand for truck only lanes.

- 8) **Average Hourly HOV/HOT Lane Traffic.** Update these cells only if there are HOV or HOT lanes along the corridor. As with the average daily traffic cells, these cells require the “No Build” number of HOV/HOT lanes and the future number of HOV/HOT lanes when the project is completed. The model assumes that all lanes are constructed by Year 1.
- 9) **Percent Trucks.** Enter the percent truck composition of the traffic stream, and note that this cell is formatted as a percentage. The model assumes a nine percent truck composition for the “No Build” scenario as a default, and assumes zero percent for the “Build” project scenario, because of the shift in truck traffic from general lanes to the truck only lane. However, this is a very busy truck corridor, so type a “13” in the red cell.
- 10) **Truck Speed.** For passing lane projects, trucks travel on grades at the speed entered when there is no passing lane. Cal-B/C calculates the automobile speed based on the volume and capacity of the roadway using volume/capacity relationships provided in the 2010 Highway Capacity Manual. Trucks may have a much slower speed on grades where a passing lane



project is constructed. Leave this cell empty for our project. This allows the model to estimate truck speeds depending on traffic flow.

- 11) **Average Vehicle Occupancy (AVO).** This is the average number of people per vehicle on the highway. Let us use the model default of 1.30 for the non-peak AVO and 1.15 for the peak AVO in the “No Build” scenario. There should be no change in AVO since this is a truck project.

The model has the statewide averages already entered in Exhibit C3. Assume, however, that we have some highway accident data available for our project.

**Exhibit C3: Project Information Worksheet Section 1C**

1C

**HIGHWAY ACCIDENT DATA**

<b>Actual 3-Year Accident Data (from Table B)</b>		
	Count (No.)	Rate
Total Accidents (Tot)	237	0.40
Fatal Accidents (Fat)	2	0.003
Injury Accidents (Inj)	64	0.11
Property Damage Only (PDO) Accidents	171	0.29

<b>Statewide Basic Average Accident Rate</b>		
	No Build	Build
Rate Group		
Accident Rate (per million vehicle-miles)		
Percent Fatal Accidents (Pct Fat)		
Percent Injury Accidents (Pct Inj)		

- 12) In the **Actual 3-Year Accident Data (from Table B)** cells, assume there were 237 accidents on the parallel highway corridor over the past three years: 2 fatal accidents, 64 injury accidents, and 171 PDO accidents. (Note: PDO accidents can be calculated in the blue cell by taking the total accidents and subtracting fatal and injury accidents.)

- 13) If available, insert statewide average accident rates per million vehicle-miles for road classifications similar to the existing and proposed facilities. Include Base Rate and ADT factors, where applicable. Also, insert statewide percent of accidents that are fatal and injury accidents for road classifications similar to “No Build” and “Build” facilities. The model uses adjustment factors (the ratio of actual rates to statewide rates for existing facility) to estimate accident rates by accident type for new road classifications. The Model Inputs worksheet presents results that the user can edit.

For this example, we do not have accident rates per million vehicle miles available, so we will leave these cells blank. The user can enter alternate accident rates and factors in Exhibit C4, in the *Model Inputs* worksheet.





**Exhibit C4: Model Inputs Worksheet Section 2B**

2B

**HIGHWAY ACCIDENT RATES**

	Calculated by Model	Changed by User	Used for Proj. Eval.	Reason for Change
<b>No Build</b>				
Fatal Accidents	0.003		0.003	
Injury Accidents	0.11		0.11	
PDO Accidents	0.30		0.30	
Total Accidents	0.413			
<b>Hwy Safety or Weaving Improvement</b>		10%	collision reduction factor (per HSIP Guidelines)	
<b>Adjustment Factor (Actual/Statewide Avg. Existing)</b>				
Fatal Accidents	0.9000		0.9000	
Injury Accidents	0.9000		0.9000	
PDO Accidents	0.9000		0.9000	
<b>Build</b>				
Fatal Accidents	0.003		0.003	
Injury Accidents	0.10		0.10	
PDO Accidents	0.27		0.27	
Total Accidents	0.372			

14) **Highway Safety or Weaving Improvement.** We may assume that the addition of one truck only lane will eliminate accidents that involve both vehicles and trucks, since truck and vehicle traffic will be separated on this section of road. Let vehicle-truck accidents comprise 10 percent of all motor vehicle accidents on this highway, resulting in a 10 percent reduction in accidents. Enter “10” as the collision reduction factor. Note that this cell is formatted as a percentage.

Since this is a truck only lane project, the rail and transit data box (Section 1D) of the *Project Information* worksheet will not need to be updated.

Now, we are almost finished with the first part of data entry required to perform a truck only analysis. Users with project-specific information can change any parameter within the model. Please refer to the technical supplement for a more detailed discussion of the model assumptions.

15) Enter the **Initial Project Costs.** Enter the project costs for Years 1 as shown in Exhibit C5 on the next page.



**Exhibit C5: Project Information Worksheet Section 1E**

(1E) **PROJECT COSTS** (enter costs in thousands of dollars)

Col. no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
Year	DIRECT PROJECT COSTS			SUBSEQUENT COSTS		Mitigation	Transit Agency Cost Savings	TOTAL COSTS (in dollars)	
	Project Support	R / W	Construction	Maint./ Op.	Rehab.			Constant Dollars	Present Value
<b>Construction Period</b>									
1	\$4,000	\$300	\$0					\$4,300,000	\$4,300,000
2	2,000	800	30,000					32,800,000	31,538,462
3	900		35,000					35,900,000	33,191,568
4	100		20,000					20,100,000	17,868,827
5								0	0
6								0	0
7								0	0
8								0	0
<b>Project Open</b>									
1				\$50				\$50,000	\$42,740
2				\$50				50,000	41,096
3				\$50				50,000	39,516
4				\$50				50,000	37,996
5				\$50				50,000	36,535
6				\$50				50,000	35,129
7				\$50				50,000	33,778
8				\$50				50,000	32,479
9				\$50				50,000	31,230
10				\$50				50,000	30,029
11				\$50				50,000	28,874
12				\$50				50,000	27,763
13				\$50				50,000	26,695
14				\$50				50,000	25,669
15				\$50				50,000	24,681
16				\$50				50,000	23,732
17				\$50				50,000	22,819
18				\$50				50,000	21,942
19				\$50				50,000	21,098
20				\$50				50,000	20,286
<b>Total</b>	\$7,000	\$1,100	\$85,000	\$1,000	\$0	\$0	\$0	\$94,100,000	\$87,502,944

16) Before moving on to enter data for the truck only lane, please review the work done to this point. In the project cost section, you should have a total project cost of about \$94.1 million (net present value of \$87.5 million).

We have completed the *Project Information* worksheet and the *Model Inputs* worksheet. To see how to enter more specific model data in the *Model Inputs* worksheet for another project, please review the rail project in Appendix A.

The first part of the project input has been completed and we are ready to add the data for the truck only lane. In the Project Information worksheet, click the gray button beneath the rail and transit data box (Section 1D), labeled “Prepare Model for Second Road.” Enter a name for the project (without a file extension, “Project\_TOL” for example) and click save. The macro saves the current file, data, and results under the name specified with “Part1” appended (e.g., “Project\_TOL.Part1.xlsm”), and reads another file (e.g., “Project\_TOL.Part2.xlsm”) for the truck only lane input and results.

Most of the *Project Data* should not change between the general lanes and the truck only lane: the type of project, location, construction period, and roadway type (one- or two-way) should



remain constant. The user could change the length of peak period(s) if desired, but for this example it will remain the same.

In the *Highway Design and Traffic Data* section of the project information worksheet (Exhibit C6) there are a couple data points the user may specify for the truck only lane(s).

**Exhibit C6: Project Information Worksheet Section 1B**

1B HIGHWAY DESIGN AND TRAFFIC DATA		
<b>Highway Design</b>		
	No Build	Build
Roadway Type (Fwy, Exp, Conv Hwy)		F
Number of Truck Lanes	0	1
Number of HOV/HOT Lanes		
HOV Restriction (2 or 3)		
Exclusive ROW for Buses (y/n)		
Truck Lane Free-Flow Speed		65
Ramp Design Speed (if aux. lane/off-ramp proj.)		
Length (in miles) Highway Segment		5.0
Impacted Length		5.0
<b>Average Daily Traffic</b>		
Current		
	No Build	Build
Base (Year 1)		14,118
Forecast (Year 20)		16,341
<b>Average Hourly HOV/HOT Lane Traffic</b>		
Percent of Induced Trips in HOV (if HOT or 2-to-3 conv.)		
<b>Percent Traffic in Weave</b>		
Percent Trucks (include RVs, if applicable)		100%
<b>Truck Speed</b>		
<b>On-Ramp Volume</b>		
	Peak	Non-Peak
Hourly Ramp Volume (if aux. lane/on-ramp proj.)		
Metering Strategy (1, 2, 3, or D, if on-ramp proj.)		
<b>Queue Formation</b> (if queuing or grade crossing project)		
	Year 1	Year 20
Arrival Rate (in vehicles per hour)		
Departure Rate (in vehicles per hour)		
<b>Pavement Condition</b> (if pavement project)		
	No Build	Build
IRI (inches/mile) Base (Year 1)		
Forecast (Year 20)		
<b>Average Vehicle Occupancy (AVO)</b>		
	No Build	Build
General Traffic Non-Peak	1.30	1.30
Peak	1.15	1.15
High Occupancy Vehicle (if HOV/HOT lanes)	2.15	2.15

17) **Highway Design.** Assume that the project builds one (1) truck only lane along the highway. The model assumes the free-flow speed is equal to the one previously set. For this example that is 65 mph. The user can change this if necessary.

Note that many of the “No Build” scenario cells are empty because this additional “road” (the truck only lane) doesn’t exist in the “No Build” scenario, so there are no highway design specifications to place here.

18) **Average Daily Traffic.** If there are more accurate data available, enter the values for the base year and the forecast year. For this example, we will leave the Cal-B/C modeled values, which are calculated as the truck volumes based on the traffic levels and truck percentage from the “No Build” scenario data inputs from Part 1.



The remaining inputs in this section and the *Highway Accident Data* section can be updated by the user. The accident data and project cost data entered in Part 1 is carried over and can remain the same. For this example, the only change required is entering the 10% collision reduction in the *Highway Accident Rates* section in the Model Inputs worksheet, to mirror the reduction specified in Part 1. Note that the change in accident rates from the “No Build” to the “Build” need not always be the same between the general use lanes and the truck only lanes.

The project input for both roads has been completed, we have double-checked our data, and we are ready to review the results. Having completed the data entry means that we have completed the *Project Information* worksheet and the *Model Inputs* worksheet for both roads (or in the truck only lanes case, both lane types on the road). The results are shown in the investment analysis summary in Exhibit C7.

**Exhibit C7: Results Worksheet Section 3**

3

**INVESTMENT ANALYSIS**  
SUMMARY RESULTS

Life-Cycle Costs (mil. \$)	\$87.5
Life-Cycle Benefits (mil. \$)	\$261.1
Net Present Value (mil. \$)	\$173.6
Benefit / Cost Ratio:	3.0
Rate of Return on Investment:	14.1%
Payback Period:	8 years

ITEMIZED BENEFITS (mil. \$)	Passenger	Freight	Total Over	Average
	Benefits	Benefits	20 Years	Annual
Travel Time Savings	\$159.7	\$65.4	\$225.1	\$11.3
Veh. Op. Cost Savings	\$9.2	\$2.5	\$11.7	\$0.6
Accident Cost Savings	\$11.5	\$1.7	\$13.2	\$0.7
Emission Cost Savings	\$1.7	\$9.4	\$11.1	\$0.6
<b>TOTAL BENEFITS</b>	<b>\$182.1</b>	<b>\$79.1</b>	<b>\$261.1</b>	<b>\$13.1</b>
Person-Hours of Time Saved			25,386,753	1,269,338

**Should benefit-cost results include:**

1) Induced Travel? (y/n)	<input type="text" value="Y"/>	Default = Y
2) Vehicle Operating Costs? (y/n)	<input type="text" value="Y"/>	Default = Y
3) Accident Costs? (y/n)	<input type="text" value="Y"/>	Default = Y
4) Vehicle Emissions? (y/n)	<input type="text" value="Y"/>	Default = Y

includes value for CO<sub>2</sub>e

EMISSIONS REDUCTION	Tons		Value (mil. \$)	
	Total Over 20 Years	Average Annual	Total Over 20 Years	Average Annual
CO Emissions Saved	359	18	\$0.0	\$0.0
CO <sub>2</sub> Emissions Saved	108,692	5,435	\$2.9	\$0.1
NO <sub>x</sub> Emissions Saved	228	11	\$8.0	\$0.4
PM <sub>10</sub> Emissions Saved	0	0	-\$0.1	-\$0.0
PM <sub>2.5</sub> Emissions Saved	0	0		
SO <sub>x</sub> Emissions Saved	1	0	\$0.1	\$0.0
VOC Emissions Saved	27	1	\$0.1	\$0.0