Cal-B/C Training Module 9a1

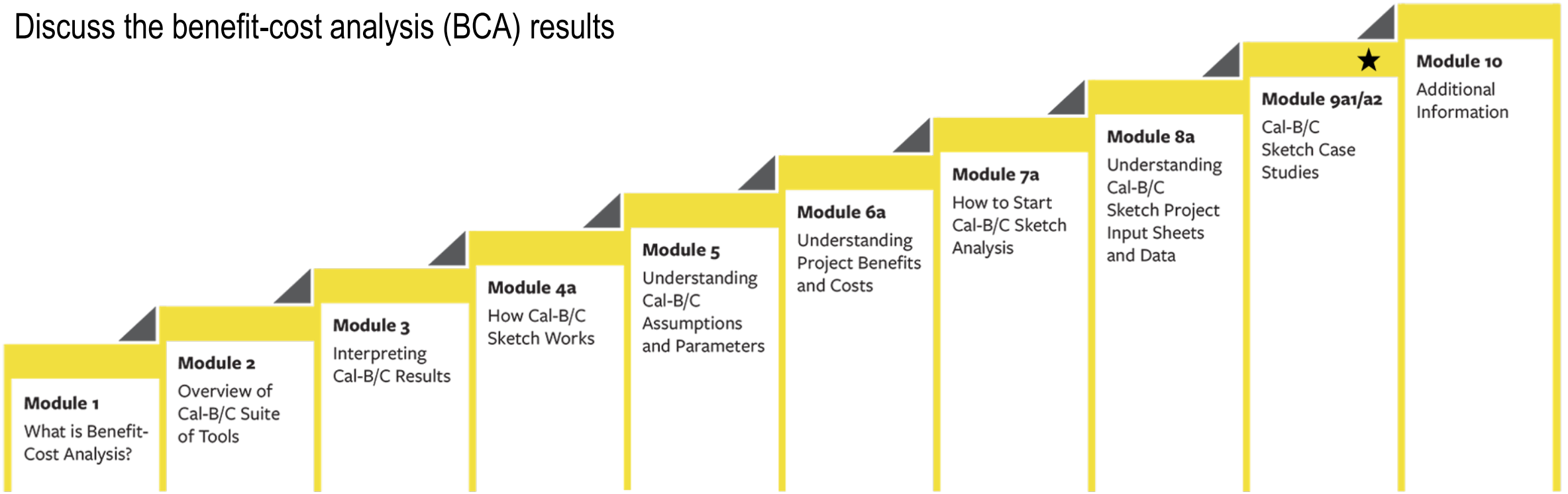
Cal-B/C Sketch
Light-Rail Transit Case Study

01

About This Module

This module will…

- Walk you through a hypothetical project – a Light-Rail Transit (LRT) preliminary feasibility analysis
- Provide details on where to get data to input into the example
- Discuss the benefit-cost analysis (BCA) results



★ *This module is covered in this presentation*

Previous Modules…

- Module 1 provided a basic introduction on benefit-cost analysis (BCA) and a general overview of how to conduct a BCA
- Module 2 described the Cal-B/C suite of tools, discussed the types of projects that can be evaluated, and provided guidance on which tools to use for various project types
- Module 3 presented the Cal-B/C results page, detailed what each output measure means, and explained how they are calculated
- Module 4a presented an overview of how Cal-B/C Sketch works including a review of all worksheets and inputs
- Module 5 highlighted the information in the Parameters worksheet and discussed key assumptions used by Cal-B/C
- Module 6a provided detailed information on how Cal-B/C Sketch calculates benefits
- Module 7a presented the 1-2-3 approach to starting a Cal-B/C Sketch analysis
- Module 8a discussed potential data sources that can be used in a Cal-B/C Sketch analysis

02

Project Information Worksheet

1) Project Information Worksheet Overview (from Module 4a)

- The primary data entry worksheet for Cal-B/C Sketch
- Other worksheets should be modified if project specific information is available

1A Project Data

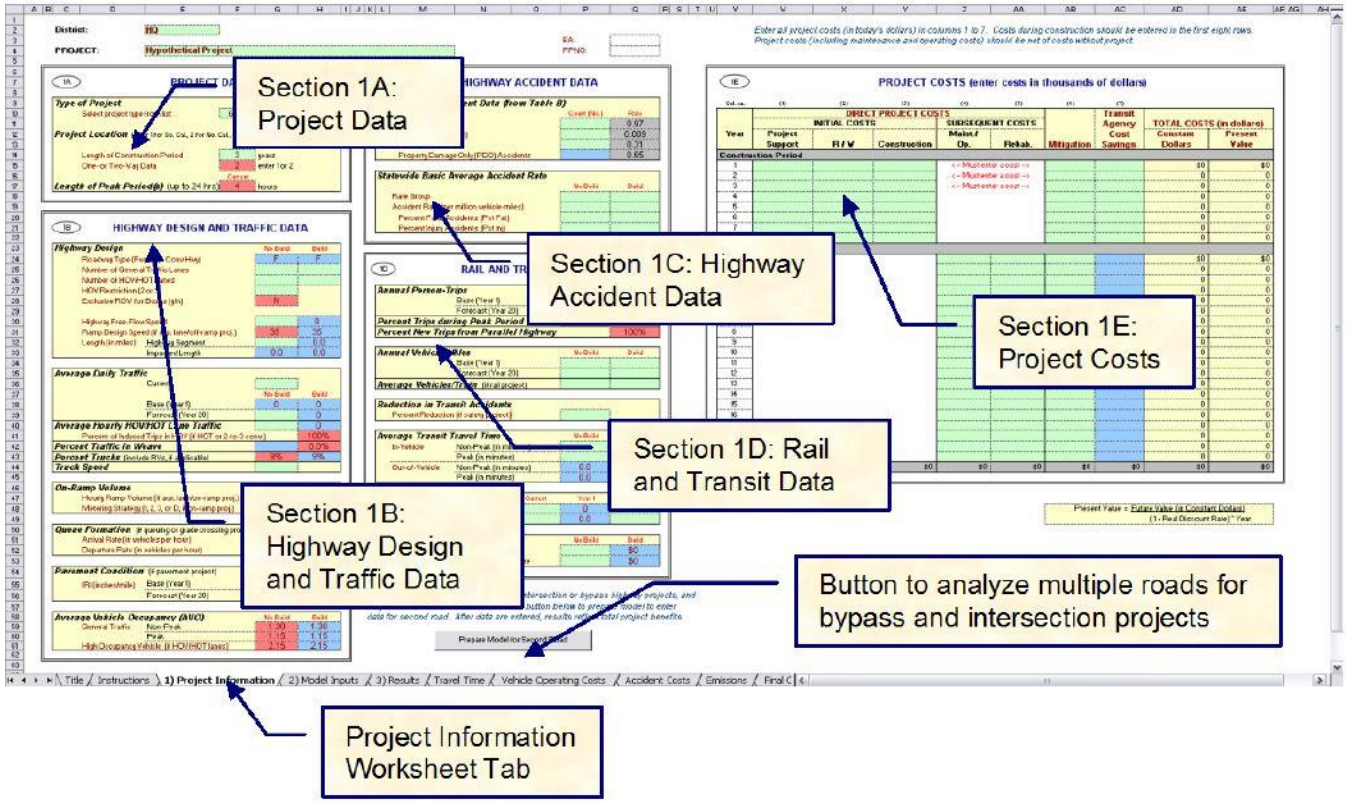
- Required for all projects

1B Highway Design and Traffic Data

- Required data for roadway geometrics, traffic demand, and speed data for route parallel to light-rail transit (LRT)
- Data such as AVO numbers can be obtained from public sources
- On-ramp volume, queue length, and pavement condition sections do not need to be filled out

1C Highway Accident (i.e., Collision) Data

- This section does not need to be filled out because the project does not address safety



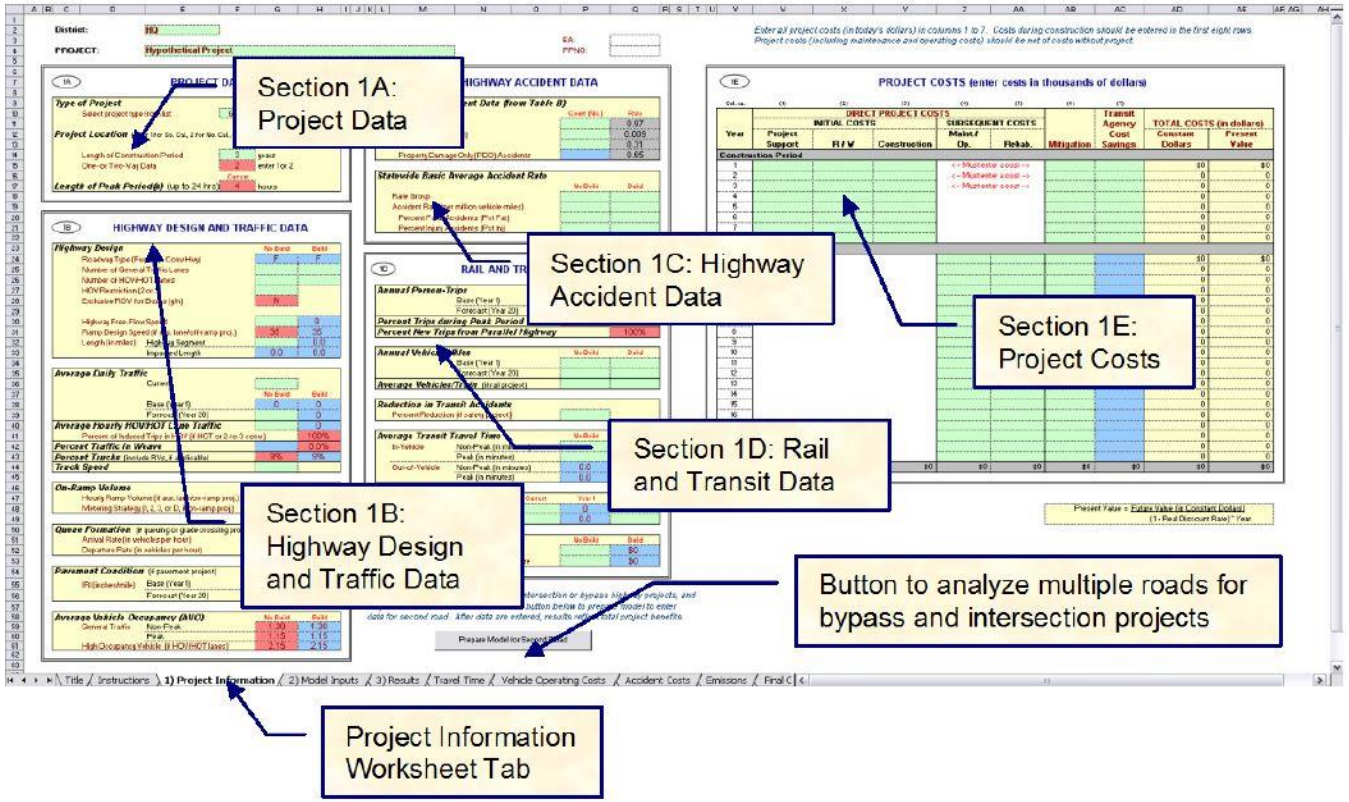
1) Project Information Worksheet Overview (from Module 4a)

1D Rail and Transit Data

- Required data for service demand characteristics (e.g., person trips) and service supply characteristics
- Sections for Reduction in Transit Accidents, Highway Grade Crossing, and Transit Agency Costs are not needed for this analysis

1E Project Costs

- Required to fill in for each year of construction period.
- Recommended to estimate O&M costs based on existing LRT projects (more details provided later)
  - O&M costs should be the difference between the No Build and Build Scenarios



New Light-Rail Project Description

- Hypothetical preliminary planning level analysis for a new LRT Line in Southern California

No Build Case:

- No LRT
- Some parallel bus services that will be eliminated for the faster LRT service
- Highly congested parallel highway corridor

Build Case:

- 15-mile, at-grade light-rail line

1A) Enter Project Data

Input Project Identifier Data (optional):

- Input unique project identifiers (optional): Caltrans District, Project Name, EA number, and PPNO

Type of Project

- Select **"Light Rail (LRT)"** in pull-down menu

Project Location

- Enter **"1"** for Southern California

Length of Construction Period

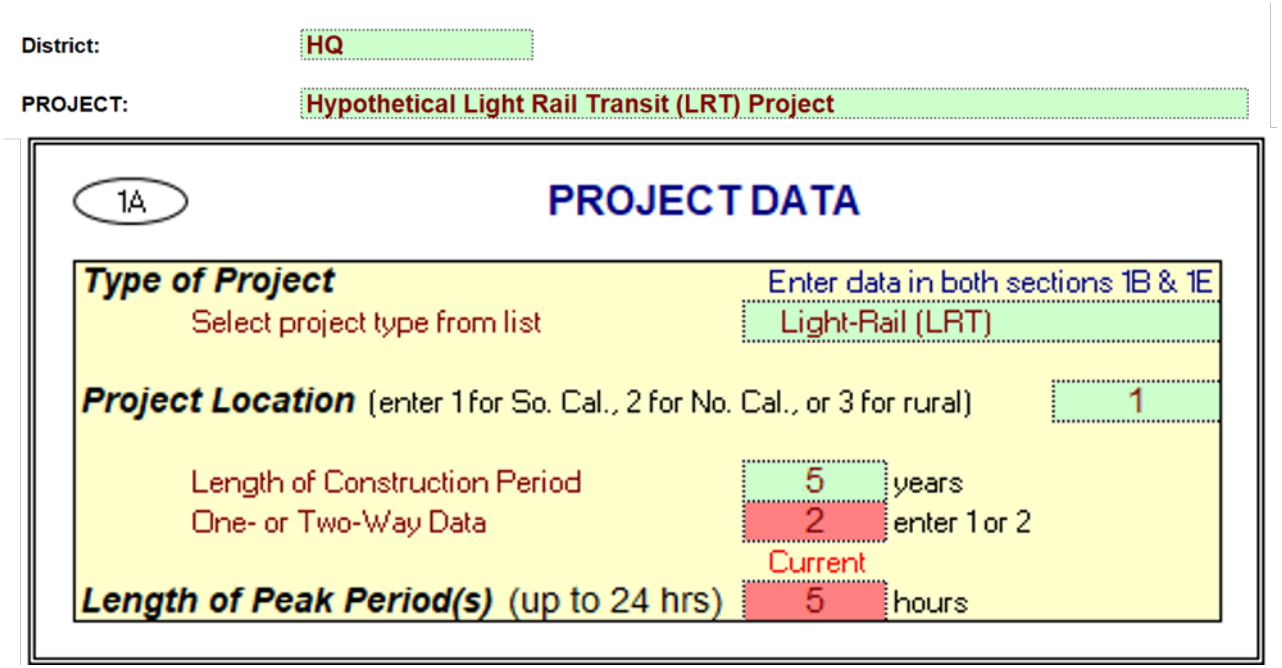
- Enter **"5"** for an estimated 5 years of construction typical for an LRT.

One- or Two-Way Data

- Enter **"2"** to indicate that average daily traffic (ADT) data is provided for both directions of the corridor

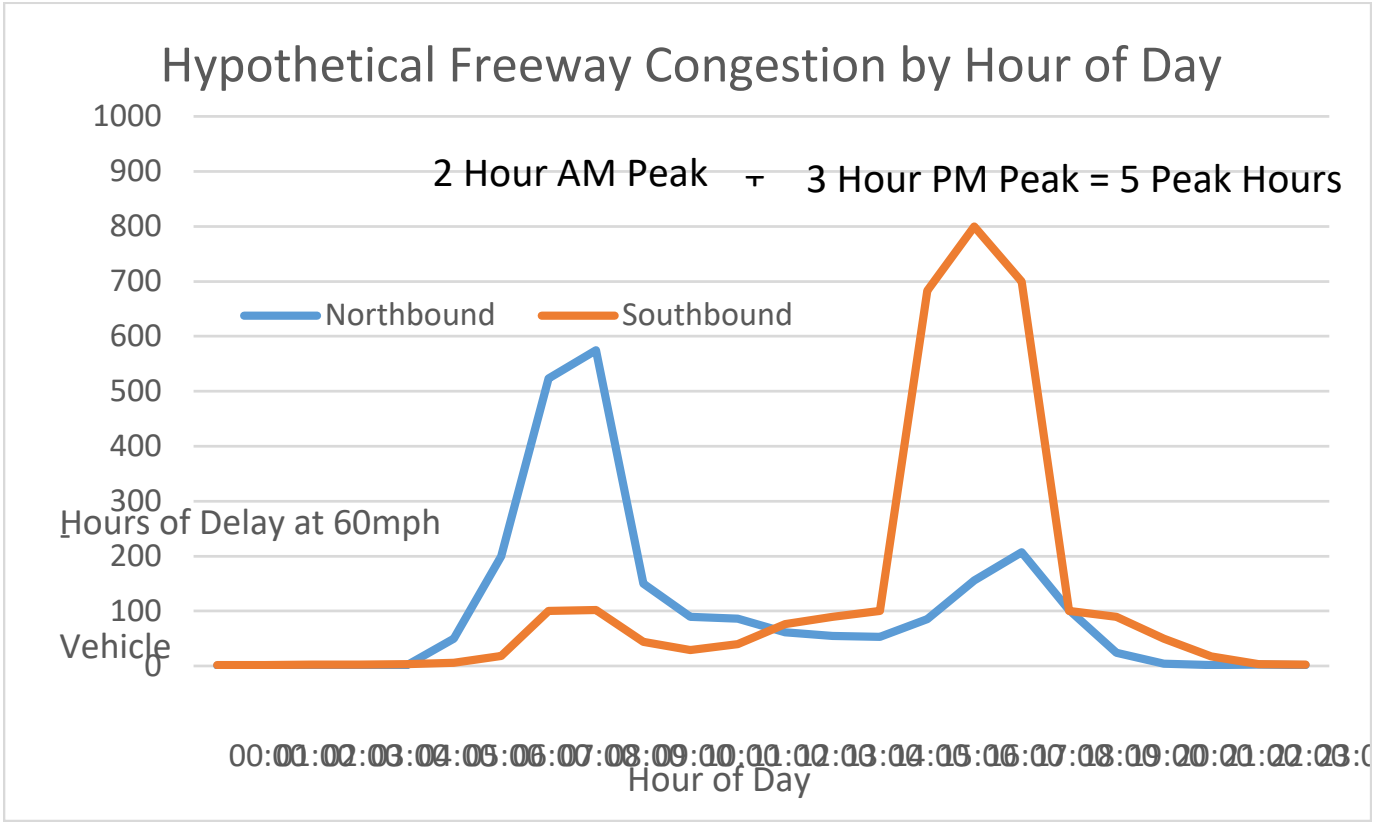
Length of Peak Period(s)

- Enter **"5"** for total peak period hours (e.g., 2 hours in the AM and 3 hours in the PM)



1A) Enter Project Data – How to get peak period hours

- PeMS data for the freeway being analyzed can be reviewed to identify length of peak period
- If no PeMS data available or data quality is poor, then use data from another corridor with similar travel characteristics
- PeMS can be used to download daily traffic volumes for a corridor or specific location to obtain ADT estimates



1B) Enter Highway Design and Traffic Data

Roadway Type (i.e., Freeway, Expressway, or Conventional Highway)

- Enter **"F"** (freeway)

Number of General Traffic Lanes

- Enter **"3"** for our hypothetical corridor

Number of HOV/HOT Lanes

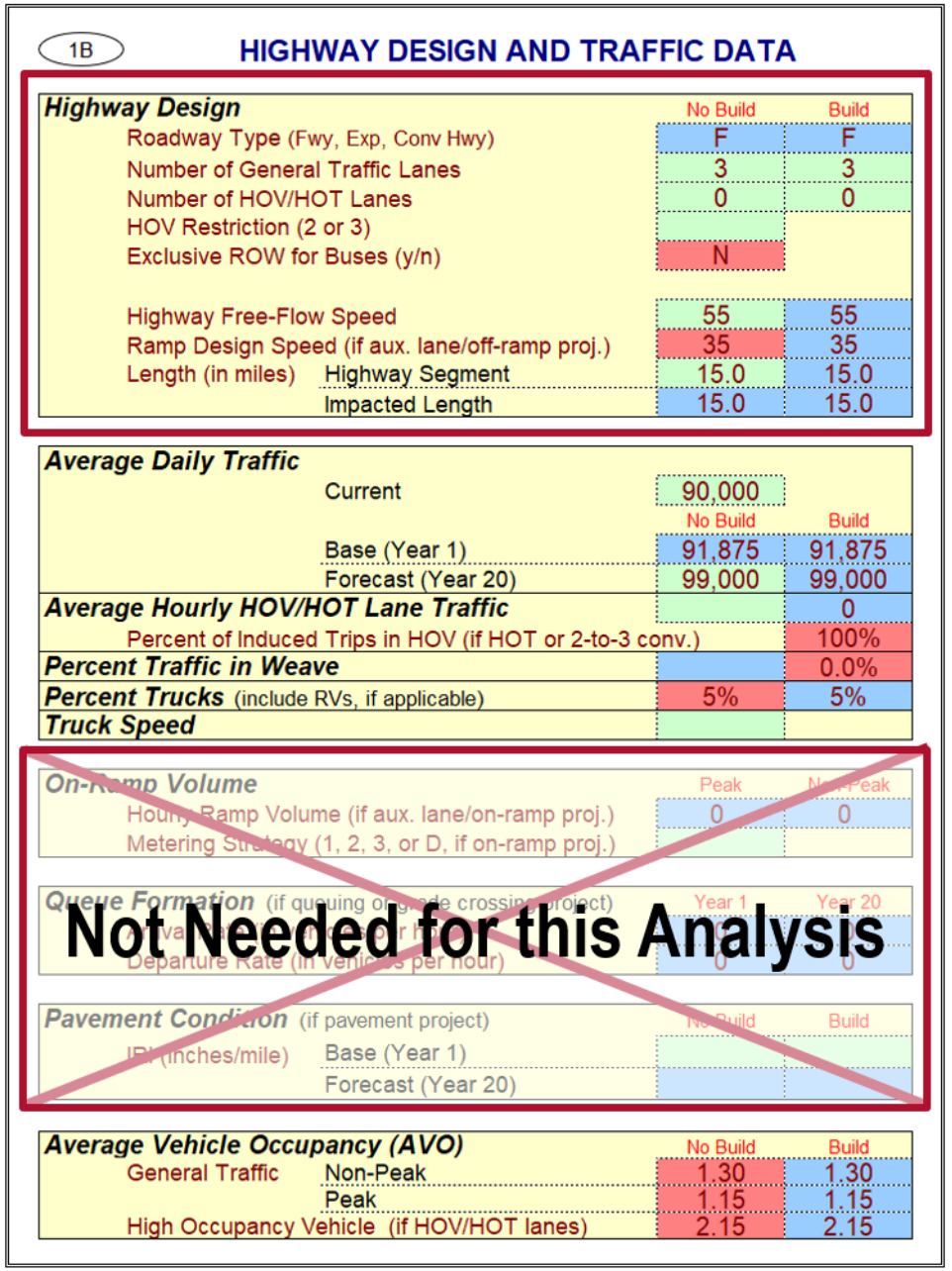
- Enter **"0"** given there are no HOV/HOT lanes in this scenario

HOV Restriction (2 or 3)

- Leave blank given there are no HOV/HOT lanes in this scenario

Exclusive ROW (Right-of-Way) for Buses

- Input **"N"**
- Not needed for this analysis



1B) Enter Highway Design and Traffic Data

Highway Free-Flow Speed

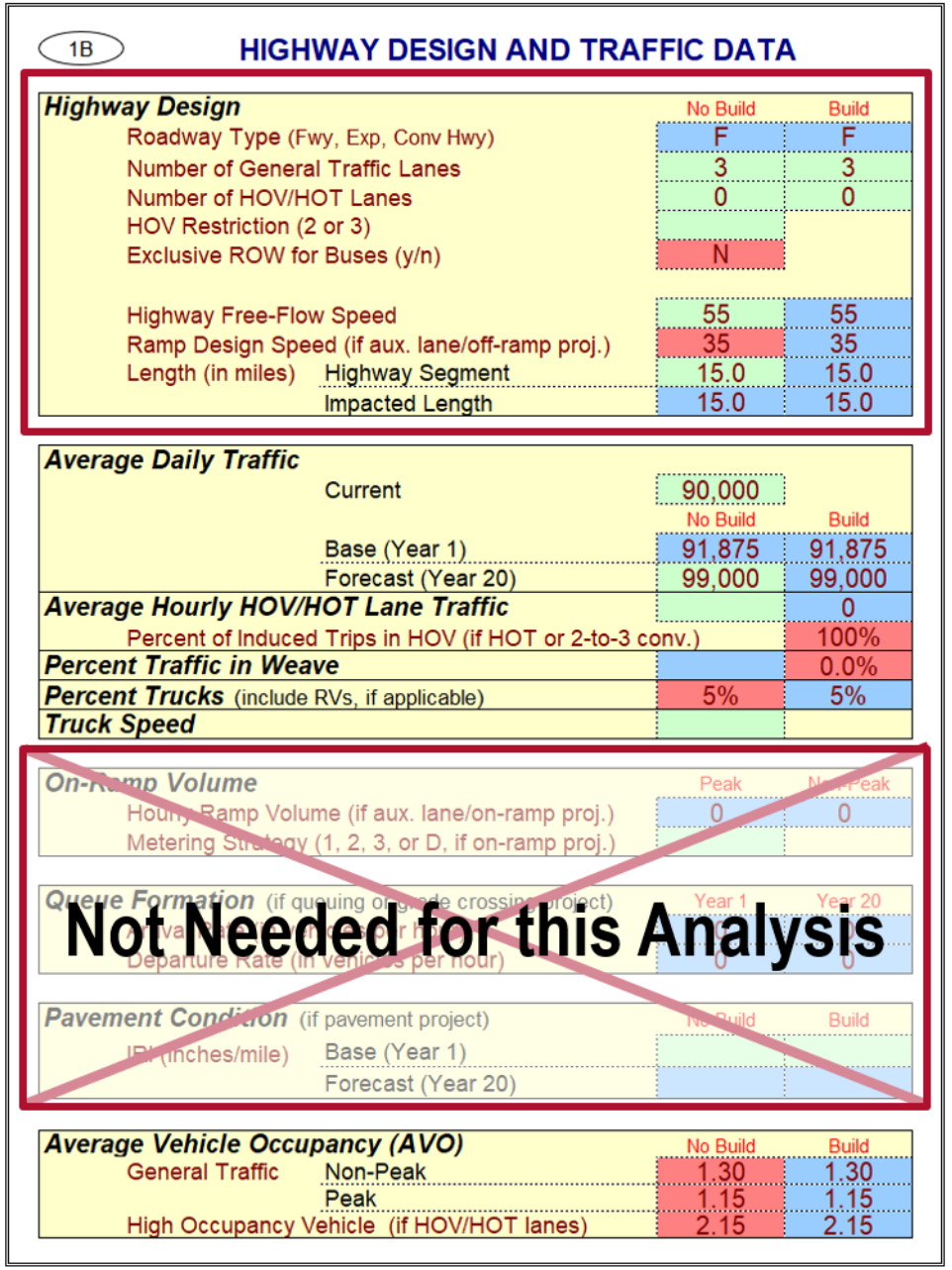
- Input **"55"** for the design speed for this urban highway

Ramp Design Speed (if auxiliary lane/off-ramp project)

- This is not needed for the analysis, so keep the default ramp speed

Length

- The transit project in this hypothetical example will impact the same distance as the highway segment length
- Input **"15"** for Highway Segment Length of the freeway corridor
- Keep "**15**" for Impacted Length (Cal-B/C Sketch automatically calculates to be equal to No Build corridor)



1B HIGHWAY DESIGN AND TRAFFIC DATA

Highway Design		No Build	Build
Roadway Type (Fwy, Exp, Conv Hwy)		F	F
Number of General Traffic Lanes		3	3
Number of HOV/HOT Lanes		0	0
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	15.0	15.0
	Impacted Length	15.0	15.0

Average Daily Traffic			
	Current	90,000	
		No Build	Build
	Base (Year 1)	91,875	91,875
	Forecast (Year 20)	99,000	99,000
Average Hourly HOV/HOT Lane Traffic			0
Percent of Induced Trips in HOV (if HOT or 2-to-3 conv.)			100%
Percent Traffic in Weave			0.0%
Percent Trucks (include RVs, if applicable)		5%	5%
Truck Speed			

On-Ramp Volume		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.)			

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

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

Not Needed for this Analysis

Average Vehicle Occupancy (AVO)		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

1B) Highway Design and Traffic Data – Travel Demand, Weaving, and Trucks

Average Daily Traffic (ADT)

- Current: Enter **"90,000"** for general purpose highway ADT
  - In 1A) we entered a **"2"** to indicate that this ADT represents one-way traffic
- Forecast: Enter **"99,000"** for estimated ADT 20 years after the project opening date (opening year + 20)

Average Hourly HOV/HOT Lane Traffic

- Leave blank since segment has no existing HOV/HOT lane

Percent of Induced Trips in HOV (if HOT or 2-3 conversion)

- Keep the **"100%"** default value. There is no HOV/HOT lane on our corridor, changing the default value would not impact this analysis.

Percent Traffic in Weave

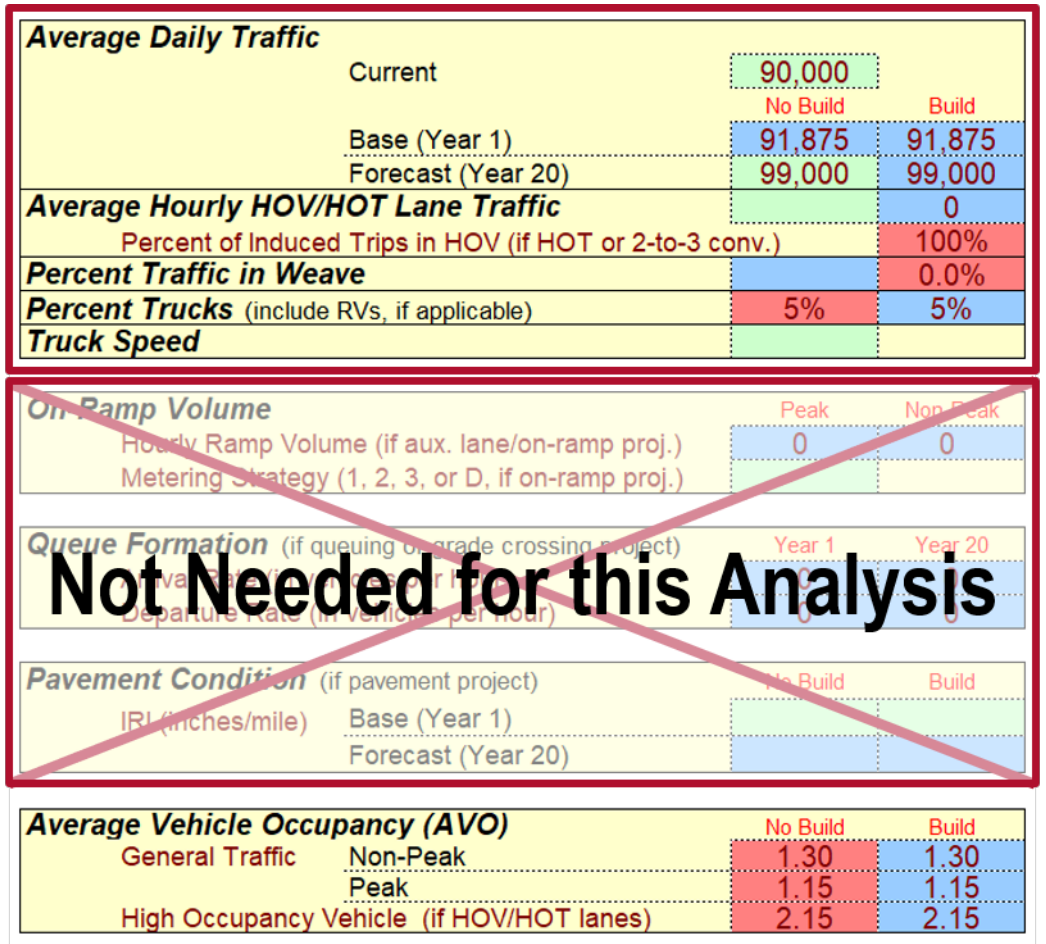
- Leave blank since project is not an operational improvement

Percent Trucks

- Enter **"5%"** for percentage of trucks on highway segment (See next slide)

Truck Speed

- Leave blank since this is not a passing lane project

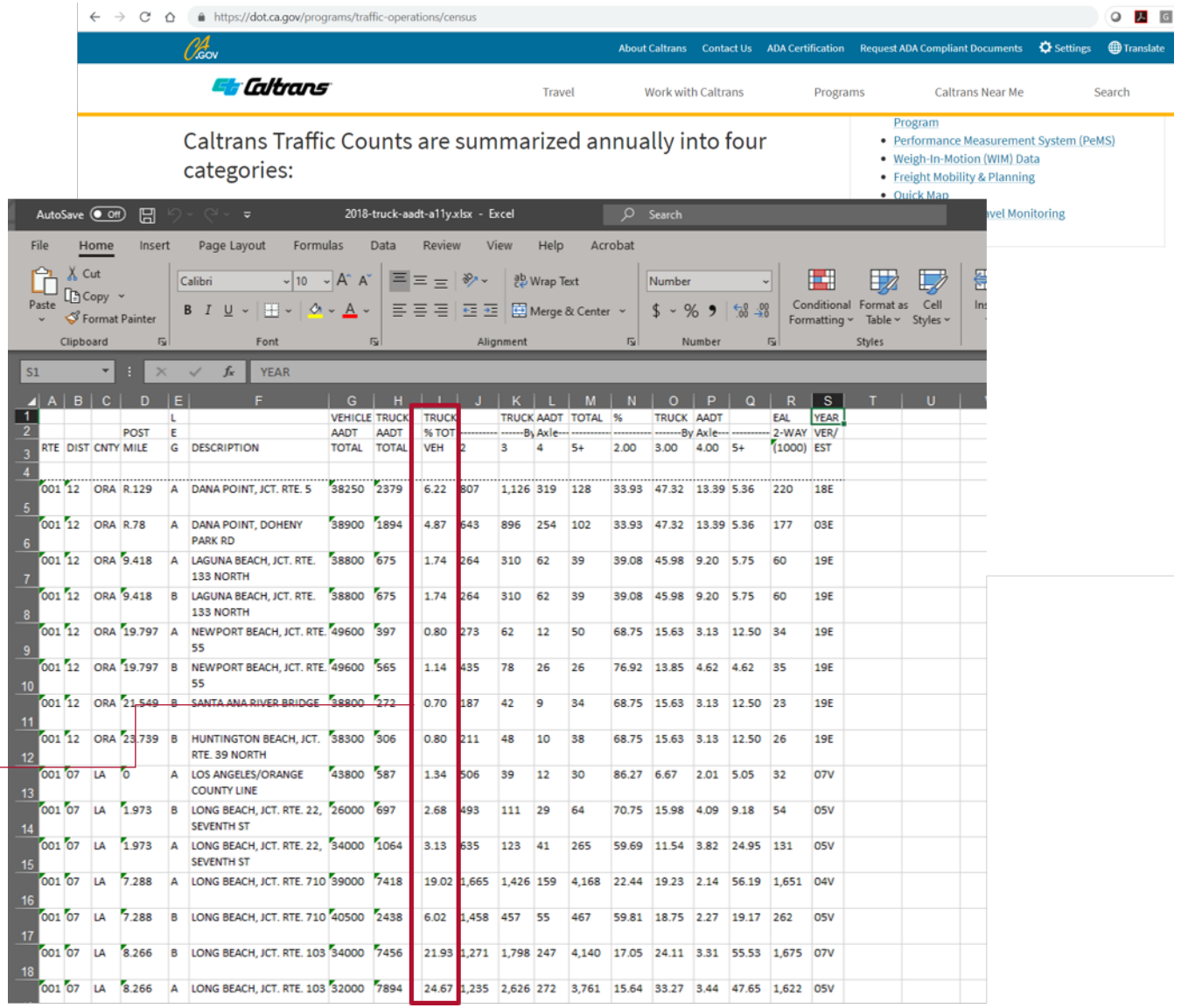


1B) Highway Design and Traffic Data – Where to Get Percent Trucks

Data Sources

- Caltrans Traffic Census Program website https://dot.ca.gov/programs/traffic-operations/census
- Annual Average Daily Truck Traffic

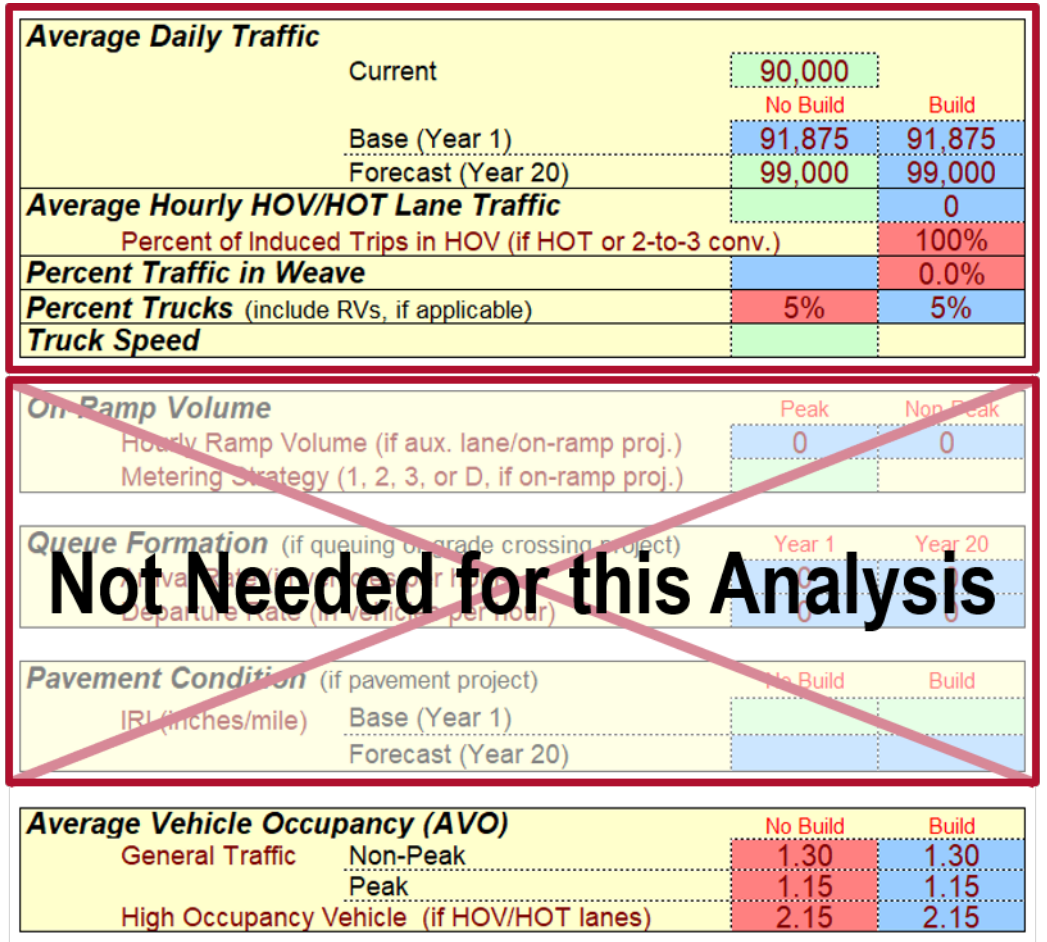
There are many methods to get Truck % from these data sources



1B) Highway Design and Traffic Data – Average Vehicle Occupancy

Average Vehicle Occupancy (AVO)

- Keep the default values for this analysis
- AVO data can be obtained from several sources including:
  - Caltrans Managed Lanes Annual Reports
  - Regional Travel Demand Models
  - U.S. Census American Community Survey Data (at county level)
  - Field data collection – vehicle classification and occupancy counts



Average Daily Traffic			
	Current	90,000	
		No Build	Build
	Base (Year 1)	91,875	91,875
	Forecast (Year 20)	99,000	99,000
Average Hourly HOV/HOT Lane Traffic			0
Percent of Induced Trips in HOV (if HOT or 2-to-3 conv.)			100%
Percent Traffic in Weave			0.0%
Percent Trucks (include RVs, if applicable)		5%	5%
Truck Speed			

On-Ramp Volume		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.)			

Queue Formation (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

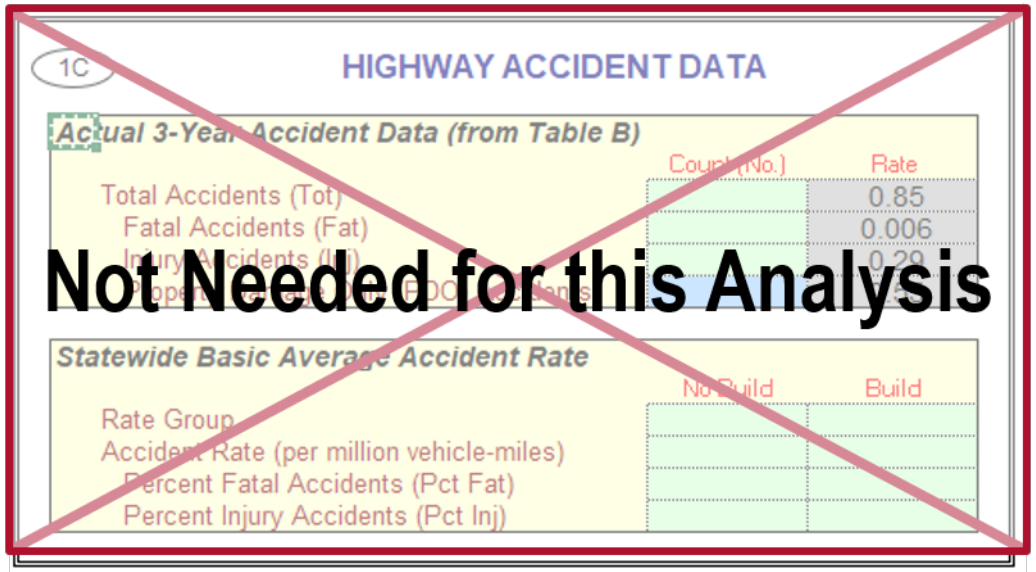
Pavement Condition (if pavement project)		No Build	Build
IRI (inches/mile)	Base (Year 1)		
	Forecast (Year 20)		

Not Needed for this Analysis

Average Vehicle Occupancy (AVO)		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

1C) Highway Accident Data

- Not needed for this analysis since it's not a highway safety project
- If you have collision data for the parallel highway, you can enter it here



1D) Enter Rail and Transit Data

Annual Person Trips

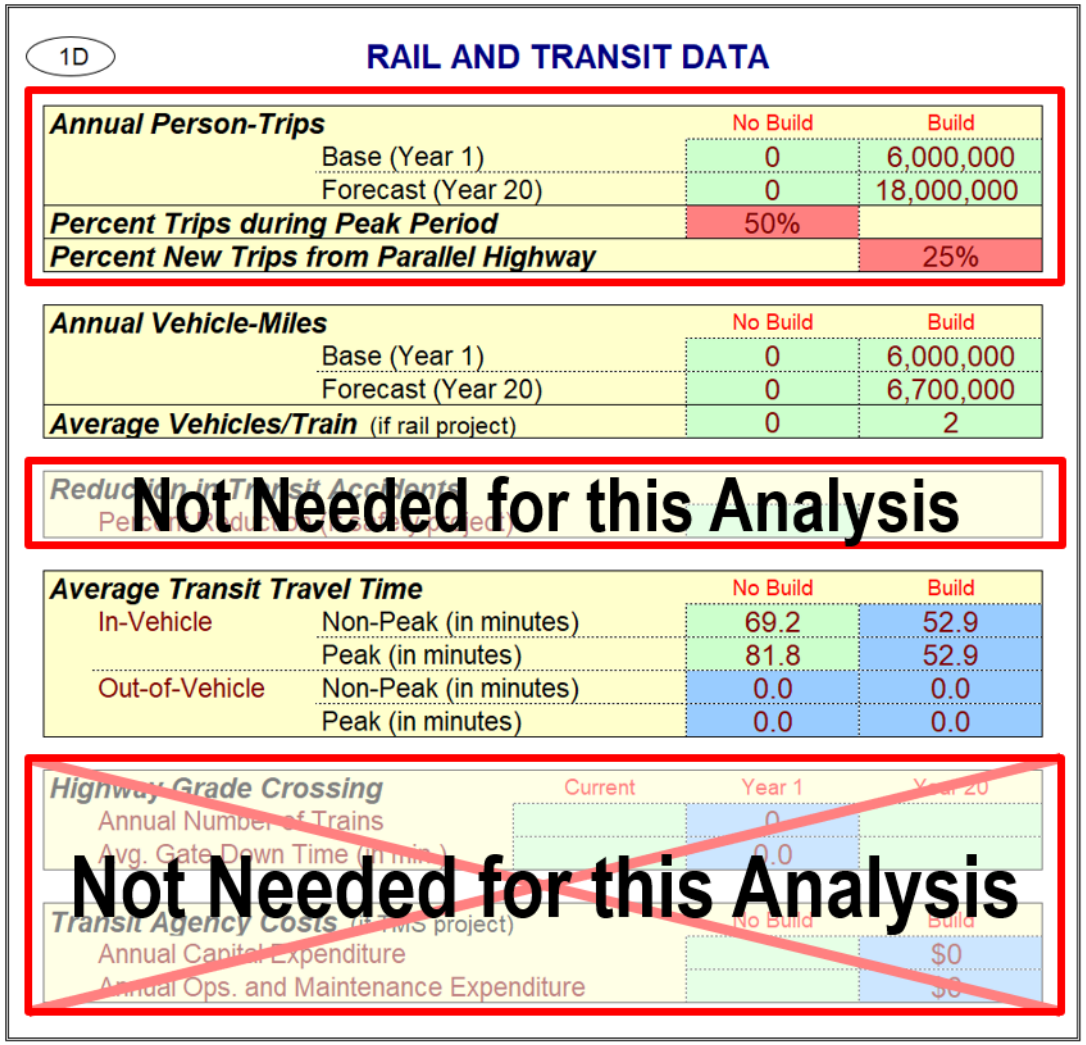
- Base (Year 1)
  - Enter **"0"** for passenger trips in 'No Build' cells. There is no existing transit service in our example.
  - Enter **"6,000,000"** for passenger trips of 'Build' (the first year after the project is built) – based on an assumption that transit ridership takes multiple years to build up
- Forecast (Year 20)
  - Enter **"0"** for passenger trips of 'No Build' since there is no existing LRT
  - Enter **"18,000,000"** for passenger trips of 'Build' (project completion date plus 20 years)

Percent Trips during Peak Period

- Enter **"50%"** as the ratio of peak period ridership to daily ridership
- This can be obtained from transit operators or estimated at a conceptual level from the NTD using peak period data

Percent New Trips from Parallel Highway

- Enter **"25%"** as the estimated percentage of trips that are people who drove or carpooled prior to the implementation of the transit project



1D) Enter Rail and Transit Data

Annual Vehicle-Miles / Average Vehicles per Train

- Input **"6,000,000"** for base year and **"6,700,000"** for Forecast (Year 20)
- Enter **"2"** for the Average Vehicles/Train

Reduction in Transit Accidents (collisions)

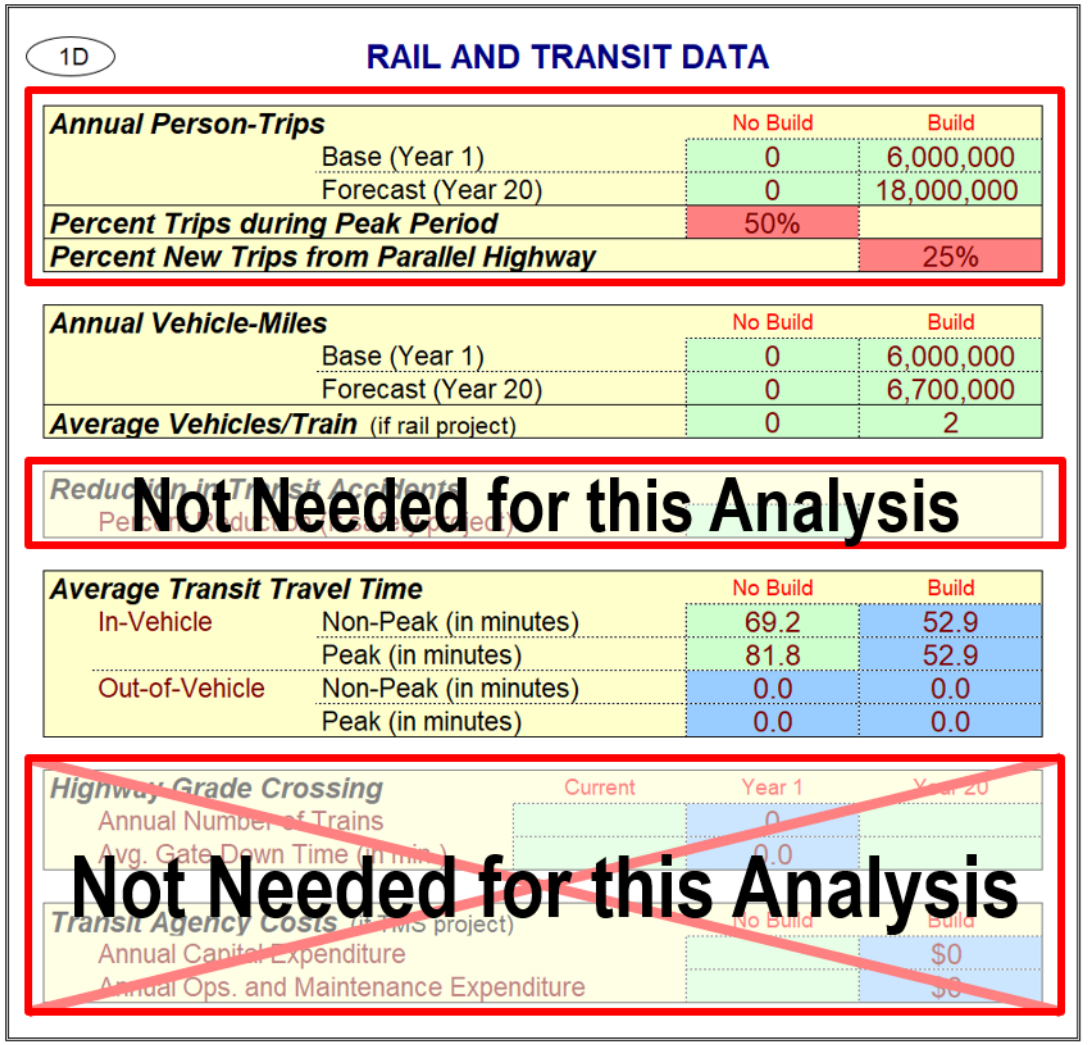
- Leave blank as this project does not directly address safety. Only enter if an expected change in collisions is expected to occur due to the project.

Highway Grade Crossing

- Leave blank as this project does not involve highway grade crossings

Transit Agency Costs

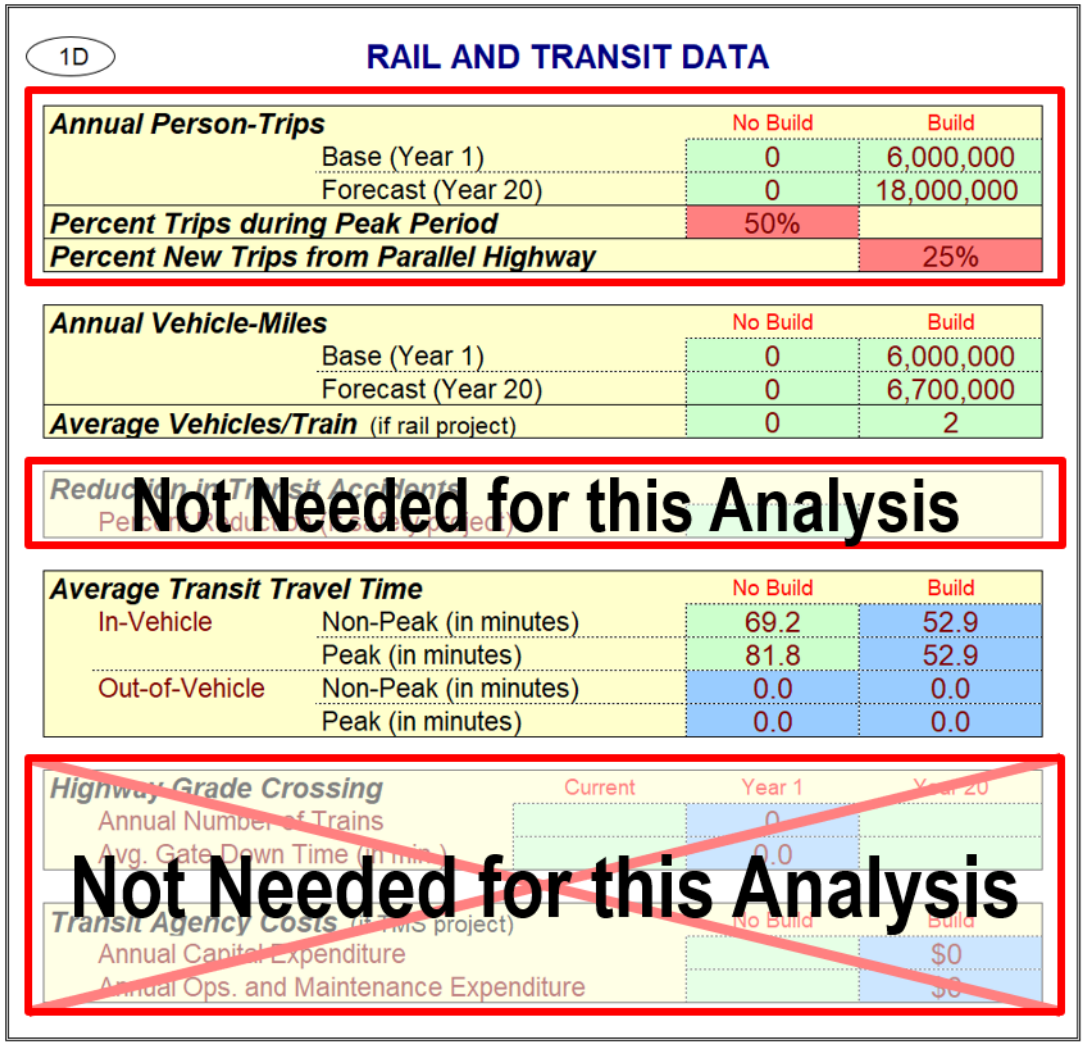
- Leave blank as this is not relevant to this analysis. O&M costs for the individual project will be input in 1E) Project Costs



1D) Rail and Transit Data – Transit Travel Times

In-Vehicle Travel Time

- No Build Non-Peak: Enter **"69.2"** for average travel time spent in transit traveling to the rider's destination
- No Build Peak: Enter **"81.8"** for average travel time spent in transit traveling to the rider's destination
- Build Non-Peak and Peak: Enter **"52.9"** for average travel time spent in transit
  - Cal-B/C estimates future travel time, but you can override that value if better data is available



1E) Project Costs – Overview

Project Data Information:

- Capital Costs: $177,000,000 (2016 dollars)
- Annual Operating Costs $70,000,000 (2016 dollars)

1E

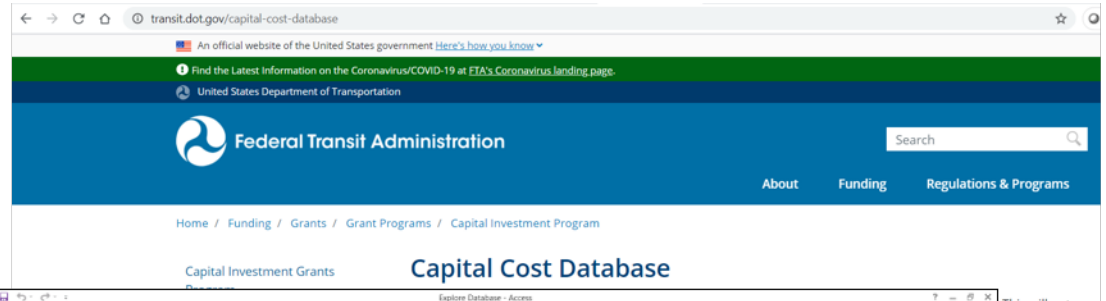
PROJECT COSTS (enter costs in thousands of dollars)

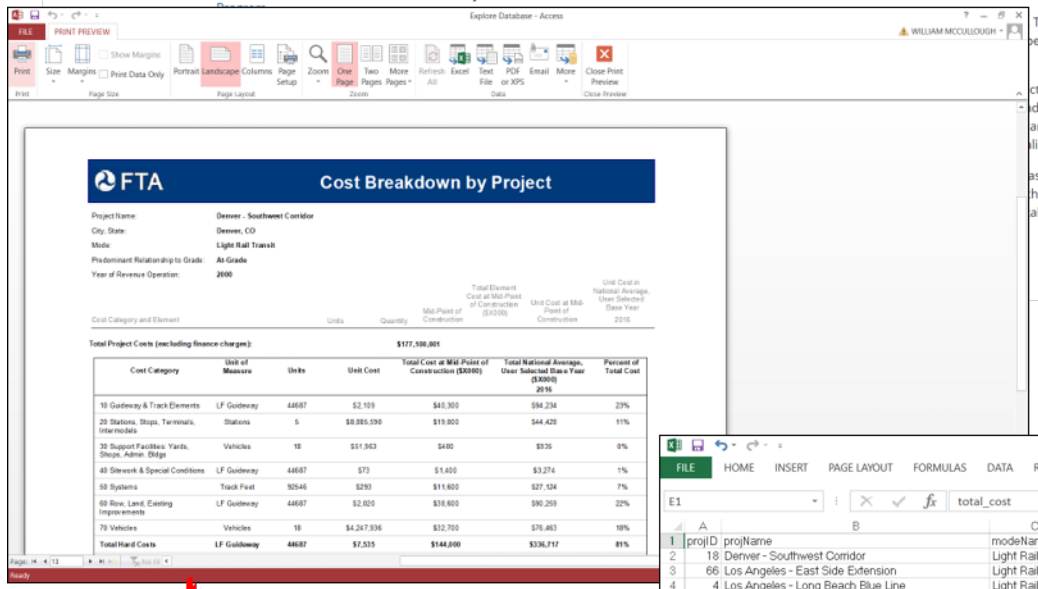
Col. no.	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
Year	DIRECT PROJECT COSTS					Mitigation	Transit Agency Cost Savings	TOTAL COSTS (in dollars)	
	INITIAL COSTS			SUBSEQUENT COSTS					
	Project Support	R / W	Construction	Maint./ Op.	Rehab.			Constant Dollars	Present Value
Construction Period									
1	$20,000	$30,000	$12,000					$62,000,000	$62,000,000
2	15,000	10,000	15,000					40,000,000	38,461,538
3			25,000					25,000,000	23,113,905
4			20,000					20,000,000	17,779,927
5			30,000					30,000,000	25,644,126
6								0	0
7								0	0
8								0	0

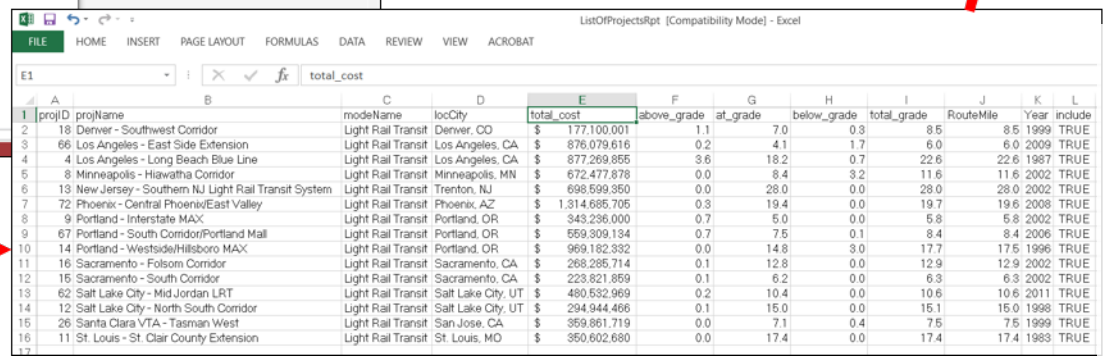
Initial Costs

- Enter the initial project costs for project support, right-of-way (R/W), and construction as shown.
- Since the project is expected to take 5 years as indicated in section 1A), 5 years of initial cost data must be entered.
- For projects in the preliminary planning phases it is not necessary to input detailed cost data.

1E) Project Costs – Capital Costs – Where Did They Come From?







	A	B	C	D	E	F	G	H	I	J	K	L
1	projID	projName	modeName	locCity	total_cost	above_grade	at_grade	below_grade	total_grade	RouteMile	Year	include
2	18	Denver - Southwest Corridor	Light Rail Transit	Denver, CO	$ 177,100,001	1.1	7.0	0.3	8.5	8.5	1999	TRUE
3	66	Los Angeles - East Side Extension	Light Rail Transit	Los Angeles, CA	$ 876,079,616	0.2	4.1	1.7	6.0	6.0	2009	TRUE
4	4	Los Angeles - Long Beach Blue Line	Light Rail Transit	Los Angeles, CA	$ 877,269,855	3.6	18.2	0.7	22.6	22.6	1987	TRUE
5	8	Minneapolis - Hiawatha Corridor	Light Rail Transit	Minneapolis, MN	$ 672,477,878	0.0	8.4	3.2	11.6	11.6	2002	TRUE
6	13	New Jersey - Southern NJ Light Rail Transit System	Light Rail Transit	Trenton, NJ	$ 698,599,350	0.0	28.0	0.0	28.0	28.0	2002	TRUE
7	72	Phoenix - Central Phoenix/East Valley	Light Rail Transit	Phoenix, AZ	$ 1,314,685,705	0.3	19.4	0.0	19.7	19.6	2008	TRUE
8	9	Portland - Interstate MAX	Light Rail Transit	Portland, OR	$ 343,236,000	0.7	5.0	0.0	5.8	5.8	2002	TRUE
9	67	Portland - South Corridor/Portland Mall	Light Rail Transit	Portland, OR	$ 559,309,134	0.7	7.5	0.1	8.4	8.4	2006	TRUE
10	14	Portland - Westside/Hillsboro MAX	Light Rail Transit	Portland, OR	$ 969,182,332	0.0	14.8	3.0	17.7	17.5	1996	TRUE
11	16	Sacramento - Folsom Corridor	Light Rail Transit	Sacramento, CA	$ 268,285,714	0.1	12.8	0.0	12.9	12.9	2002	TRUE
12	15	Sacramento - South Corridor	Light Rail Transit	Sacramento, CA	$ 223,821,859	0.1	6.2	0.0	6.3	6.3	2002	TRUE
13	62	Salt Lake City - Mid Jordan LRT	Light Rail Transit	Salt Lake City, UT	$ 480,532,969	0.2	10.4	0.0	10.6	10.6	2011	TRUE
14	12	Salt Lake City - North South Corridor	Light Rail Transit	Salt Lake City, UT	$ 294,944,466	0.1	15.0	0.0	15.1	15.0	1998	TRUE
15	26	Santa Clara VTA - Tasman West	Light Rail Transit	San Jose, CA	$ 359,861,719	0.0	7.1	0.4	7.5	7.5	1999	TRUE
16	11	St. Louis - St. Clair County Extension	Light Rail Transit	St. Louis, MO	$ 350,602,680	0.0	17.4	0.0	17.4	17.4	1983	TRUE

PROJECT COSTS (enter costs in thousands of dollars)

Col. no.		(1)	(2)	(3)	(4)	(5)	(6)	(7)		
		DIRECT PROJECT COSTS							TOTAL COSTS (in dollars)	
		INITIAL COSTS			SUBSEQUENT COSTS					
	Year	Project Support	R / W	Construction	Maint./ Op.	Rehab.	Mitigation	Transit Agency Cost Savings	Constant Dollars	Present Value
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	4			20,000					20,000,000	17,779,927
	5			30,000					30,000,000	25,644,126
	6								0	0
	7								0	0
	8								0	0
Project Open										
	1				$70,000				$70,000,000	$57,534,897
	2				70,000				70,000,000	55,322,017
	3				70,000				70,000,000	53,194,247
	4				70,000				70,000,000	51,148,314
	5				70,000				70,000,000	49,181,071
	6				70,000				70,000,000	47,289,492
	7				70,000				70,000,000	45,470,665
	8				70,000				70,000,000	43,721,793
	9				70,000				70,000,000	42,040,186
	10				70,000				70,000,000	40,423,256
	11				70,000				70,000,000	38,868,515
	12				70,000				70,000,000	37,373,572
	13				70,000				70,000,000	35,936,127
	14				70,000				70,000,000	34,553,968
	15				70,000				70,000,000	33,224,970
	16				70,000				70,000,000	31,947,086
	17				70,000				70,000,000	30,718,352
	18				70,000				70,000,000	29,536,877
	19				70,000				70,000,000	28,400,843
	20				70,000				70,000,000	27,308,503
	Total	$35,000	$40,000	$102,000	$1,400,000	$0	$0	$0	$1,577,000,000	$980,194,251

Capital Cost Database downloaded and unit costs developed (e.g., $ per mile of guideway)

- Costs allocated to year (e.g., by using project cost data from previous similar projects)
- For Cal-B/C preliminary planning analyses, user can also enter costs as occurring evenly over the construction period if better cost data not available

1E) Project Costs – Overview

Project Data Information:

- Capital Costs: $177,000,000 (2016 dollars)
- Annual Operating Costs $70,000,000 (2016 dollars)

Project Open									
1				$70,000				$70,000,000	$57,534,897
2				$70,000				70,000,000	55,322,017
3				$70,000				70,000,000	53,194,247
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5				$70,000				70,000,000	49,181,071
6				$70,000				70,000,000	47,289,492
7				$70,000				70,000,000	45,470,665
8				$70,000				70,000,000	43,721,793
9				$70,000				70,000,000	42,040,186
10				$70,000				70,000,000	40,423,256
11				$70,000				70,000,000	38,868,515
12				$70,000				70,000,000	37,373,572
13				$70,000				70,000,000	35,936,127
14				$70,000				70,000,000	34,553,968
15				$70,000				70,000,000	33,224,970
16				$70,000				70,000,000	31,947,086
17				$70,000				70,000,000	30,718,352
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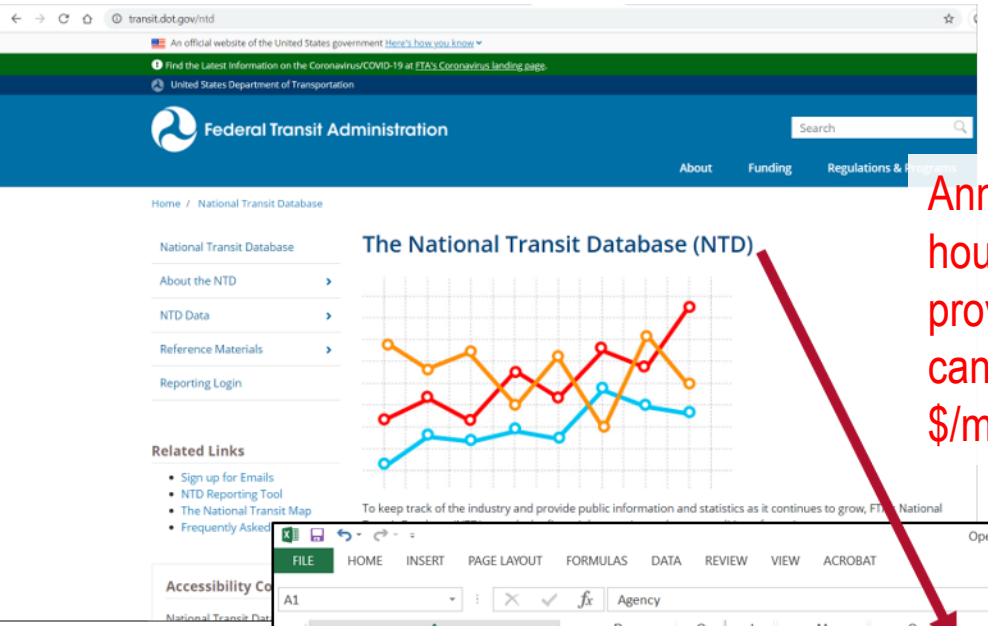
19				$70,000				70,000,000	28,400,843
20				$70,000				70,000,000	27,308,503
Total	$35,000	$40,000	$102,000	$1,400,000	$0	$0	$0	$1,577,000,000	$980,194,251

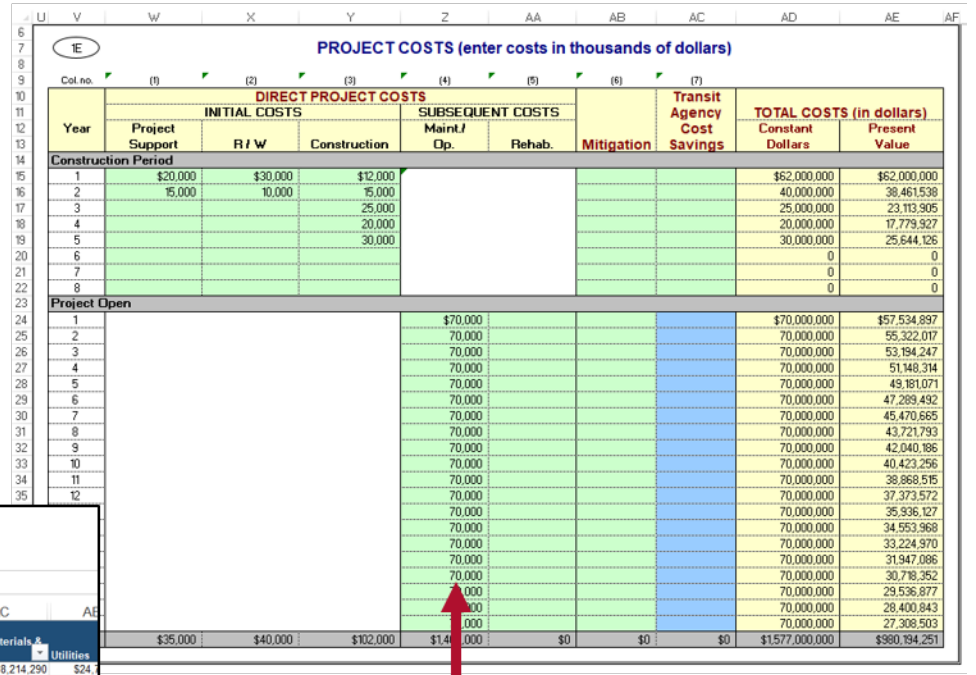
Subsequent Costs

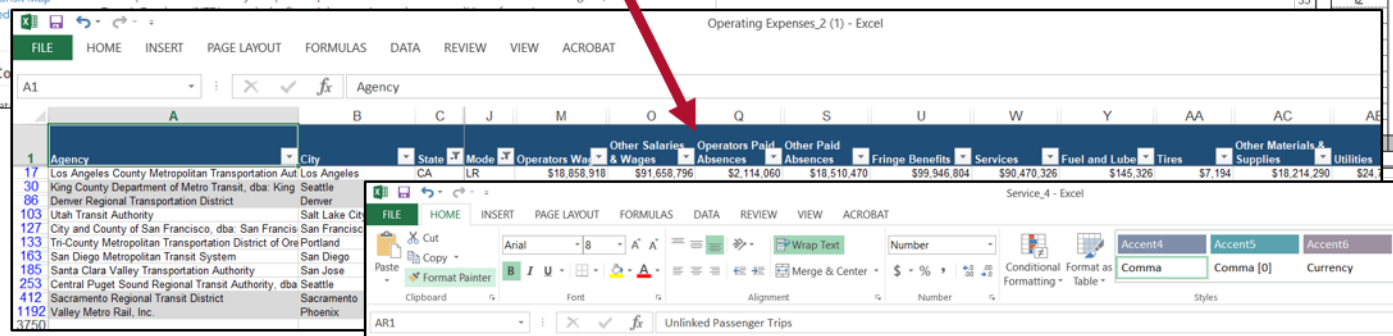
- Assume $70,000,000 cost per year. Enter as **"$70,000"** (values are in thousands of dollars).
- These cost estimates were developed from unit costs from the Federal Transit Administration (FTA).

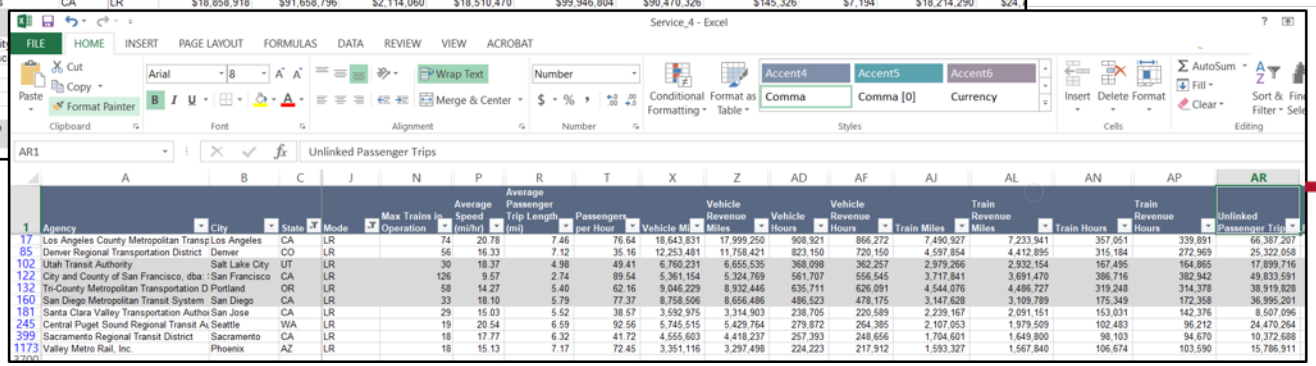
1E) Project Costs – Annual Operating Costs – Where Did They Come From?



Annual operating costs, total hours and miles of service provided for similar systems can be used to develop unit $/mile operated







These can be used along with the Annual-Vehicle Miles estimate from Section 1D) to estimate annual operating costs for project

04

Model Inputs Worksheet

2) Model Inputs Worksheet

- Review this worksheet to make sure that your volumes and speeds make sense
- Year 1 speeds (the year after construction is completed) can be visually examined as a "reality check" on Cal-B/C calculations
- You can enter updated values in the green cells if better data is available.

Does this peak period speed make sense for your corridor?

Remember Year 1 is only a few years away (5 years after construction), so speeds calculated by Cal-B/C should likely reflect what you know to be the operating conditions on the roadway.

2A

HIGHWAY SPEED AND VOLUME INPUTS

	Calculated by Model	Changed by User	Used for Proj. Eval.	Reason for Change
No Build				
Year 1				
Peak Period				
HOV Volume	0		0	
Non-HOV Volume	35,174		35,174	
Weaving Volume	0		0	
Truck Volume	1,851		1,851	
HOV Speed	55.0		55.0	
Non-HOV Speed	20.8		20.8	
Weaving Speed	55.0		55.0	
Truck Speed	20.8		20.8	
Non-Peak Period				
Non-HOV Volume	52,107		52,107	
Weaving Volume	0		0	
Truck Volume	2,742		2,742	
Non-HOV Speed	55.0		55.0	
Weaving Speed	55.0		55.0	
Truck Speed	55.0		55.0	
Year 20				
Peak Period				
HOV Volume	0		0	
Non-HOV Volume	37,902		37,902	
Weaving Volume	0		0	
Truck Volume	1,995		1,995	
HOV Speed	55.0		55.0	
Non-HOV Speed	12.3		12.3	
Weaving Speed	55.0		55.0	
Truck Speed	12.3		12.3	
Non-Peak Period				
Non-HOV Volume	56,148		56,148	
Weaving Volume	0		0	
Truck Volume	2,955		2,955	
Non-HOV Speed	55.0		55.0	
Weaving Speed	55.0		55.0	
Truck Speed	55.0		55.0	

05

Results Worksheet

3) Model Results

- This project has a modest, yet economically efficient, **1.7** B/C Ratio
- Payback Period is **9 years**
- Increased accident costs due to rail collisions based on the train miles
- Increased PM10 emissions
- Some mode shifts from autos, other transit vehicles since transit travel times improved
- Adjusting input variables can be done to test the sensitivity of these results
  - What happens if highway demand grows faster than what was input?
  - What happens if transit ridership is lower than forecast?

(3)

INVESTMENT ANALYSIS
SUMMARY RESULTS

Life-Cycle Costs (mil. $)	$776.9
Life-Cycle Benefits (mil. $)	$1,316.4
Net Present Value (mil. $)	$539.5
Benefit / Cost Ratio:	1.7
Rate of Return on Investment:	13.9%
Payback Period:	9 years

ITEMIZED BENEFITS (mil. $)	Passenger Benefits	Freight Benefits	Total Over 20 Years	Average Annual
Travel Time Savings	$1,090.5	$96.1	$1,186.6	$59.3
Veh. Op. Cost Savings	$282.5	$12.9	$295.4	$14.8
Accident Cost Savings	-$189.8	$0.0	-$189.8	-$9.5
Emission Cost Savings	$14.4	$9.8	$24.2	$1.2
TOTAL BENEFITS	$1,197.6	$118.8	$1,316.4	$65.8
Person-Hours of Time Saved			122,423,447	6,121,172

Should benefit-cost results include:

1) Induced Travel? (y/n)	Y	Default = Y
2) Vehicle Operating Costs? (y/n)	Y	Default = Y
3) Accident Costs? (y/n)	Y	Default = Y
4) Vehicle Emissions? (y/n) includes value for CO_2e	Y	Default = Y

	Tons		Value (mil. $)	
EMISSIONS REDUCTION	Total Over 20 Years	Average Annual	Total Over 20 Years	Average Annual
CO Emissions Saved	1,840	92	$0.2	$0.0
CO_2 Emissions Saved	807,910	40,396	$22.7	$1.1
NO_X Emissions Saved	161	8	$5.1	$0.3
PM_{10} Emissions Saved	-16	-1	-$4.9	-$0.2
$PM_{2.5}$ Emissions Saved	7	0		
SO_X Emissions Saved	8	0	$0.9	$0.0
VOC Emissions Saved	147	7	$0.3	$0.0

06

Conclusion

In this module, you learned…

- How to perform a Cal-B/C BCA for a transit project
- What data sources can be used for this type of example
- How to interpret findings

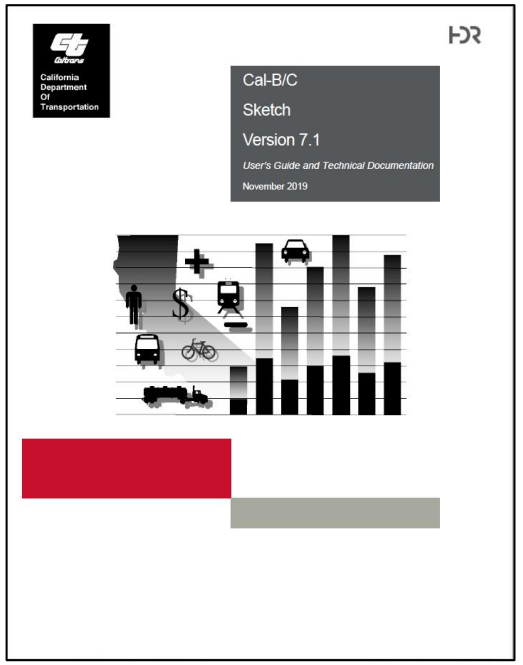
What's Next?

- **Module 10** is the final module in this training series and provides additional information and data sources for BCA

Cal-B/C Documentation

- The Users Guide for each tool provides documentation for the parameters (see Module 10 for more information)
  - User-focused overview with step-by-step instructions and project examples
  - Describes model framework, project types, and updated parameters
- The Parameter Guide for all tools describes economic values and parameters
- User's Guide for all Cal-B/C tools is available on the Caltrans Transportation Economics Branch website: https://dot.ca.gov/programs/transportation-planning/economics-data-management/transportation-economics

User's Guide



Parameter Guide