STATE OF CALIFORNIA • DEPARTMENT OF TRANSPORTATION

TECHNICAL REPORT DOCUMENTATION PAGE

DRISI-2011 (REV 10/1998)

Lock Data on Form

1. REPORT NUMBER	2. GOVERNMENT ASSOCIATION NUMBER	3. RECIPIENT'S CATALOG NUMBER
CA16-2836		

4. TITLE AND SUBTITLE
Develop a Plan to Collect Bicycle Infrastructure and Volume Data for Future Incorporation into the Traffic Accident Surveillance and Analysis System – Transportation System Network TASAS - TSN

5. REPORT DATE
June 30, 2016

6. PERFORMING ORGANIZATION CODE

7. AUTHOR
Yuanyuan Zhang, Ryan E Reeves, Wesley Jin, and Offer Grembek,

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
UC Berkeley Safe Transportation Research & Education Center
2614 Dwight Way, #7374
Berkeley, CA 94720-7374

10. WORK UNIT NUMBER

11. CONTRACT OR GRANT NUMBER
65A0567

12. SPONSORING AGENCY AND ADDRESS
California Department of Transportation
Division of Research and Innovation, MS-83
1227 O Street Sacramento CA 95814

13. TYPE OF REPORT AND PERIOD COVERED
Final report

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT
This project evaluates the feasibility of developing a bicycle infrastructure database and volume database for the California state highway system. While Caltrans currently maintains such data for motor vehicles in the Traffic Accident Surveillance and Analysis System - Transportation System Network (TASAS-TSN) database, the agency does not keep records on bicycle facilities. This information is crucial for improving the safety of these vulnerable road users. This project developed a proposed database structure and corresponding data collection methodology. It is recommended that the databases be linked to TASAS using the connection ID instead of incorporating them directly into the existing database. The volume and infrastructure databases will be constructed separately to accommodate different data collection procedures. The research team tested the structure and collection methodology by populating the database for 50 miles of state highway across seven districts. Parallel to testing the consistency and integrity of the database, the team also generated a time-cost estimate for data collection for different facilities across the state highway system. The research team estimates that collecting the data in the field for the entire state highway system will require approximately 25,000 hours, while remote (computer-based) data collection will require about 4,500 hours.

17. KEYWORDS
Bicycle, TASAS, Infrastructure, database, safety, California, Caltrans, Bike, transportation

18. DISTRIBUTION STATEMENT
No restrictions.

19. SECURITY CLASSIFICATION (*of this report*)	20. NUMBER OF PAGES	21. COST OF REPORT CHARGED
Unclassified	77	

DISCLAIMER STATEMENT

DEVELOP A PLAN TO COLLECT BICYCLE INFRASTRUCTURE AND VOLUME DATA FOR FUTURE INCORPORATION INTO THE TRAFFIC ACCIDENT SURVEILLANCE AND ANALYSIS SYSTEM – TRANSPORTATION SYSTEM NETWORK TASAS – TSN

FINAL TECHNICAL REPORT

PREPARED BY THE
UC BERKELEY SAFE TRANSPORTATION RESEARCH AND EDUCATION CENTER
FOR THE
CALIFORNIA DEPARTMENT OF TRANSPORTATION

JUNE 30, 2016

YUANYUAN ZHANG
RYAN E REEVES
WESLEY JIN
OFFER GREMBEK

ACKNOWLEDGEMENTS

The authors would like to thank the California Department of Transportation for their support of this project. We especially acknowledge the support and comments from Aileen Loe, Ann Mahaney, Jacob Mathew, Seth Cutter. The assistance and advice of Julia Griswold and Natalia Sanz are also greatly appreciated. This work couldn’t have been possible without the dedication and motivation of Ryan E Reeves, Diana A Teremzawi, Chad Vo, and Wesley who conducted the data collection efforts.

TABLE OF CONTENTS

EXECUTIVE SUMMARY **1**
1 INTRODUCTION **2**
2 BACKGROUND RESEARCH ON BICYCLE INFRASTRUCTURE INVENTORIES AND VOLUME MODELING **4**
2.1 BICYCLE INFRASTRUCTURE INVENTORIES 4
2.2 POTENTIAL ITEMS TO INCLUDE IN BICYCLE DATABASE 9
2.3 CONCLUSIONS 13
3 DATABASE STRUCTURE AND DESIGN **15**
3.1 DECOMPOSITION OF A TYPICAL ROAD SEGMENT 15
3.2 COMPONENT DEFINITIONS AND CONNECTIONS 16
3.3 DATABASE STRUCTURE 19
4 DATA COLLECTION MANUAL **20**
4.1 FACILITY DATA COLLECTION 23
4.2 VOLUME DATA COLLECTION 37
5 DATA COLLECTION PILOT **40**
5.1. Computer Data Collection 40
5.2. FIELD DATA COLLECTION 45
5.3 VOLUME DATA COLLECTION 45
6 TIME COST FOR DATA COLLECTION **50**
6.1 COMPUTER DATA COLLECTION 51
6.2 FIELD DATA COLLECTION 52
6.3 COMPARISONS 53
7 CONCLUSIONS AND RECOMMENDATIONS **55**
7.1 CONCLUSIONS 55
7.2 RECOMMENDATIONS 56
Appendix 1. Comments and responses on Variables 58
Appendix 2. Datebase structure 62
Appendix 3. Field Data Collection Packet 64
Appendix 4. Time Estimation Spreadsheet Tool 71
Appendix 5. Routes with multiple roadway classifications 72

EXECUTIVE SUMMARY

In this report, a database format is proposed for storing bicycle infrastructure and volume data collected across the California state highway network. Data collection protocols are detailed for filling both databases. Additionally, a pilot data collection effort was conducted to verify that the data can be collected both via computer-based imagery and field-based collection. In the process of conducting the pilot data collection, the amount of time required was recorded and used to estimate the total time cost for collecting data across the entire state highway network.

The database is comprised of two sub-databases, one for infrastructure and one for volumes. Both of these databases are structured around two "core elements"—nodes and approaches. These core elements give spatial structure to the database. Nodes are defined as including typical highway intersections and intersections between highways and cross streets, as well as mid-block crossings, pedestrian over/underpasses, and periodic locations along highways where a node has not otherwise been triggered. Approaches are simply defined as connecting nodes, with one approach for each direction of the highway. "Secondary elements" are then defined to represent bicycle infrastructure and volumes, which are linked to the core elements based on spatial location. For example, bikeways are defined with reference to a single approach, whereas right/left turn pocket are defined with reference to one node and two approaches.

Using this framework, a number of secondary elements are defined for bicycle infrastructure and volumes, including bikeways, bicycle parkings, bicycle related signage, etc. For each of these elements, a number of attributes are defined. For example, bikeway attributes include bikeway types, colors, surface quality, and other similar features. Data collection protocols for all of these elements are defined, including using Google maps/Google Street View and via field observation.

The computer-based data collection procedures were tested on 50 miles of state highway, and a five-mile (4.7) subset of data was collected using field data collection. In addition to verifying that the data collection process works as intended, the pilot was used to estimate a time cost for collecting this data across the entire state highway system.

It is uncertain whether the database will eventually be merged into Caltrans' Traffic Accident Surveillance and Analysis System (TASAS) - Transportation System Network (TSN), or whether it will be developed as a separate database with links to TASAS - TSN. Caltrans staff will need to make a decision about which option fits best within the existing technological framework.

1 INTRODUCTION

This report documents "Develop a Plan to Collect Bicycle Infrastructure and Volume Data for Future Incorporation into TASAS-TSN." For this project, a relational database was developed to store information on bicycle infrastructure and volume. This database is designed to be linkable to the existing Caltrans Traffic Accident Surveillance and Analysis System (TASAS) - Transportation System Network (TSN) database, which includes information on California's state highway system including infrastructure (e.g., number of lanes, lane widths, etc.), vehicular volumes, and crashes. However, the existing database does not include any information on bicyclist-specific infrastructure, such as the presence of bicycle parking, bikeways, bicycle signage, etc.

In addition to designing the database, a data collection process to populate the database was developed and pilot tested across a subset of the state highway system. The data collection process was developed for both computer-based data collection and field-data collection. The pilot test encompassed 50 miles using the computer data collection method and 4.7 miles using the field data collection method.

The primary goals of this project are to (1) design a flexible database to store bicycle infrastructure and volume data to be queried in safety analyses, for network deficiencies, and any other uses; (2) to determine an efficient method of collecting data that can be scaled for use across the entire state highway system; (3) to pilot test the data collection process and ensure that all data can be feasibly collected and stored within the database framework; and (4) to estimate the total time-cost of collecting this data across the entire state highway system.

Key Components

The report is divided into seven chapters that describe the overall project and findings.

Chapter 1 includes an introduction that elaborates on the purpose and background of the project.

Chapter 2 presents a review of similar bicycle infrastructure inventories carried out in various cities and states. Chapter 3 also includes a review of literature on bicycle safety studies and relative manuals. This review aims to help determine a list of data to be collected in the pilot.

Chapter 3 describes the database developed during this project to store bicycle infrastructure and volume data. The structure used is based on two core elements, nodes and approaches, which provide the spatial structure for the highway network. Nodes correspond to intersections, midblock crosswalks, over/under passes, and points every 1-mile along remote highways (i.e., whenever nodes do not occur for any other reason). Approaches refer to the connections between nodes. Approaches are defined by the direction of motor vehicle traffic, meaning that between two intersections (two nodes) on a bidirectional road, there are two approaches. Secondary elements such as bikeways, bicycle parking, and bicycle signage are then each related by a unique ID to the approaches and nodes. Separate tables are used for each element type.

Chapter 4 includes the Data Collection Manual, a document describing all of the data elements to be collected for this database in detail. Directions are given for taking different measurements and for classifying categorical information, such as bikeway types.

Chapter 5 describes the pilot data collection process and provides instructions for collecting data in the field. The pilot was conducted with the goals of refining the data collection process and database format, estimating the total time required to collect data across the entire state highway network, and checking the feasibility of collecting infrastructural data using remote imagery. The data collection pilot was conducted in seven districts.

Based on the results of the data collection pilot, *Chapter 6* provides estimates of the time required for collection of bicycle infrastructural data across the entire California state highway network using various data collection processes (computer-based and field-based). Cost estimates are not provided for populating the volume database. Volume data is proposed for collection as part of regular traffic safety investigations and other field visits, as the cost of installing a Miovision camera is very low. The volume data should be collected as frequently as is feasible.

Finally, *Chapter 7* presents conclusions and recommendations for implementation of the data collection process documented herein. Areas for future discussion include software for use in implementing the database, whether a GIS-based approach should be considered, connections to the existing TASAS-TSN system, and plans and a timeline for conducting the complete bicycle infrastructure inventory.

2 BACKGROUND RESEARCH ON BICYCLE INFRASTRUCTURE INVENTORIES AND VOLUME MODELING

This project recommends that bicycle infrastructure and volume data fields be added to the Caltrans transportation system information database. This involves developing a database structure, collecting data on the State Highway System, integrating the bicycle data with all other transportation system variables, and maintaining the data over time. Similar efforts have been undertaken by other agencies, and lessons learned from these experiences can help form the process of updating Caltrans' State Highway System database. This document presents background research on two main topics: 1) bicycle infrastructure inventories, and 2) bicycle volume models. The example inventories and models are from both California and other parts of North America.

Ultimately, new bicycle data fields can form the foundation of a database including bicycle crash, bicycle exposure, and detailed bicycle infrastructure information. Combining these three main types of data makes it possible to track bicycle crash risk over time, analyze roadway features associated with bicycle crash risk, develop bicycle crash modification factors, and conduct other useful analyses. This rich set of information will help Caltrans select the most effective engineering, education, and enforcement treatments to reduce bicycle injuries on the State Highway System and other roadways in California.

Based on this review, a list of potential data fields for inclusion in the Caltrans bicycle infrastructure inventory are itemized.

2.1 BICYCLE INFRASTRUCTURE INVENTORIES

2.1.1 EXISTING INVENTORIES

This section summarizes several successful bicycle infrastructure inventories conducted by agencies at the state, county, and city levels. The description of each inventory includes the data fields collected, as well as the year of collection and the name of the database, as shown in Table 1.

Table 1. Existing Bicycle Infrastructure Inventories

Agency	Year	Database Name	Data Collected
Massachusetts	2013	Bicycle Facility Inventory (BFI)	Facility Type, Traffic Direction, Surface, Bicycle Sign Type
Washington	2002	Statewide Bicycle and Pedestrian Facility Inventory	Bike Lanes, Shoulders, Shared-use pathways beside the roadway, Sidewalks, Walking paths, Signalized and unsignalized intersections, Roadway medians, Marked crosswalks, Transit stops, ADA facilities

North Carolina	2015	Pedestrian and Bicycle Infrastructure Network (PBIN)	facility type, Signing and Marking, Roadway name; Cardinal direction, Point facility type (such as bike maintenance station, bike parking, bike share, bike detection, bike signal, bike box, etc.), point signage (such as bike lane, bike lane ahead/ends, no parking-bike lane, etc.)
Minnesota	2003	Regional Bikeways Dataset	Side, Type, Miles, Width, Direction, Grade, Speed, Quality, Lighted, Stops, Class, Road Speed, Road Heavy Commercial Traffic, Lane Number, Lane Width, Lane Direction, Lane Type, Shoulder Width, Shoulder Type, Shoulder Rumble Stripped, Shoulder Parking, Shoulder Bus Only, Shoulder Drainage, Road AADT, Surface Type, Surface Quality
Los Angeles County, California	2013	Bike Paths	Name, Class, Source
Atlanta, Georgia	2014	Metro Atlanta Bicycle Facility Inventory	Facility types, Name, Signed, State bike route, Marked, Surface structure, On-road or Off-road
Denver, Colorado	2001	Bicycle Facility Inventory	Type, Status, Name, Sign, Width

Massachusetts: The Bicycle Facility Inventory (BFI) is a continuing data development effort carried out by the Massachusetts Department of Transportation (Mass DOT) office of Transportation Planning, to create a database of bicycle information usable in a geographic information system (GIS) for map production, reporting, and analysis. This spatial data in the BFI contains existing bicycling facilities across the Commonwealth of Massachusetts, as well as those accommodations that are in construction, design, or feasibility study phases and those that are merely proposed or envisioned. Both on-road facilities (bike lanes, routes, and tracks) and off-road facilities are included. Persistent identification of features across release cycles is supported through the use of a unique identifier. Other attached attributes include links to the Road Inventory, principal names from overlapping naming schemes, relationship to the Bay State Greenway system described in the Massachusetts Bicycle Transportation Plan, development status, physical characteristics, involved agencies and entities, usage statistics, and references.

North Carolina: The Pedestrian and Bicycle Infrastructure Network (PBIN) is a geodatabase that includes data on existing and proposed bicycle and pedestrian facilities throughout North Carolina. North Carolina Department of Transportation (NCDOT) partners at the North Carolina State University- Institute collected the initial data for Transportation Research and Education (ITRE). The PBIN data is not comprehensive, however, and updates to the geodatabase are ongoing. Municipalities are encouraged to submit their data, in a standardized format compatible with NCDOT's existing geodatabase.

Minnesota: the Minnesota Department of Transportation (MNDOT) created the regional bikeways dataset in 2003. It has been maintained and updated by the Land Management Information Center (LMIC) through contract with the Metropolitan Council. Dataset includes bicycle routes within nine Twin Cities metropolitan counties: Anoka, Carver, Chisago, Dakota, Hennepin, Ramsey, Scott, Washington, and Wright. The bikeways are from a number of sources including the Metro Bicycle Network map book (2001), supplemented by information from maps published by city, state, county and regional government agencies, and city and county planning maps. The map shows on-road and off-road bikeways, proposed and existing bikeways, and includes bike lanes, bike-able road shoulders, and trails.

Los Angeles County, California: The County is working to combine bike path data from different sources into a single authoritative data source.

Atlanta, Georgia: the Transportation Access & Mobility Division of the Atlanta Regional Commission developed The GIS layer of bicycle facilities. The inventory was updated from the 2008 version with updated shapefiles from cities and counties in the region, which were merged and verified using Bing Imagery and Google Earth.

Denver, Colorado: Denver metropolitan Regional inventory of bicycle route data collected from Denver Regional Council of Governments (DRCOG) member governments.

2.1.2 BICYCLE SAFETY RESERACH

This section summarizes several bicycle safety studies conducted by researchers all over the world. The description of each record includes the bicycle related data fields used in the study, as shown in Table 2.

Table 2. Bicycle Infrastructure Data Used in Bicycle Safety Studies

Reference	Data Along the Roadway
Zohreh Asadi-Shekari, Mehdi Moeinaddini & Muhammad Zaly Shah	Bike route, signal, bike box, marking, slope, barriers and buffers, trial crossing, pavement, grade, lighting, traffic speed
Makarand Gawade Achilleas Kourtellis, Ph.D.* Pei-Sung Lin, Ph.D., P.E., PTOE	pedestrian warning signs, number of traffic lanes, retail location and size, bicycle lanes present, median present, Sidewalk present, crossing on a crosswalk vs not crossing on the crosswalk, site characteristics, intersection size, Type of crosswalk, Number of crosswalks, T intersection
Dr G.J. Wijlhuizen, Dr A. Dijkstra & J.W.H. van Petegem, MSc	volume of bicycle traffic, visibility of potential collision opponents , speed differences, width of bicycle facilities, means and degree of separation of road users, quality of the surface of the cycling facility, surface width of the cycling facility, public lighting, edge marking, slipperiness, lighting, drain covers, quality of verge, traffic lights, roundabout, crossing, type of intersection, visibility of curve, visibility of pole
A. Lee, L. Dias, S. Mohanty, T. Carvalho, J. Commandeur, G. Lovegrove	mean travel speed, mean cyclist speed, number of stops divided by segment length, environmental noise, obstruction frequency, curve frequency, average slope, pavement condition, road maintenance, parked car density, maximum cycling speed, mean cycling speed, speed limit of the road, perceived vehicle volume travelling in the same direction as the participant, Perceived close vehicle pass volume travelling in the same direction as the participant., Undulations frequency, Minimum lane width of the bike path in the road segment, Lane width of the bike path in the majority of the road segment, Intersection frequency, Road hierarchy, Adjacent driveway density

Cara Hamanna, Corinne Peek-Asa	on road bicycle facilities present at intersection, sidewalks[index street/non-index street, traffic controls present, bicycle volume, motor vehicle volume, curb to curb width, one lane width, speed limit, number of lanes
J.C.O. Madsen, T. Andersen, H.S. Lahrmann	surface type, surface quality, presence of exits, curves or no curves, speed limit, narrowing, road markings, lighting, median island, lighting, markings, poles, street light
Phoebe Spencer, Richard Watts, Luis Vivanco, Brian Flynn	street lighting, road plowing, salting of roads
Kyunghui Oh, Aaron Rogoff, Tonya Smith-Jackson	signs and alternative signs of: bicycling, bicycling warning, no bicycling, pedestrian and bicycle crossing vs person pushing bike, hill, bicycle surface condition,
Robert A. Chaney, MS, Changjoo Kim, PhD	bus route lengths, land-use mixture, number of bus stops
Max A. Bushell, Bryan W. Poole, Charles V. Zegeer, Daniel A. Rodriguez	pavement/crosswalk markings, curb and gutter, mid-block crossings, overpass, underpass, median, traffic calming measures, curb ramp, fence/gate, gateway, railing, street furniture, street closures, sidewalks, signals, pedestrian and bicycle detection speed trailer, striping, pavement marking, roundabout traffic circle, pedestrian crossings and paths, signals for drivers and pedestrians
Irene Isaksson-Hellman	Bike lane, Speed limit (of cars), Traffic environment (urban, non-urban), Light condition (daylight, dark, dusk), Road state (Dry, wet, ice), Weather conditions (clear, fog, rain), Speed-limit, roundabouts, intersections left/right turn of cars or bicycles
Jeffrey J. LaMondia and Jennifer C. Duthie	Road: # of lanes; width; presence of center lane, shoulders and sidewalks; Signs, Sharrows, signage, Approach volume, Distance between Motorist and Cyclist, Cyclist and curb..
Chen Wang & Nikiforos Stamatiadis	Roadway condition, Roadway character, Roadway type, Speed Limit, # of Lanes, Light condition, Weather condition, Method of Traffic Control
Luis F. Miranda-Moreno, Jillian Strauss, and Patrick Morency	Volume, Presence of median, Parking entrance, # of bus stops in 50m buffer
J.P. Schepers, P.A Kroeze, W. Sweers, J.C. Wust Elsevier	Priority road, Intersection design: 3-armed vs 4-armed, type of bike facility, distance b/w bike track and side of road, marking/use of colors, presence of speed reducing measure, # of lanes of main road and side road, presence of middle islands
Paul Schepers & Karin Klein Wolt	light condition, road situation, curves and intersections vs straights, road surface condition, condition of road surface, presence of parked cars, fences, curbs
Becky P.Y. Loo, K.L. Tsui	Distance between car/cycle tracks, Obstacle in way
Jennifer Duthie, John F. Brady, Allison F Mills, Randy B. Machemehi	Site Type, Lane width, Type of lane adjacent to outside vehicle lane, Traffic volume (VPH), Truck traffic, Observed speed, Adjacent land use, Parking type, Presence of parked motor vehicles
Glen Koorey, Elizabeth Mangundu	Colored or Uncolored Bike Facility, Types of Facilities, Advanced Stop Lines, Stop Boxes, Position of motorist at intersection, Volume of cars turning at intersection
M. Kokura, M. Suga, B. Lee, K. Shirakawa, T. Suwa, N Ohmori	Intersections, Traffic volume, Traffic complications, Safety facilities Approach, Sharp bend, Visibility of traffic, Presence of Guardrails, Presence of Bike lanes

2.1.3 RELEVANT MANUALS

Four official manuals have been reviewed to identify the useful variables for bicycle infrastructure design, planning, and management. The reviewed manuals include “Pedestrian and Bicycle Facilities in California, A Technical Reference and Technology Transfer Synthesis for

Caltrans Planners and Engineers" (PBF), "the 2014 California Manual on Uniform Traffic Control Devices" (CA MUTCD), "Complete Intersections: A Guide to Reconstructing Intersections and Interchanges for Bicyclists and Pedestrians" (CI), and "Highway Capacity Manual 2010" (HCM). Table 3 lists the types of data included in each of these manuals.

Table 3. Bicycle Related Data in Guidance and Manuals

Data	Manuals
Intersection markings	P & B facilities in CA
Bicycle Detection	P & B facilities in CA, MUTCD, Complete intersections,
Width of the outside through lane	HCM Multilane/Two lane Highway/signalized intersections
Shoulder width	HCM Multilane/Two lane Highway
Motorized vehicle volumes	HCM Multilane/Two lane Highway/signalized intersections
Number of directional through lanes	HCM Multilane/Two lane Highway
Posted speed	HCM Multilane/Two lane Highway, Complete intersections
Heavy-vehicle percentage	HCM Multilane/Two lane Highway
Pavement condition	HCM Multilane/Two lane Highway
Percent occupied on-highway parking	HCM Two lane Highway
Bicycle travel speed	HCM Urban street facilities (only when a bicycle lane is present)
Width of bicycle lane	HCM signalized intersections
Width of outside paved shoulder	HCM Urban street segments
Median type and curb presence	HCM Urban street segments
No. of access point approaches	HCM Urban street segments
Bicycle delay	HCM Urban street segments
Bicycle flow rate at intersection	HCM signalized intersections
Street width	HCM signalized intersections, Complete intersections
Number of lanes	HCM signalized intersections, Complete intersections
Width of paved outside shoulder	HCM signalized intersections
Width of parking lane	HCM signalized intersections
Signal cycle length	HCM signalized intersections
Yellow change	HCM signalized intersections
Red clearance	HCM signalized intersections
Duration of phase serving pedestrians and bicycles	HCM signalized intersections
Directional hourly bicycle volumes	HCM Off-street bicycle facility (Bike path)
Path mode split by user group	HCM Off-street bicycle facility (Bike path)
Path peak hour factor	HCM Off-street bicycle facility (Bike path)
Mean and standard deviation of speed by user group	HCM Off-street bicycle facility (Bike path)
Path width	HCM Off-street bicycle facility (Bike path)
Presence of centerline on path	HCM Off-street bicycle facility (Bike path)
Proportion of users blocking two lanes by user group	HCM Off-street bicycle facility (Bike path)
Crossing distance	Complete intersections
No. of right turn lanes	Complete intersections
No. of left turn lanes	Complete intersections
Right turn pocket presence	Complete intersections
Right turn pocket control	Complete intersections
Bicycle phasing	Complete intersections
Yield control	Complete intersections
Stop control	Complete intersections
Signal control	Complete intersections

Signal actuation	Complete intersections
	Complete intersections
Refuge area presence	Complete intersections
Turning radii	Complete intersections

2.2 POTENTIAL ITEMS TO INCLUDE IN BICYCLE DATABASE

2.2.1 BICYCLE INFRASTRUCTURE DATA

Based on the review of the existing inventories, bicycle safety studies, and relevant manuals, a list of data items was proposed to Caltrans team for comments (See Appendix 1). Table 4 presents the final list according to the discussion.

Table 4. Proposed List of Data Items

Category	Variable	Description
Bicycle facilities along approaches	Bikeway type	Standard bikeway; Buffered bikeway; Contraflow bikeway; Shared-use bike route; Other
	Bikeway width	0-99
	Effective bikeway width	0-99
	Bikeway barrier type[a]	Chain linked fence; Dense shrubs; Raised traffic bars; Concrete barrier; Steel guard railing
	Bikeway surface quality	Above average; Below average
	Bikeway surface type	Concrete; Asphalt; Gravel; Stone; Crushed rock
	Drain cover presence	ID[b]
	Slope increase	0-999
	Slope decrease	0-999
	Starting elevation	0-999
	Ending elevation	0-999
	Number of access point[c]	0-99
	Bicycle parking facility type	Standard rach; Bicycle locker; Bike stations
	Bike share station presence	ID[b]
	Median Cut Through for Bicycles	ID[b]
	Bikeway color[*]	Green; Other; None
	Bikeway alignment[*]	Left of parking; Right of parking; None
	Regional Bikeway[*]	Yes; None
Bicycle treatments at intersections	Bicycle signal type	Bicycle signal; Bicycle HAWK Beacon; Bicycle control signal
	Bike lane on the left side of the right turn only lane[e]	Yes; None
	Bike lane on the right side of the left turn only lane[e]	Yes; None
	Bike left turn waiting area/box /pocket	Yes; None
	Weaving area presence[f]	Yes; None
	Bike detection symbol/marking[g*]	ID[b]
Roadway features along approaches	Type of lane adjacent to outside vehicle lane[h]	Opposite direction; Same direction; Median; Two-way left turn lane
	Width of the outside through lane	0-99
	Rumble Strip presence	ID[b]
	Rumble strips Type	Spaced; Continuous
	Speed reducing / traffic calming measure presence	Curb extensions; Speed humps; Special pavement; Raised crossing; Pedestrian refuge;

Category	Variable	Description
		Roundabout or traffic circle
	Curb presence	Yes; None
	Bus stop presence	ID[b]
	Number of lanes on the roadway[**]	0-99
	Width of the roadway[***]	0-99
	Presence of shoulders[**]	Yes; None
	Paved shoulder presence[**]	Yes; None
	Median presence[**]	Yes; None
	Median type[**]	Undivided not separated or striped; Undivided striped; Undivided reversible peak hour lanes; Divided reversible peak hour lanes; Divided Two-way left turn lane; Divided continuous left-turn lane; Divided paved median; Divided unpaved median; Divided separate grades; Divided separate grades with retaining wall; Divided sawtooth unpaved; Divided sawtooth paved; Divided ditch; Divided separate structure; Divided railroad or rapid transit; Divided bus lanes
	ADT[**]	0-9999999
	Roadway classification	Urban freeways, Urban freeways < 4 lanes, Urban two lane roads, Urban multilane divided non-freeways, Urban multilane undivided non-freeways, Rural freeways, Rural freeways < 4 lanes, Rural two lane roads, Rural multilane divided non-freeways, Rural multilane undivided non-freeways, Others.
Roadway features at intersections	Intersection type	90 degree 3-way; Non 90 degree 3-way; 4-way; Skewed 4-way; Offset; Skewed offset
	Intersection/mid-block crossing control[i][**]	No control; Stop signs on cross street only; Stop signs on mainline only; Four-way stop signs; Four-way flasher (red on cross street); Four-way flasher (red on mainline); Four-way flasher (red on all); Yield signs on cross street only; Yield signs on mainline only; Signals pretimed (2 phase); Signal pretimed (multi-phase); Signals semi-traffic actuated 2 phase; signals semi-traffic actuated multi-phase; signals full traffic actuated 2 phase; signals full traffic actuated multi-phase; other
	No. Of right turn only lanes	0-99
	No. Of left turn only lanes	0-99
	Vehicle left turn pocket presence	ID[b]
	Vehicle right turn pocket presence	ID[b]
	Vehicle right turn slip lane control	Signal; Stop sign; Yield sign; Flashing beacon; None
	Number of lanes on the cross street	0-99
On street parking	Vehicle parking presence	ID[b]
	Maximum number of parking spots	0-99
	Vehicle parking type	Parallel; Angled
	Vehicle parking marking type	Stripe; Stall; None

Category	Variable	Description
	Width of vehicle parking lane	0-99
Bicycle related markings and signs along approaches and at intersections	Pavement marking types	Bike symbol; Helmeted bike symbol; Words; Bicycle detector pavement marking; Shared lane marking
	Pavement marking color	Yellow; White
	Pavement marking quality	New; Partially worn; Faded
	Signage type	CAMUTCD numbering, such as “W11-1”

Note:

- **a.** Barriers between vehicle lane and bike lane
- **b.** Instead of using Yes or No to represent the presence, we use a sub-table for a facility’s presence. If there exists that type of facility, we assign it an ID in the sub-table.
- **c.** Access points can be driveways
- **d.** A combined bike lane/turn lane places a suggested bike lane within the inside portion of a dedicated motor vehicle turn lane. See http://nacto.org/publication/urban-bikeway-design-guide/intersection-treatments/combined-bike-laneturn-lane/
- **e.** If there is no separate bike lane on the left side of the Right-Turn-Only lane, it means the bike lane is combined with the vehicle-turning lane at the intersection. See page 1386 in http://www.dot.ca.gov/hq/traffops/engineering/mutcd/pdf/camutcd2014/Chapter9C.pdf
- **f.** Dashed or gap part on bike lane striping for turning vehicles to cross the bike lane to enter the right turn only lane or left turn only lane
- **g.** For bicycle loop detection presence.
- **h.** This variable is associated with the maneuver of vehicles in the outside vehicle lane when they want to pass bicycles.
- **i.** Mid-block crossing control is not available in TASAS.

***.** This variable is added according to the comments from Caltrans team.

****.** This variable is added according to the comments from Caltrans team and available in TASAS.

***. The total width of the roadway is available in TASAS. However, the width of each direction is not available.

2.2.2 BICYCLE VOLUMES

Bicycle volume data are an important element for inclusion in the Caltrans State Highway System information database. Bicycle volumes should be provided for intersections (e.g., total count of bicycles entering an intersection in different directions during a specific time period) as well as along roadway segments (e.g., total count of bicycles passing the midpoint of a roadway segment in different directions during a specific time period). Many state or local agencies have already started to collect bicycle volumes at selected locations. Table 5 summarizes state or local agencies’ efforts to collect bicycle volume data for different applications.

Table 5. Examples of Existing Bicycle Volume Data Collection

Agencies	Volume Counts	Other Variables	Collection Methods
San Luis Obispo, CA	Intersections: Total counts, Counts for left turn, though, and right turn bicycles; Screenline Counts	Bicycle count data Helmet usage Sidewalk usage	Manual
San Mateo County	Total Count	Gender	Manual
LA County	Sum of each bound		Manual
Washington State	Total count	Gender Helmet use	Manual

The potential use of the volume data includes:

- Conducting risk or exposure analyses. For example, estimating the relative risk of bicycle crashes for individuals traveling along state highways (i.e., bicycle crashes/bicycle volume)

- Identifying and prioritizing projects. For example, identifying locations that have higher relative bicycle risk can indicate which project should be conducted to reduce bicycle crashes and injuries the most cost-beneficial.
- Evaluating the effects of new infrastructure or project on bicycle activity, such as traffic impact analysis.
- Tracking changes in bicycle activity over time to make sure the realization of the planning goals.
- Modeling transportation networks to estimate annual volumes in the network or for the other locations where bicycle volume data were not collected.

In the proposed database, two types of bicycle volumes will be collected, including screenline counts and intersection counts. Screenline counts are counts of the number of bicyclists crossing an imaginary line on the roadway. Intersection counts include counts of bicyclists turning left, turning right, or going straight. See Figure 1. It should be noted that intersection counts have a number of uses, but the technologies available at present to collect these counts are limited to (1) manual counts in the field, (2) manual counts from video, and (3) automated counts from video. (The same technologies are also used for collecting motorized vehicle counts at intersections.)

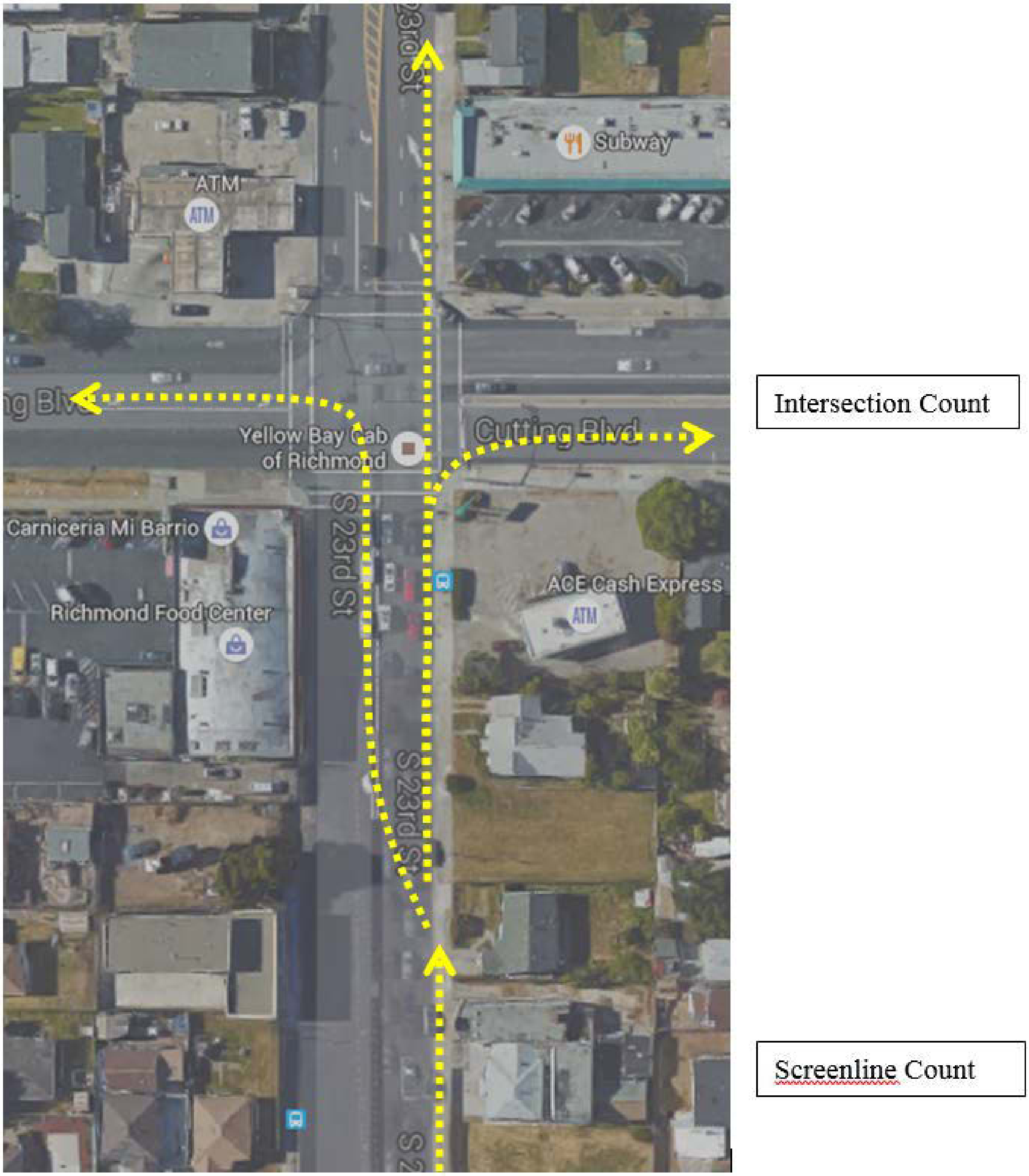


Figure 1. Intersection Counts

2.3 CONCLUSIONS

Based on existing examples of bicycle infrastructure inventories and volume counting performed by other state DOTs and local governments and data used in safety research and relevant manuals, potential items for inclusion in the Caltrans State Highway System database have been identified. The list of specific bicycle infrastructure and volume data include the data both at crossing points and along segments.

The information in this report provides useful background for Task 3 and 4 of this project, which involve developing a database structure to store the determined items and methods of collecting that data.

3 DATABASE STRUCTURE AND DESIGN

The proposed database stores bicycle infrastructure and volume data in two parallel sub-databases. The infrastructure sub-database consists of two component types: core components and secondary components. The *core (or primary) components* form the skeleton of the data structure—consisting of nodes and approaches. *Nodes* consist of components that lie in between adjoining segments. This includes intersections/junctions, midblock crosswalks, pedestrian/bicycle overpass/underpass or simply one-mile breaking point when the length of an individual segment exceeds one mile. *Approaches* are defined as unidirectional road segments demarcated by nodes. Approaches represent the two sides of the roadway. The *secondary components* are the key part of this data collection effort. These components include bikeways, bike parking, bike related signs, and other bicycle related infrastructure elements (details can be found in Section 3 "Infrastructure"). Every secondary component is linked to a set of primary components—acting as a subset of the primary components. For example, a bikeway is linked to a single approach, while intersection treatments (e.g. bike box) are linked to a node and an approach. The links are developed following the logic detailed as below.

In this chapter, the structural details of the database are presented. Examples of each class of secondary component are depicted graphically, including a description of how they relate to the core components in addition to instructions on how they should be entered in the database to reflect these relations.

3.1 DECOMPOSITION OF A TYPICAL ROAD SEGMENT

Figure 2 shows the main components comprising a typical street segment. The two core components are nodes and approaches which are shown in red shades, while the others are the secondary components which will link to the primary components.

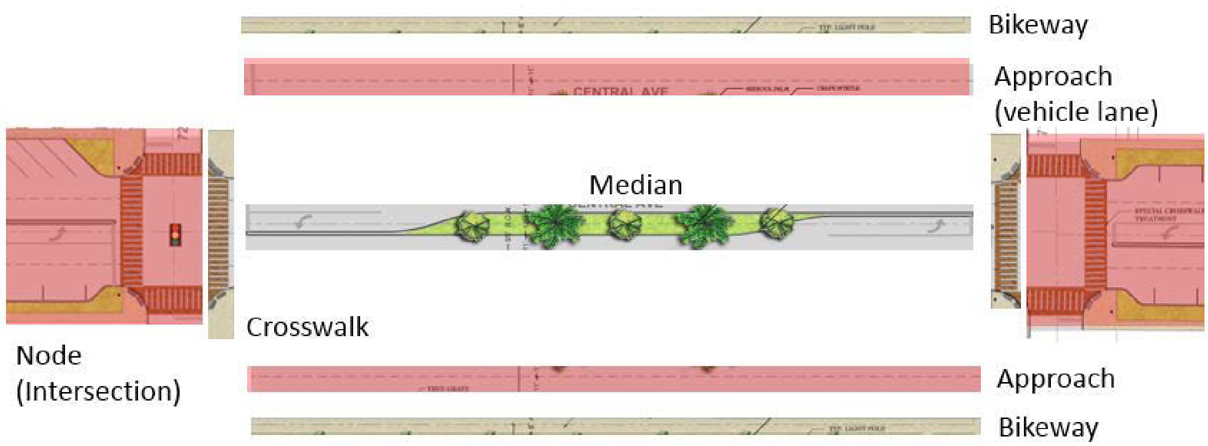


Figure 2. Components of a Typical Roadway Segment

The relationship between the components is developed based on their physical relationship to each other. Figure 3 shows how the secondary components relate to the core components. There are two core components to which other sub-components connect to. For example, bikeways and bike parkings are connected to the approach with which they are associated. Following the same logic, signals and signs at crossings are associated with the intersections or mid-block crossings and approaches which advance toward or depart from the crossing.

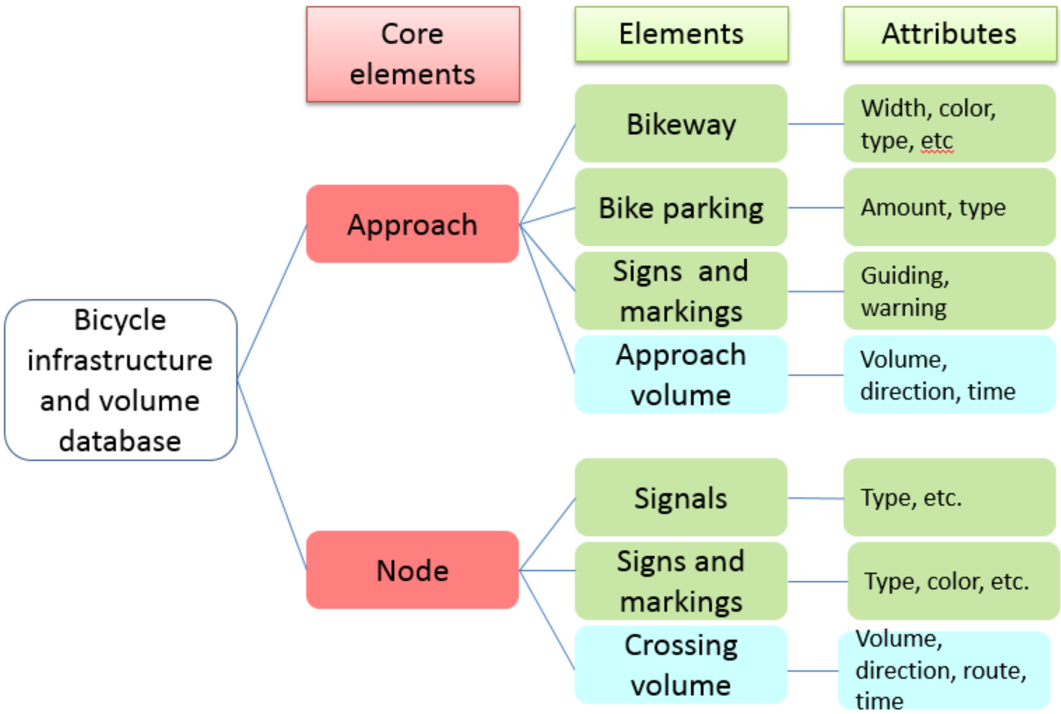


Figure 3. Relationships Between Components

Note: this figure is an illustration of the connections between different levels of elements. It doesn't include all of the elements and attributes in the proposed database. The full content of the elements and attirbutes are shown in xxx.

3.2 COMPONENT DEFINITIONS AND CONNECTIONS

3.2.1 Recording a "Node" and an "Approach"

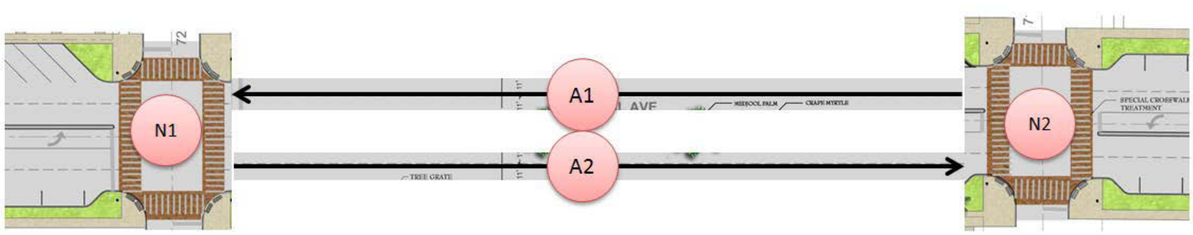


Figure 4. Example of Recording a "Node" and an "Approach"

In constructing the database framework, the nodes are defined first. Nodes are located, as previously mentioned, at any intersection/junction, midblock crosswalk, pedestrian/bicycle overpass/underpass or simply one-mile breaking point when the length of an individual segment exceeds one mile. Nodes are named (based on the names of the intersecting roads) and uniquely numerically identified. The approaches are then defined based upon the nodes that they connect.

The *ID number* of the nodes and approaches consist of 7 digits. The first 3 digits represent the route number and the remaining 4 digits represent the number of the node or the approach. For example, the first node identified on route 13 should be indexed as 0130001. However, meaning should not be ascribed to the sequentiality of the node IDs, so that in case any core elements are missed in the initial identification process, they can be added later without any loss of generality.

As an example, in Figure 4 Approach A1 rims from N2 to N1, so it is defined by these two nodes. In the "approach table," A1 would be recorded as follows (see Table 6):

Table 6. Connecting an Approach to the Nodes

Approach ID	From Node ID	To Node ID	Other Attribute
A1	N2	N1	…
A2	N1	N2	…

3.2.2 Recording a Marking or Sign at Intersection

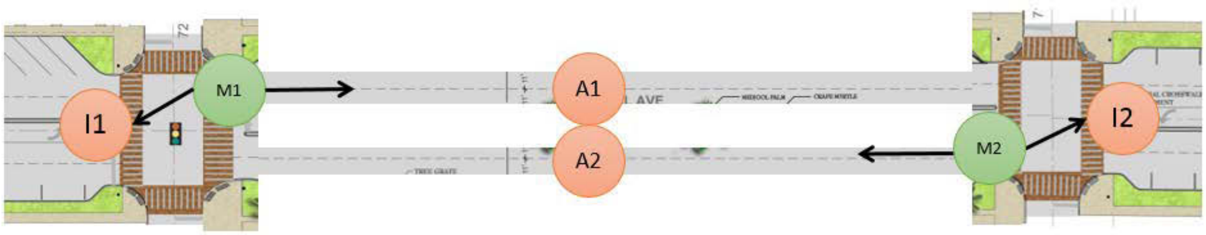


Figure 5. Example of Recording a "Crosswalk"

After defining the two core components, all of the other secondary components are defined based on the physical relationship to the core components. For example, markings at an intersection are defined by one node and one approach. Figure 6 depicts a marking (M1) that is bounded by N1, A1, which would be recorded in the table as follows (see Table 7):

Table 7. Connecting a Crosswalk to the Nodes and Approaches

Marking ID	Node ID	Approach ID	Other Attribute
M1	N1	A1	…
M2	N2	A2	…

3.2.3 Recording a "Bikeway"

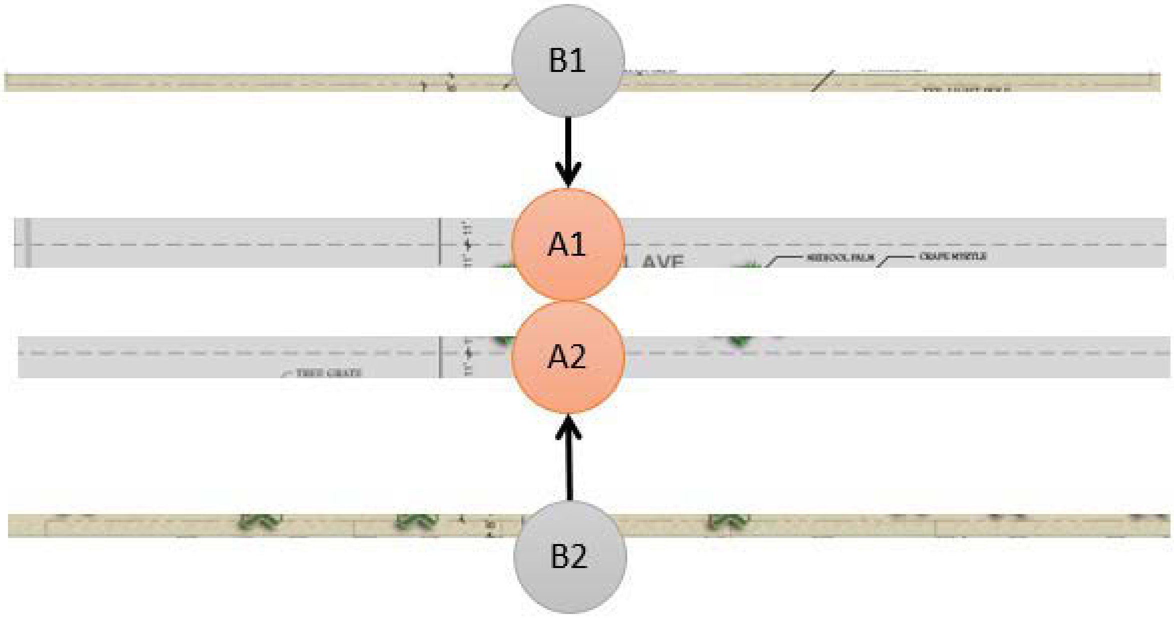


Figure 6. Example of Recording a "Sidewalk"

Following the same logic, the bikeways are defined by the approaches along which they run. For example, in Figure 6, Bikeway B1 is alongside approach A1, so in the "bikeway table" B1 would be recorded as follows (see Table 8):

Table 8. Connecting a Sidewalk to the Approaches

Sidewalk ID	Approach ID	Other Attribute
B1	A1	…
B2	A2	…

3.2.4 Recording Other Components

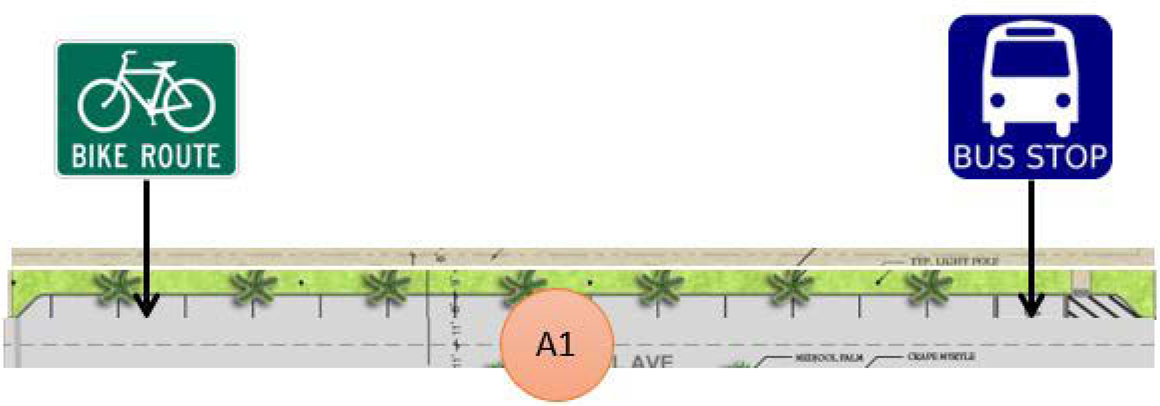


Figure 7. Example of Recording "Signage" or a "Transit Stop"

Any other components (such as bicycle-related signage or transit stops) are recorded in a similar manner. For example, as shown in Figure 7, the bike route signage is located along Approach A1, so in the table it will be recorded as follows (see Table 9):

Table 9. Connecting Signage or a Transit Stop to the Approaches

Signage ID	Approach ID	Other Attribute
SN1	A1	…
Transit ID	Approach ID	Other attribute
TR1	A1	…

3.2.5 Recording Volumes

The volume sub-database follows a similar structure. In this case, volume observations are secondary "components" linked to the core approach and node components. Volume observations will be made along approaches and at intersections. These values will then be linked to the core components. The database is also flexible to accommodate recording mid-block crossing counts.

3.3 DATABASE STRUCTURE

Based on the relationships displayed earlier, the structure of the database is shown in Appendix 2.

4 DATA COLLECTION MANUAL

The primary method for collecting bicycle infrastructure data for this project will use aerial and street level imagery available online. Data collectors navigate the state highway network collecting data for the database.

The highway network is divided into a series of coded approaches and nodes. For the purposes of the Task 3 pre-pilot, these have been stored in a Google Map layer. The stored data attributes in these layers could later be incorporated into CT Earth and can be attached to existing CTEarth files, as shown in the example in Figure 8.

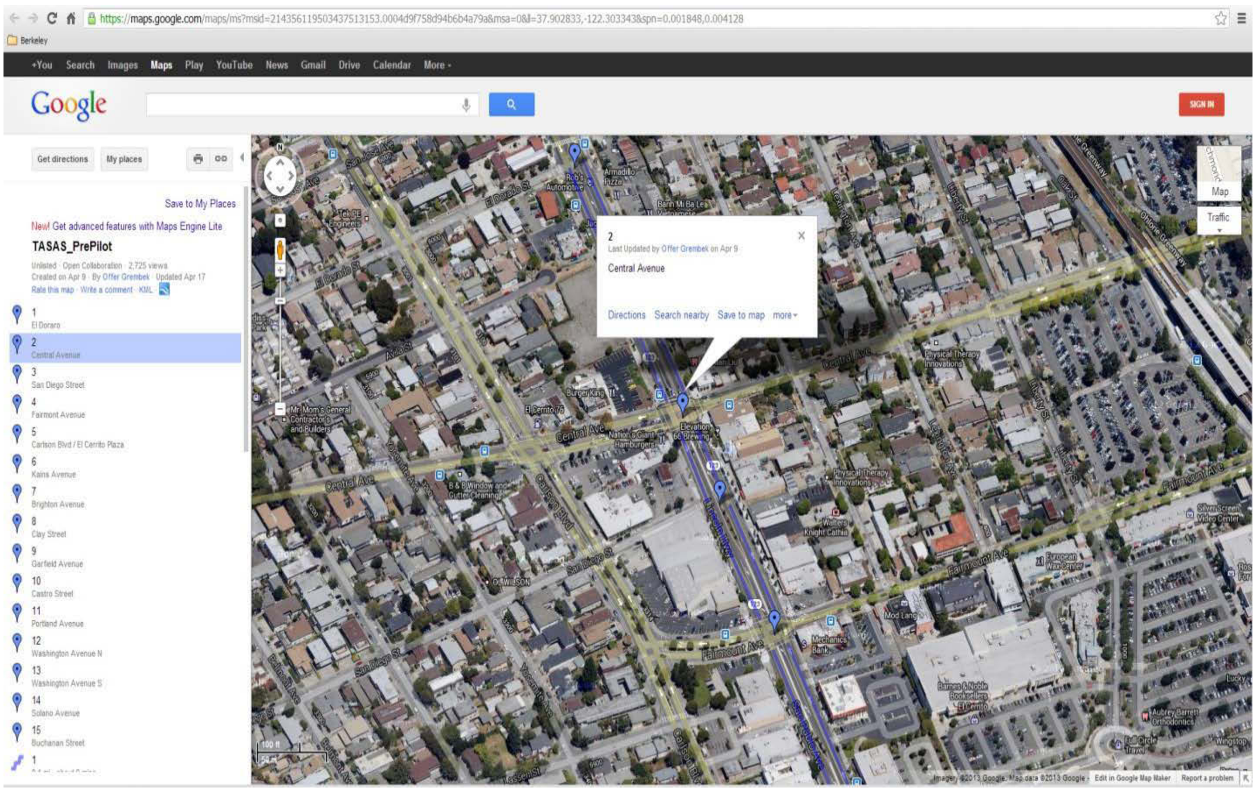


Figure 8. Stored Routes in Google Maps

As data collectors navigate through the highway network, the following information is collected along each approach and at all nodes. The following sections explain how each of these elements is collected in order to establish a consistent collection approach. Figure x (in Section 4.3) shows schematically how the various components fit together. Each of the tables in Figure 9 represents a component type, which are listed below in Table 10 and described in the following section.

Table 10. Attributes of the Components to be collected

Core Components	Attributes
Node	Node ID
	Node Name
	Node Type
	Intersection Type

		Crossing Control Type[ab]
		No. of Lanes on the Crossing Street
		Collection Date
Approach		Approach ID
		From Node ID
		To Node ID
		Roadway Classification[a]
		Type of Lanes Adjacent to the Outside Lane
		Curb Presence[a]
		No. of Lanes[a,b]
		Width[a,b]
		Shoulder Presence[a,b]
		Paved Shoulder Presence[a,b]
		Median Presence[a,c]
		Median Type[a,c]
		ADT[a,c]
		Collection Date
Secondary Components		**Attributes**
Infrastructures along an approach	Bikeway	Bikeway ID
		Approach ID
		Bikeway Type
		Bikeway Width
		Width of the Outside Lane[d]
		Bikeway Surface Type
		Bikeway Surface Quality
		Bikeway Color
		Slope Increase
		Slope Decrease
		Starting Elevation
		Ending Elevation
		No. of Access Points
		Weaving Presence
		Regional Bikeway[a,e]
		Collection Date
	Bike Related Signage	Signage ID
		Approach ID
		Signage Type
		Collection Date
	Bikeway Barrier	Barrier ID
		Approach ID
		Barrier Type
		Collection Date
	Drainage Cover	Cover ID
		Approach ID
		Collection Date
	Bike Parking	Bike Parking ID
		Approach ID
		Bike Parking Type
		Collection Date
	Bike Share	Bike Share Station ID
		Approach ID
		Collection Date
	Vehicle Parking	Vehicle Parking ID

		Approach ID
		Vehicle Parking Type
		Parking Marking Type
		No. of Parking Spots
		Parking Lane Width
		Bikeway Alignment
		Collection Date
	Median Cut Through for Bicycles	Cut ID
		Approach ID
		Collection Date
	Rumble Strips	Rumble Strip ID
		Approach ID
		Type
		Collection Date
	Pavement Marking	Marking ID
		Approach ID
		Marking Type
		Marking Color
		Marking Quality
		Collection Date
	Bus Stop	Stop ID
		Approach ID
		Collection Date
	Speed Reducing	Measurement ID
		Node ID
		Approach ID
		Measurement Type
		Collection Date
Infrastructures at Crossings	Right Turn Only Lane	Lane ID
		Node ID
		Approach ID
		No. of Lanes
		Bike Lane on Left Side of the Lane
		Collection Date
	Left Turn Only Lane	Lane ID
		Node ID
		Approach ID
		No. of Lanes
		Bike Lane on Right Side of the Lane
		Collection Date
	Vehicle Left Turn Pocket	Pocket ID
		Node ID
		Approach ID
		Collection Date
	Vehicle Right Turn Pocket	Pocket ID
		Node ID
		Approach ID
		Collection Date
	Vehicle Right Turn Split Lane Control	Split Lane ID
		Node ID
		Approach ID
		Control Type
		Collection Date

	Bike Turn Waiting Area/Box	Box ID
		Node ID
		Approach ID
		Collection Date
	Bike Signal Control	Signal ID
		Node ID
		Approach ID
		Signal Type
		Bike Detection Symbol Marking[a]
		Collection Date

Notes:

a. Not collected in the pilot
b. Available in TASAS
c. Available in TASAS but not distinguished by different directions.
d. In field, the width of the outside travel lane is dangerous to collect.
e. This variable needs input from other local agencies who maintain the information about their regional bikeways.

4.1 FACILITY DATA COLLECTION

The following provides information on how to collect each variable. For all variables, a collection date is included. Because infrastructure can change over time with construction, any change to the facility has to be updated in the database. The collection date is the date when the data is observed and collected. A full description of the methodology for each variable is included in Appendix X.

4.1.1 Node Table (Core Component)

The node table provides structure to the database. "Node" records here refer to any location where approaches join each other. This includes physical intersections, midblock crossings, pedestrian/bicycle under/overpasses, and points where these other features have not been encountered for 1 mile. In addition to a primary ID field, which is used to connect secondary components to nodes, the node table contains the following fields:

Node Name
This is a narrative description of the node. In cases of physical intersections, it refers to the names of the intersecting streets. In other cases, it is simply a description of the node (e.g., "pedestrian overpass at Parkmoor Ave.," "PM 232.21 segment break" [the mileage value can be determined using Caltrans Earth], or "midblock crossing near University Ave."). Always start with the name of the main road.

Node Type
The node type field includes "intersection," "midblock crossing," "pedestrian/bicycle overpass," and "segment break." Visuals of each are shown in Figure 9.

Intersection

Midblock crosswalk

Pedestrian/bicycle overpass

Segment breaks

Figure 9. Examples of Node Types

It should be noted that entrances or exits of parking lots and junctions with trails leading to residential or farm properties do not count as nodes (see examples in Figures 10 and 11).

Figure 10. Example of Location Not to Be Considered a Node—Parking Lot Entrance

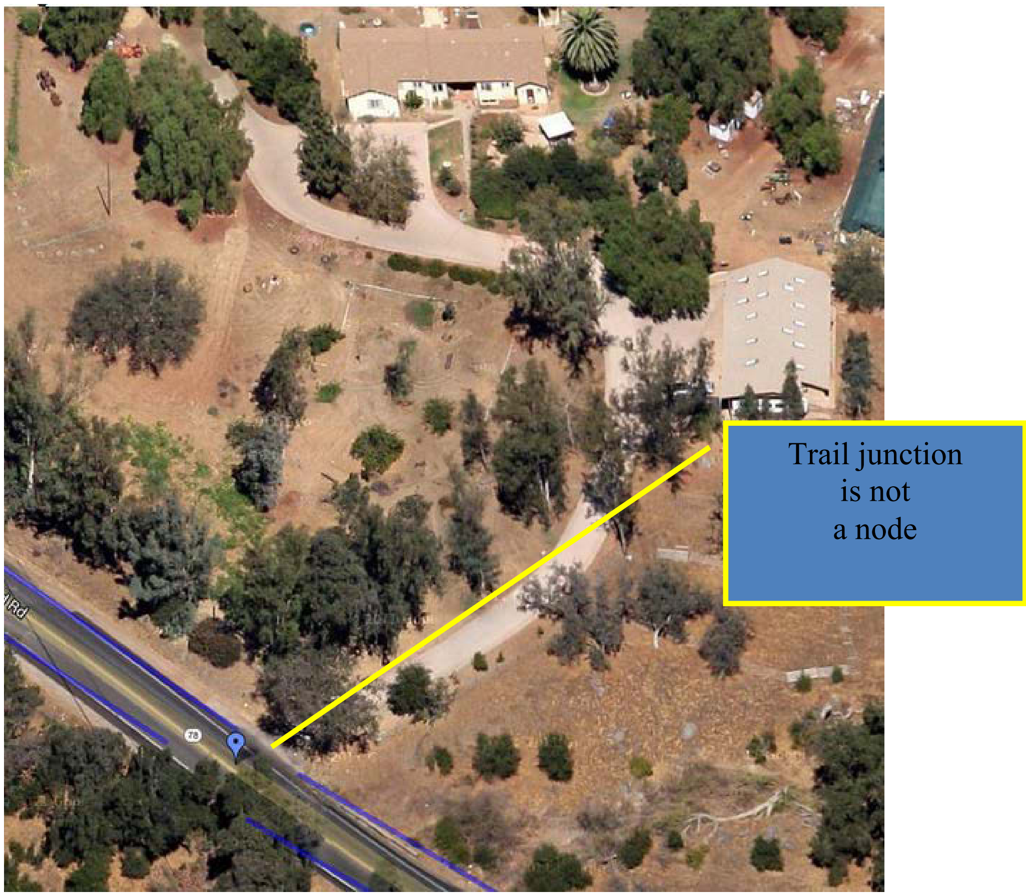
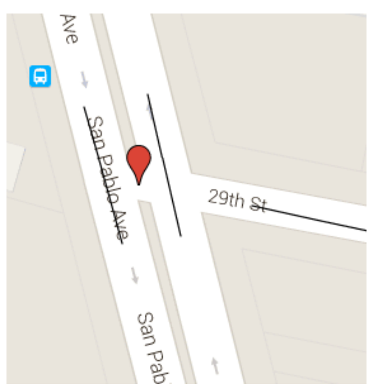


Figure 11. Example of Location Not to Be Considered a Node—Trail Junction

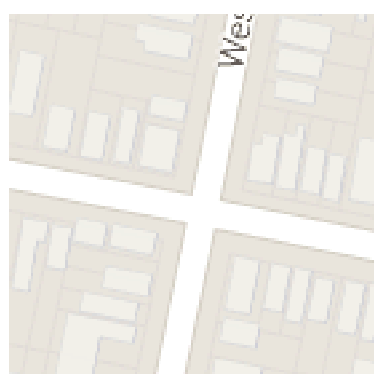
Intersection Type

If the node is an intersection, observe if what type it is, as shown in Figure 12. Choose from “90 Degree 3-Way”, “Non-90 Degree/Skewed 3-Way”, “4-Way”, “Skewed 4-Way”, “Offset”, “Skewed Offset,” and “Multi-Way.”

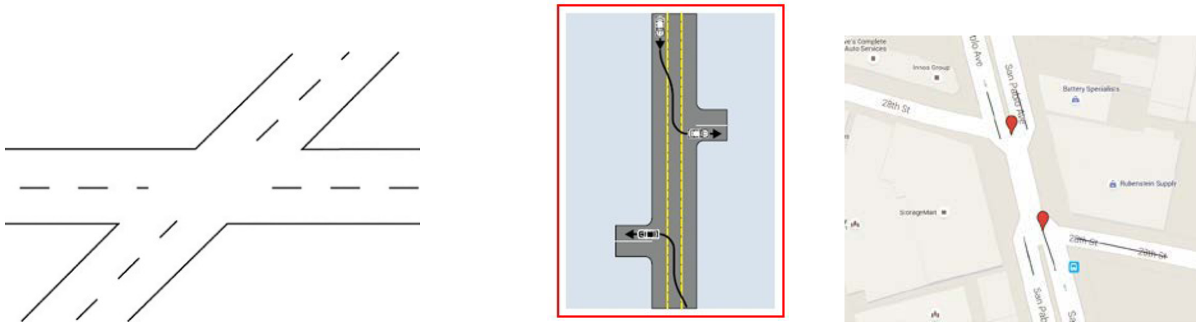
90-Degree 3-Way



Non-90 Degree 3-Way



4-Way



Skewed 4-Way Offset Skewed Offset

Figure 12. Types of Intersections

Crossing Control Type

The control types are available in TASAS, include "No control; Stop signs on cross street only; Stop signs on mainline only; Four-way stop signs; Four-way flasher (red on cross street); Four-way flasher (red on mainline); Four-way flasher (red on all); Yield signs on cross street only; Yield signs on mainline only; Signals pretimed (2 phase); Signal pretimed (multi-phase); Signals semi-traffic actuated 2 phase; signals semi-traffic actuated multi-phase; signals full traffic actuated 2 phase; signals full traffic actuated multi-phase; other."

Number of Lanes on the Cross Street

This variable refers to the number of lanes on the cross street at the intersection (at each node). For each intersection, count the number of lanes at the cross street. If there is a multi-way intersection, record the number of lanes on the cross street with the most lanes. All lanes should be recorded (including right and left turn only lanes), not just through lanes.

4.1.2 Approach Table (Core Component)

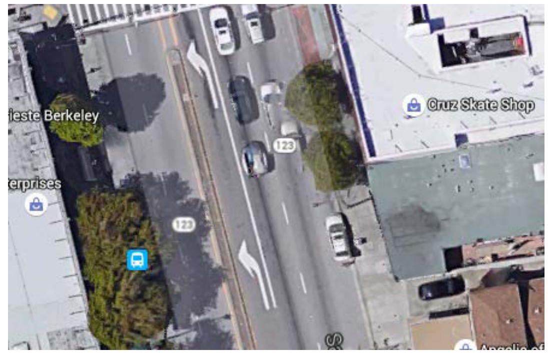
The approach table connects nodes. Each approach is defined by the two nodes at its ends. This information is stored in the fields "From_ID" and "To_ID"—these are the node IDs for the corresponding points.

Roadway Classification

The classification of the roadway indicates the category of the approach. The classification comes from the Highway Safety Information System (HSIS) manual and can help to estimate the time cost for the data collection of the entire State Highway System. Options:

- 01=urban freeways
- 02=urban freeways < 4 lanes
- 03=urban two lane roads
- 04=urban multilane divided non-freeways
- 05=urban multilane undivided non-freeways
- 06=rural freeways
- 07=rural freeways < 4 lanes
- 08=rural two lane roads
- 09=rural multilane divided non-freeways
- 10=rural multilane undivided non-freeways
- 99=others

Type of Lane Adjacent to the Outside Vehicle Lane
The type of the vehicle lane adjacent to the outside vehicle lane determines how drivers will behave when they have to share the lane with bicycles. Possible types include “vehicle lane in the same direction”, “vehicle lane in the opposite direction”, “two-way-left-turning lane,” and “median.” Note that the “outside vehicle lane” is the one furthest to the right when you are traveling in the direction of traffic. A turning lane counts as an outside vehicle lane, but a turning bay does not. This variable is collected using satellite view.



Opposite direction **same direction**


Two-way left turn lane **Median**

Figure 13. Type of lane adjacent to outside lane

Curb Presence
This variable reflects the curb presence along an approach.

No. of Lanes
This variable records the number of lanes along an approach. It can be obtained from TASAS.

Width
This variable records the total width of travel way in one direction along an approach. It can also be obtained from TASAS.

Shoulder Presence, Paved Shoulder Presence, Median Presence, and Median Type
These four variables can be obtained from the TASAS.

ADT
This variable is available in TASAS too, but it is the total vehicle volume in both directions.

4.1.3 Infrastructures Along Approaches

This section includes multiple variables associated with bikeways, including bikeway type, bikeway width, width of outside lane, bikeway surface type, bikeway surface quality, bikeway color, average slope, number of access points, and weaving area presence.

Bikeway Type

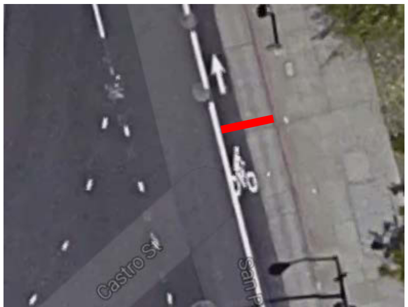
Bikeways can be classified according to the following types: standard, buffered, contraflow, shared-use or other. “Other” refers to state highway facilities that do not explicitly prohibit biking, but otherwise do not include any pavement markings to indicate bikeway type.

Standard Buffered Contraflow Shared-Use

Figure 14. Bikeway Type

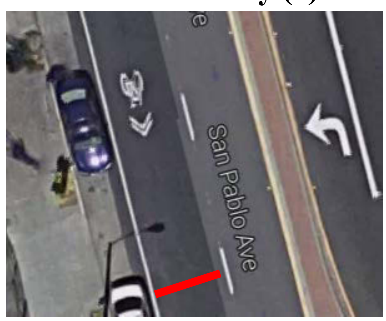
Bikeway Width

This variable refers to the width of the space where bicyclists are guided to ride safely and comfortably. The measurement approach varies depending on the bikeway type, as shown in the figure below. In Google Maps, once you identify the starting point of the measurement, right click and choose “measure distance.” Click the end point of the measurement to generate the result. If the bikeway is a trail, measure the entire width of the trail.



Standard Bikeway (1) Standard Bikeway (2) Buffered Bikeway

Contraflow Lane



Shared Use Bike Route (1)

Shared Use Bike Route (2)

Shared Use Bike Route (3)

Figure 15. Bikeway Width Measurements

Width of Outside Lane
The width of the outside lane is the width of the lane that is furthest to the right when travelling in the direction of traffic. Turning lanes are considered outside through lanes, but turning bays are not considered outside lanes.

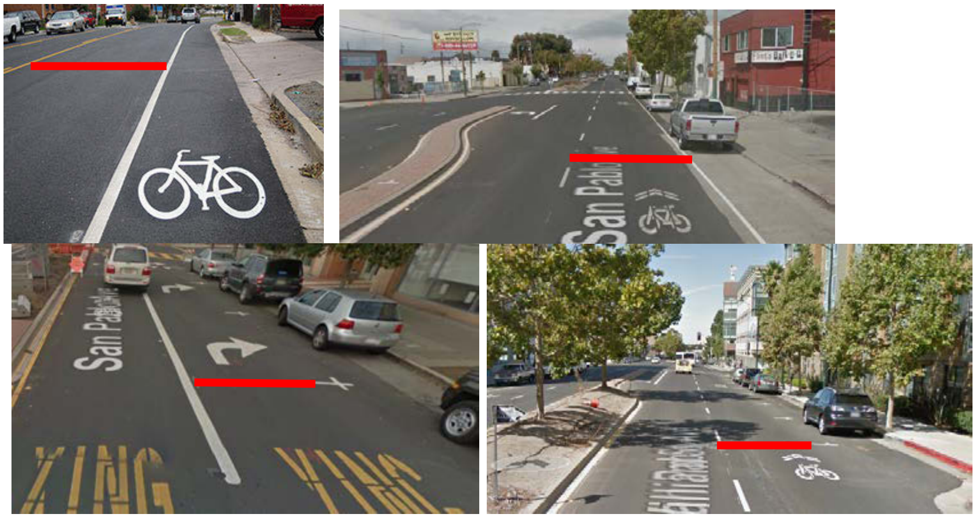


Figure 16. Measurements for Outside Vehicle Lanes

Bikeway Surface Type
The type of surface that comprises the bikeway, including concrete, asphalt, gravel, stone and crushed rock. If more than one surface type is included, record whatever type makes up the majority of the approach.

Bikeway Surface Quality
The surface quality affects the safety of cyclists: bumpy, uneven surfaces or surfaces with potholes can create dangerous cycling conditions. Quality is categorized as either above or below average.

Above Average (Smooth, no fixed obstacles, free of potholes, and pavement edges are uniform)

Below Average (Bumpy, includes potholes, uneven pavement, and/or includes loose objects)

Figure 17. Examples of Surface Quality

Bikeway Color
Bikeway pavement is sometimes created with colored pavement to distinguish it as a separate facility. Values include green, none or other. This is different from pavement marking color, which refers to the color of the markings, but not the entire pavement.

Average Slope
Average slope refers to the change in elevation for the bikeway. Using Google Maps, enter a starting and ending location for each approach. Google Maps provides a starting and ending elevation, as well as a slope increase and decrease.

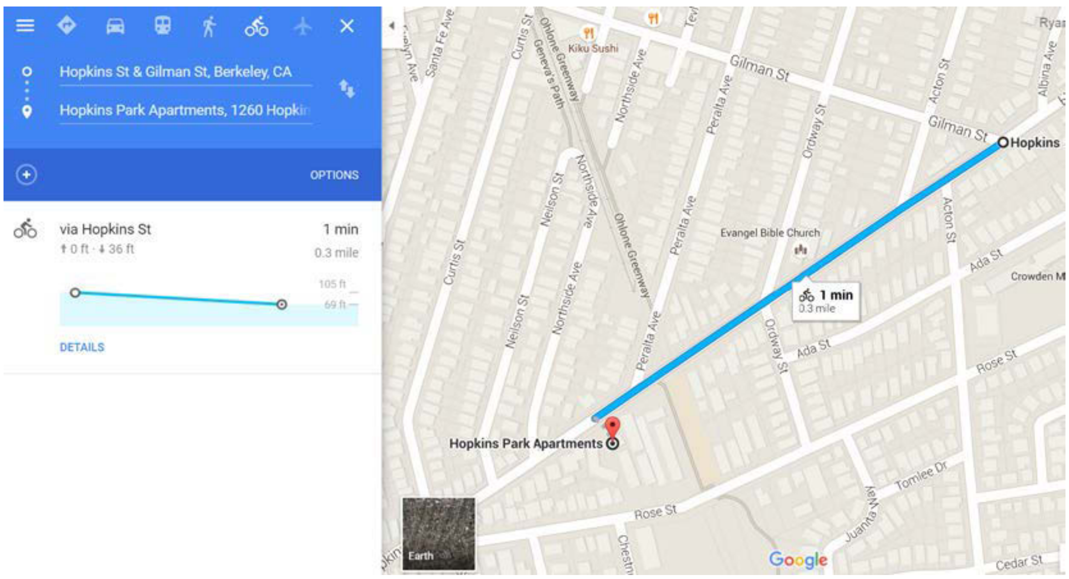


Figure 18. Average Slope

Number of Access Points
This variable refers to the number of driveways or entries to parking lots entering into a specific approach between two nodes.

Weaving Area Presence
This variable refers to a dashed or gap striping in a bikeway allowing for turning vehicles to cross the bikeway to access a right or left turn lane.

Regional Bikeway
This variable needs inputs from other local agencies who maintain the regional bikeways.

Bike Related Signage
Bike signage is indicate the presence of bicyclists to motorists (or prohibit bicyclists from entering a facility). All signage is recorded according to the California MUTCD number.

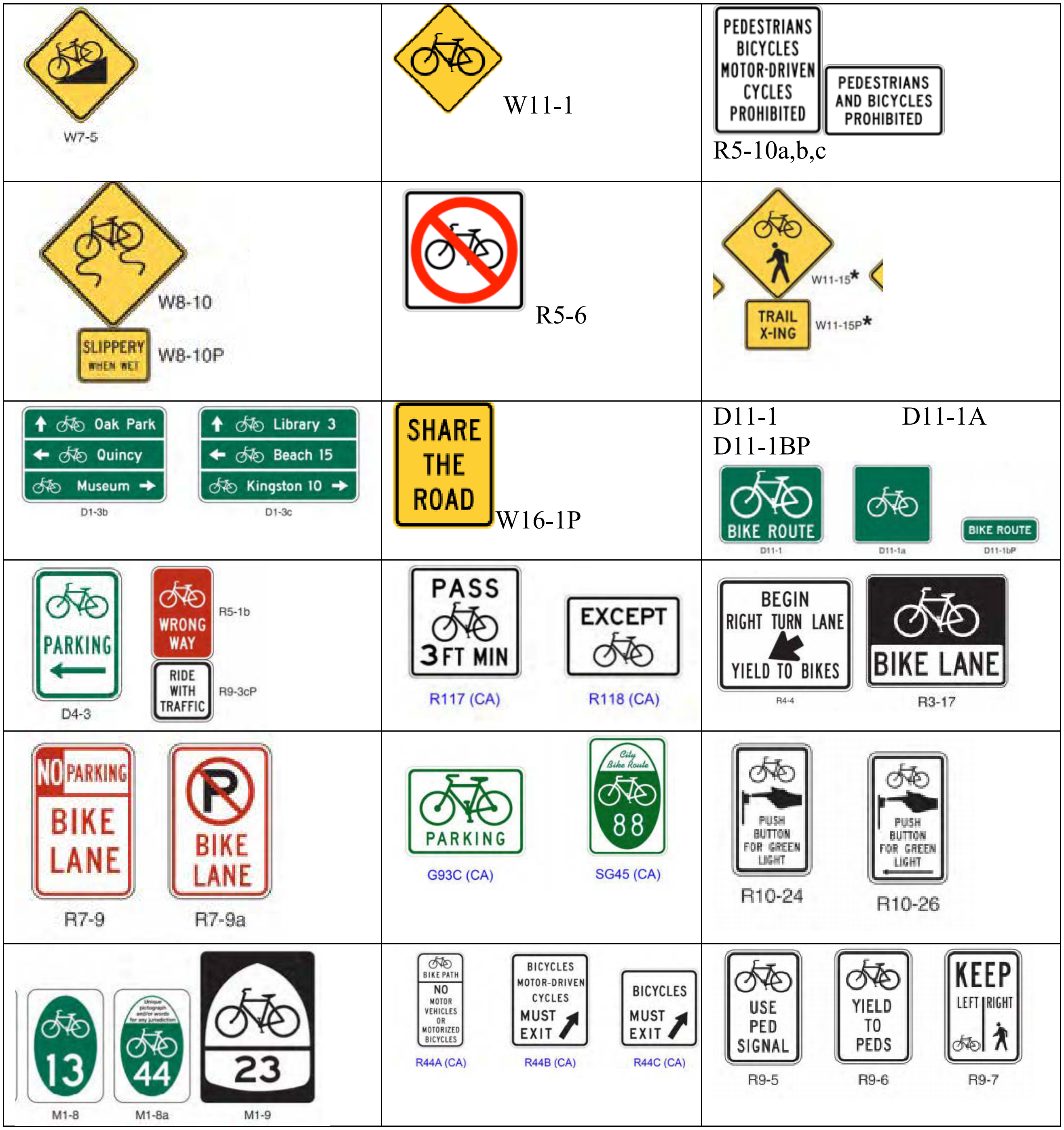


Figure 19. Bike Signage

Bikeway Barriers

Barriers refer to the physical partitioning between a bike lane and the vehicle lane adjacent to it. Examples include chain link fences, dense shrubs, raised traffic bars, concrete barriers, steel guard railing, and curbs.

Drainage Cover Presence
Drains can create unevenness in bicycle surface quality, which could create a risk of losing balance or falling. Drains are recorded only if they appear in the bikeway.

Bike Parking Presence
Bike parking facilities are used to accommodate the end-of-trip and can include both short and long-term facilities. Types include standard racks, bike lockers and bike stations.

Bike Share Presence
This variable refers to facilities, which provide bikes that can be rented or borrowed for a set period of time.

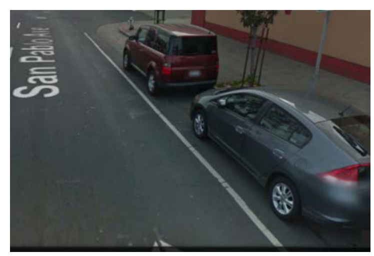
Vehicle Parking Presence
This variable identifies if parking is allowed. Sometimes parking is allowed during certain times of the day, but prohibited at others. If parking is allowed at all, this variable will indicate that parking is present.

Vehicle Parking Type
This variable refers to the type of on-street parking: parallel or angled.

Vehicle Parking Marking Type
This variable refers to the type of pavement parking associated with each parking spot. The types can include striped parking, stall parking, or no marking.


Striped Parking


Stall Parking



No Marking

Figure 20. Vehicle Parking Marking Types

Number of Parking Spots
This variable refers to the number of spots available for parking.

Width of Vehicle Parking Lane
This variable refers to the width of each parking spot. The approach for measuring depends on the type of marking for the parking lane.

Figure 21. Measurement Approach for Vehicle Parking Lane

Bikeway Alignment
Most bikeways are aligned to the left of parking (when following the direction of travel). This variable identifies if bikeways are aligned to the left or right of parking.

Median Cut Through
A median cut through allows bicycle traffic to cut through a median or intersection where automobiles are not allowed.

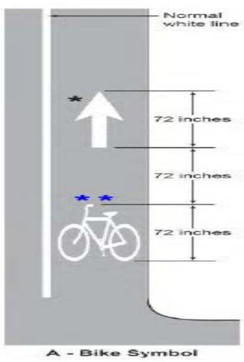
Figure 22. Median Cut Through for Bicycles

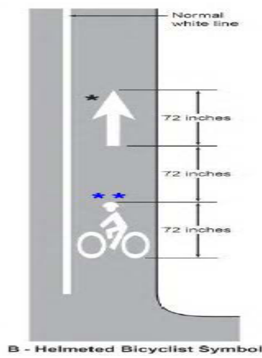
Rumble Strips
Rumble strips are raised surfaces, which are intended to be a safety feature by alerting a driver if they have drifted into the shoulder. However, the unevenness can create problems for bicyclists. This variable collects information on the location of rumble strips, and whether they are continuous or spaced.

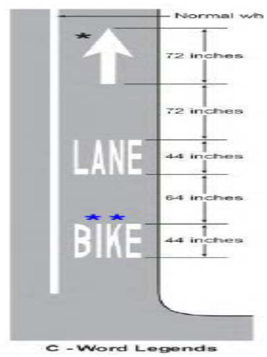
Continuous **Spaced**

Figure 23. Rumble Strip Types

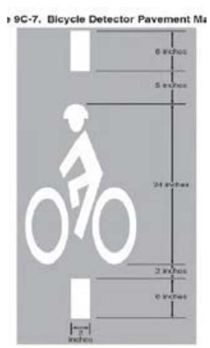
Pavement Marking Type
This variable refers to the different types of pavement markings, including bike symbols, helmeted bicyclist symbol, words, bicycle detector pavement marking and shared lane marking.

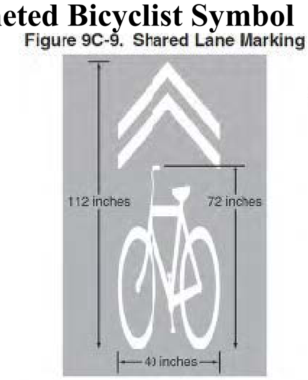






Bike Symbol **Helmeted Bicyclist Symbol** **Words**





Bicycle Detector Pavement Marking **Shared Lane Marking**

Figure 24. Pavement Marking Type

Pavement Marking Color
This variable refers to the color of the pavement marking, which includes yellow or white.

Pavement Marking Quality
This variable refers to the quality of the pavement marking, which can be new, partially worn or faded.

New **Partially Worn** **Faded**

Figure 25. Pavement Marking Quality Examples

Transit Stop Presence
Bus stops can be a location for collisions for bicyclists given the shared road space between bicyclists and buses. This variable records the location of all transit stops.

Speed Reducing / Traffic Calming Measures
Speed reducing and traffic calming strategies aim to reduce the speed of vehicles. However, these strategies may also reduce bicycles' level of comfort or safety at the same time. The types of measures included in this variable are: curb extensions, speed bumps, special pavement, raised crossings, pedestrian refuge, and roundabouts or traffic circles.

4.1.4 Infrastructures at Crossings

Number of Right Turn and Left Turn Only Lanes
This variable records separately the number of right turn and left turn only lanes. This variable excludes two-way turn lanes.

Vehicle Right or Left Turn Pocket Presence
This variable records when an additional turn lane is included at an intersection. The type of turn (left or right) is also recorded.

Vehicle Right Turn Split Lane Control
Vehicle split lanes are intended to allow easy and fast vehicle traffic to turn right, but can create a problem for pedestrians or cyclists trying to cross. Control types can include signals, stop signs, yield signs and flashing beacons.

Bike Lane on Right Side of Left Turn Only Lane
A bike lane on the right side of a left turn only lane safely places a suggested bike lane within the inside portion of a dedicated motor vehicle turn lane

Bike Lane on Left Side of Right Turn Only Lane
A bike lane on the left side of a right turn only lane safely places a suggested bike lane within the inside portion of a dedicated motor vehicle turn lane

Bike Turn Waiting Area / Box / Pocket
A bike box creates a waiting area for cyclists to get ahead of traffic. This variable also records the turning direction (right or left) if it applies.

Bike Signal Control at Intersection and Midblock Crossing
This variable refers to bicycle signals that are used for traffic control for bicyclists and indicate their turn in the traffic signal phase. Examples of the control type include: bicycle signal, bicycle High-Intensity Activated Crosswalk Beacon (HAWK), and bicycle control sign (MUTCD # R10-22).

4.2 VOLUME DATA COLLECTION

Bicycle volumes will also be collected at nodes and along approaches throughout the state highway network. This data will be stored in a database parallel to the infrastructure database. The geometries used (nodes and approaches) will be identified in an identical manner to those in the infrastructure database. However, the volume data will need to be updated more frequently; it is more efficient from a data management perspective to store the two categories of data in separate, linked repositories. Additionally, unlike infrastructure information, volume data cannot be collected remotely and must be collected during field visits.

For the purposes of the pilot project, volume data will be collected by using Miovision automated video counting equipment. Every Caltrans District is equipped with two of these devices. After completion of the pilot project, the most likely recommendation will be to use the Miovision equipment. The most significant advantage to using this equipment is that Caltrans staff can easily set it up when in the field for other purposes.

The volume table records bicyclist volume collected at both the intersection and screenline:

Screenline counts - counts of the number of bicyclists crossing an imaginary line on an approach.

Intersection counts - counts of bicyclists crossing each roadway leg or counts of bicyclists turning left, turning right, or going straight

The volume database will have fields for Node ID, approach ID, bicyclist counts in different directions, time interval (e.g., every two hours), and date of collection. In order to link Miovision data to our volume database, the "bound" variable will be included in the intersection volume table. This variable identifies the leg of the intersection in which the crosswalk bicycle volume is counted.

4.2.1 Intersection Volume Data

Node ID
This is the ID of the node or intersection or mid-block crosswalk point associated with the entering approach. It should be identical the corresponding record in the node table.

Node Name
This is the name of the street that intersects the main line. This value should be in the same format as it is in TASAS database so that is can eventually be linked to the TASAS database.

Approach ID
This is the ID of the approach associated with the bikeway where the volume is recorded. It should be identical to the corresponding record in the approach table.

Approach Name
This is the name of the state highway on which the data is collected.

Site Code
This is the location information obtained from the Miovision data report.

Left Turn Count on Road
Number of bicycles turning left on the roadway instead of using the crosswalk.

Through Count on Road
Number of bicycles going straight through the intersection on the roadway instead of using the crosswalk.

Right Turn Count on road
Number of bicycles turning right.

Count on Crosswalk
Number of bicycles moving in the crosswalk in different directions. Directions are labeled as "Clockwise" and "Counter Clockwise", see figure X.

Interval
The interval is the time period for collecting volume data. For example, if the bicycle volume is tallied every 15 minutes, then the interval should be 15.

Date
The volume is recorded on this recording date.

Start Time and End Time
These values correspond to the time when the counter starts and finishes recording each volume value.

Weather
This information reflects the weather condition at the time of the volume data recording.

Bound
The bound indicates the leg of the intersection on which the crosswalk is located. The options include: "south," "north," "west," "east," "southwest," "southeast," "northwest," and "northeast." However, if the crosswalk is a *mid-block crosswalk* then the position information should be left blank.

4.2.2 Approach Volume Data

Approach ID
This is the ID of the approach associated with the sidewalk where the volume is recorded. It should be identical to the corresponding record in the approach table.

Approach Name
This is the name of the state highway on which the data is collected.

Site Code
This is the location information obtained from the Miovision data report.

Screenline Count
Number of bicycles cross an imaginary line on the approach.

Interval
The interval is the time period for collecting volume data. For example, if the bicycle volume is tallied every 15 minutes, then the interval should be 15.

Date
The volume is recorded on this recording date.

Start Time and End Time
These values correspond to the time when the counter starts and finishes recording each volume value.

Weather
This information reflects the weather condition at the time of the volume data recording.

5 DATA COLLECTION PILOT

To compare the time cost for potential data collection methods, we conducted a pilot for data collection both on computer and in the field. The pilot involved collecting data along approximately 50 miles (49.2 exactly) of the State Highway System in, covering four classes of roadway (See section 4.1.2 for details of the roadway classification) in seven districts (see Table 11). In addition, a 4.73-mile field data collection effort was completed for comparison. This chapter details the pilot data collection process, including characteristics of the selected highways, and the procedure that data collectors followed.

Table 11. Routes for Computer Data Collection and Field Data Collection

Route	County	District	Name of Route	Roadway Classification	Miles
1	SLO	5	21st to Hinds Ave	Urban two lane roads	3.6
49	ED	3	Shanghai to Lincoln		1.2
1	ORA	12	Wartner Ave to 7th Street	Urban multilane divided non-freeways	5.0
1	ORA	12	Newland St to Riverside Ave		3.8
35	SF	4	Herbst Rd to 20th Ave		1.7
123	ALA	4	Ashby to 37th Street		1.9
273	SHA	2	Latona to Bruce		4.3
1	MEN	1	Usal to Westside	Rural two lane roads	5.8
1	SLO	5	San Geronimo to Harmony		6.7
58	SLO	5	Park Hill to Huer Huero		4.9
84	ALA	4	Vallecitos Ln to Kalhoff Common		4.5
84[a,c]	ALA	4	Old Niles Canyon Rd to Main St		2.9
130	SCL	4	Kincaid to Mt. Hamilton		5.3
13[a,b,c]	ALA	4	Mabel St to Turner Road	Urban two lane roads, Urban multilane divided non-freeways, Urban multilane undivided non-freeways	3.0
36[c]	LAS	2	Pratville to Riverside	Urban two lane roads, Urban multilane undivided non-freeways	2.9
84	SM	4	Old La Honda Rd to Portola Rd	Urban two lane roads, Rural two lane roads	2.9
145[c]	MAD	6	E 9th to Road 29	Urban two lane roads, Urban multilane undivided non-freeways Rural two lane roads	3.3
17	**11**	**7**	**-**	**-**	**66.7**

Notes:

a. Field data collection has been conducted on this route.
b. The field data collection has been conducted on part of the route, from Shattuck Ave. to Claremont Ave.
c. See Appendix 5 for details of the roadway classification of the route.

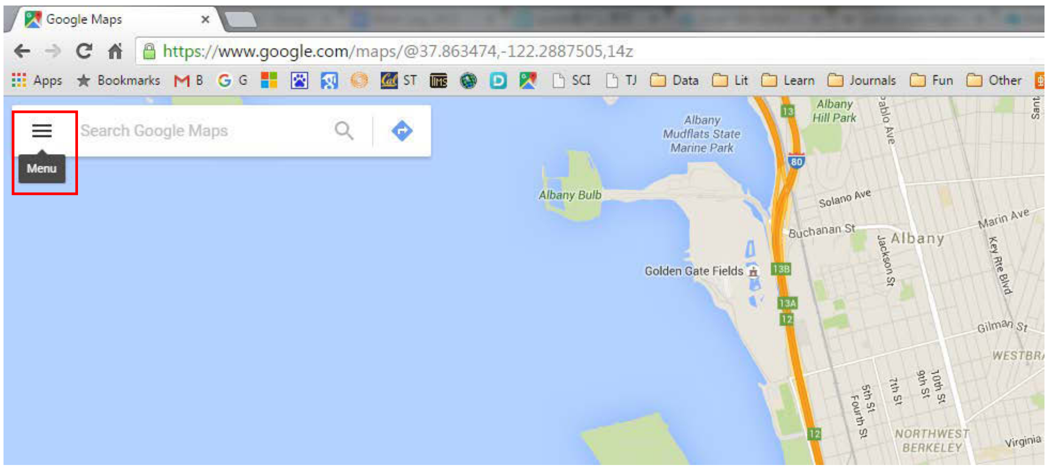
5.1. COMPUTER DATA COLLECTION

Computer data collection requires the data collectors to use Google Maps and Microsoft Office Excel. Using two monitors facilitates the efficiency of the data collection.

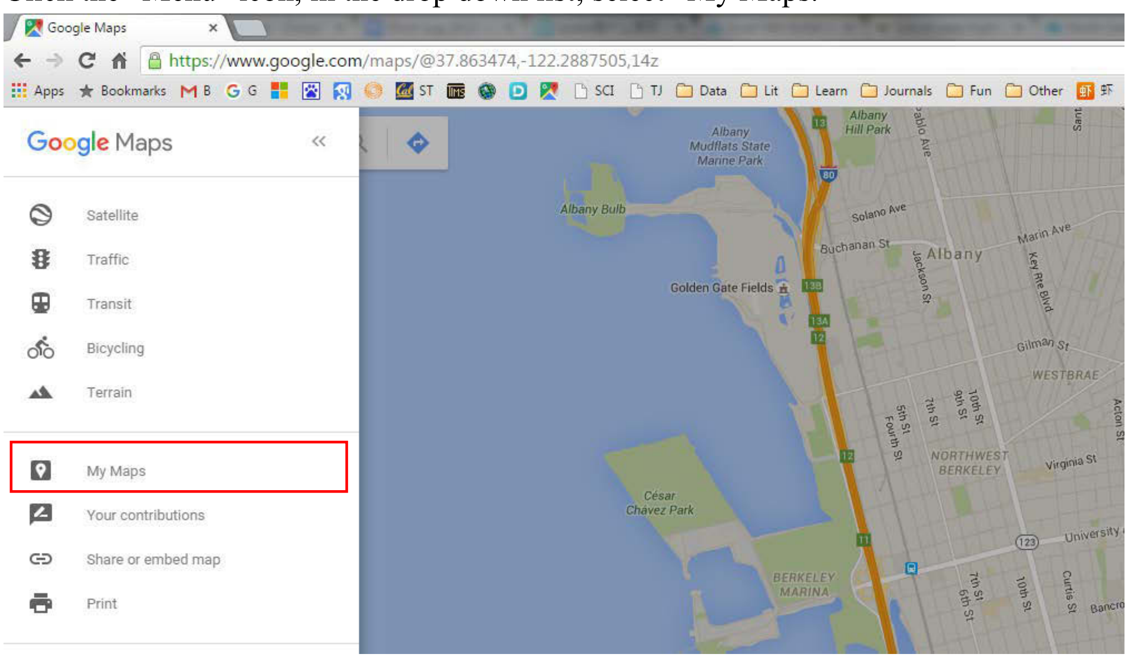
5.1.1. Creating a Map for the Route

This task creates a reference map for data collection. The reference map is built as a map layer in Google Maps, but points for nodes, lines for approaches, and node and approach IDs as name attributes of these elements. The following details how to create a reference map:

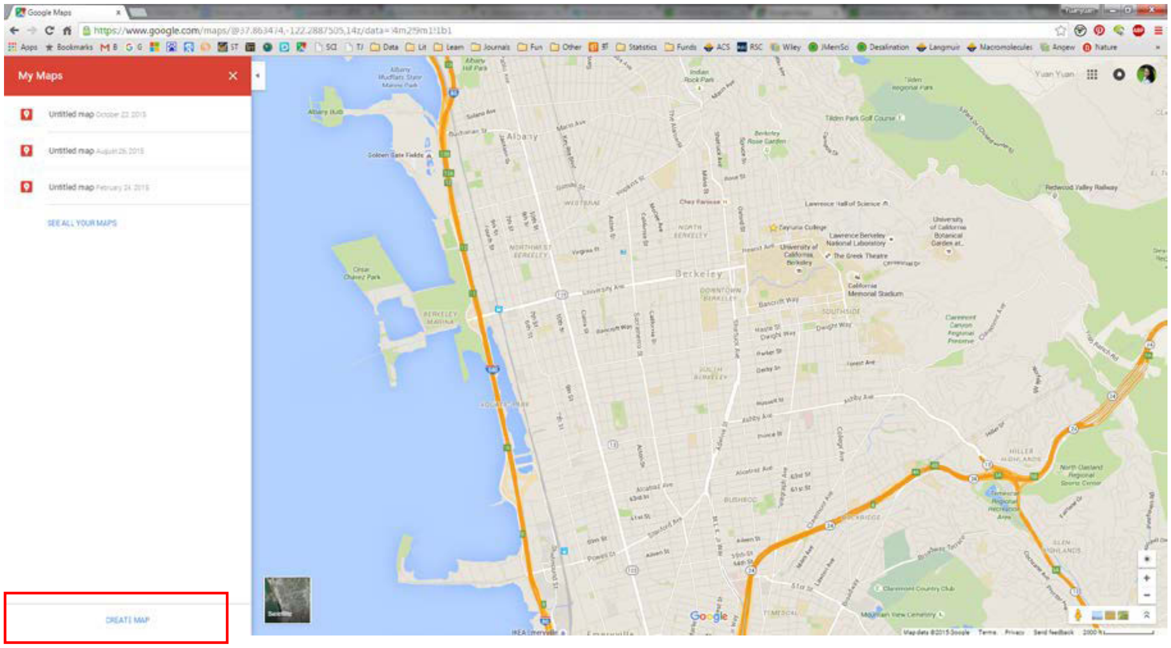
1. Sign up a Google Account (If you have one, skip this step)
2. Log in to your Google Account
3. Open Google Maps, and put the cursor on the "Menu" icon on the top left corner. See the figure below:



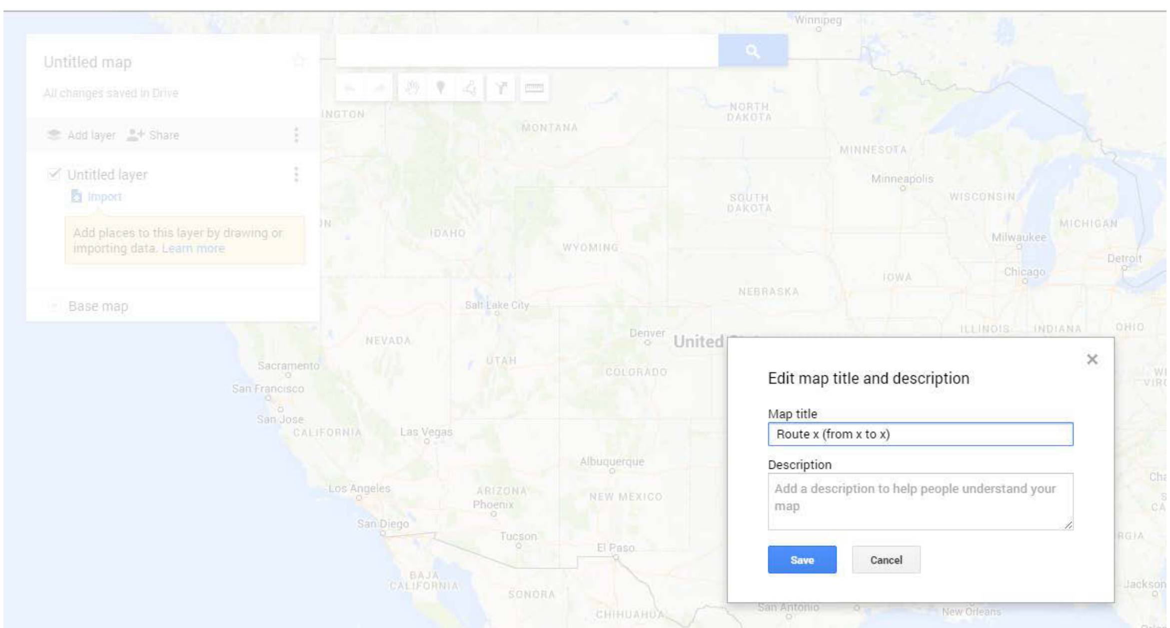
4. Click the "Menu" icon, in the drop down list; select "My Maps."



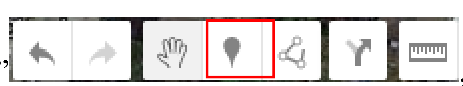
5. The "My Maps" panel will appear on the left side. At the bottom of the panel, click "CREATE MAP"



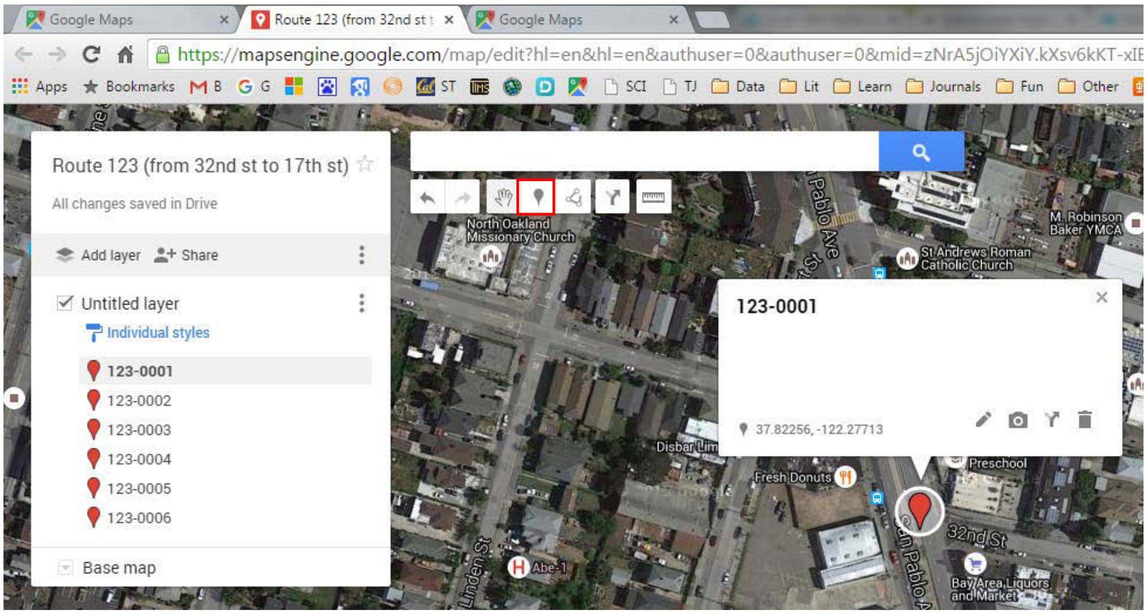
6. Name the new map as “Route x (from x st./ave./etc to x)” and save. For example, we need to create a map for “Route 123 from 32nd St. to 17th St.” in Oakland. List your name as part of the Route as well. Create a different route map for each route you are assigned. Then click “Save.”



7. Navigate to the location where you start to add the nodes. (Manually navigate or search the address “route 123 and 32nd st, Oakland, ca” in the search bar) on the map.

8. Click the icon for “Add marker” , click the center of the intersection of San Pablo Ave and 32nd St. A red point  will be added on the map.

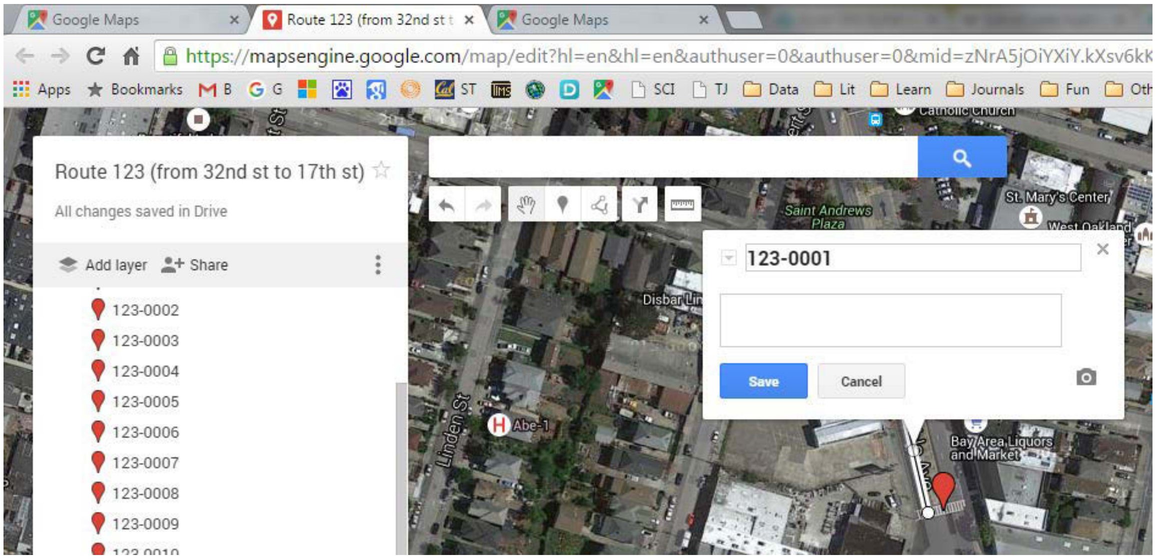
This is the starting node you make. In the point information box, name the point as "xxx-xxxx". The first three digits represent the route number (for example, Route 13 will be numbered as 013, Route 123 will be numbered as 123). The next four digits refer to the ID number of the node (for example, the first node you add will be 0001). So the first node you add in the example for "Route 123 from 32nd st. to 17th st." will be named as "123-0001". Then click "Save."



9. Continue to add nodes until the segment ends.

10. Click the icon for "Draw a line". , in the drop down list, select "Add line or shape."

11. Click the start point of the line, drag the mouse to make a line, and double click at the end of the line. In the line information box, name the line as "xxx-xxxx." Follow the naming rule of nodes in step 8. Therefore, the first line (AKA approach) is 123-0001. Then click "Save".



12. Add the next approach on the other side of the road. In step 11 and 12, you successfully made two approaches between two nodes. Continue to add approaches until you finish the entire route.

5.1.2. Using the Data Collection Macro Tool

The data measured from Google Maps should be input and stored in the Data Collection Macro Tool (referred to as "The Macro Tool.", see Appendix 4) the macro tool contains two main spreadsheets. Details can be found in the Excel file contained in the deliverable package. The spreadsheet called "data" is where collectors input the measurements. The other spreadsheet called "time cost" can automatically record the time cost for each single input in the data spreadsheet.

1. In the "Data" spreadsheet, hit **"Start"** (once you hit "start," the button will say **"Stop"**).

2. Enter data and the macro will automatically record the time costs for each cell on a separate sheet. After the pilot project, the "Time" sheet will no longer be used. This has been included simply for estimating the total cost for the state highway network. The "Data" spreadsheet is the only item Caltrans will need for collecting data from the entire State Highway System.

3. Hit the "**Break**" button if you want to take a break and leave the file **open**. The button will then change to "**Resume**"—to resume, press "Resume," and the macro will automatically start recording time again. Hit the "**Stop**" button if you want to **close** the file.

5.1.3. Data Collection

Step one Complete Node and Approach Table

1. Open the map and spreadsheet. Enter Node data, including Node ID, Node Names, Node Type, Intersection Type and Number of Lanes in the Cross Street in Node Table. All can be collected using the Satellite View in Google Maps.

2. Enter the Approach data, including Approach ID and Number of Lanes in the Cross Street. All can be collected using the Satellite View in Google Maps.

Step 2. Complete Additional Tables

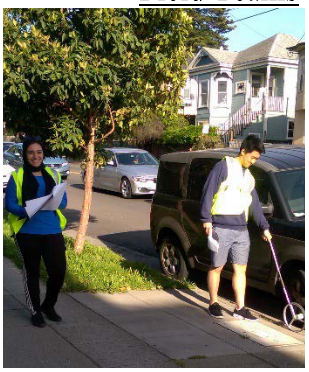
1. Using the map and spreadsheet, enter all additional data in the order they appear in the spreadsheet. The variables may need to be collected in either Satellite or Street View, and are color coded in the spreadsheet according to the specific view needed.

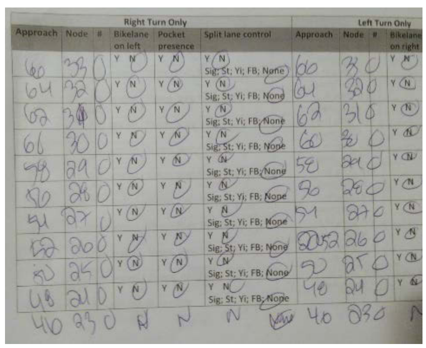
2. Complete all data collection for each approach in one direction, and then traverse the route in the opposite direction.

5.2. FIELD DATA COLLECTION

Field data collection requires a two-person team to work together on site. One-person records all the data on the data sheets, and the other data collector takes measurements and reports necessary information to be recorded. Data collection involves walking along highway sections to record information in the data collection sheets (see Appendix 3).

Field Teams | Writing Records | Input into Computer





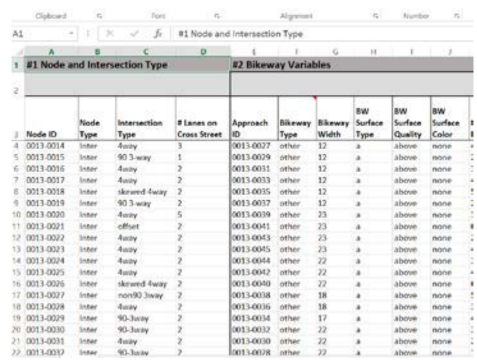


Figure 26. Materials for Field Data Collection

5.3 VOLUME DATA COLLECTION

To complement the bicycle infrastructure database currently being developed and integrated into the Caltrans TASAS database, ultimately a bicycle volume database will also be developed. This database will store bicycle volumes collected at intersections and along approaches throughout the state highway network. A likely approach for collecting this data is using Miovision automated video counting equipment, which all Caltrans districts currently use for collecting motor vehicle volumes and turning movement counts. The current process for using the Miovision equipment is described below, in addition to the steps that should be taken to ensure that bicycle volume data is collected and formatted in a way that will enable fluid integration into the TASAS database.

5.3.1 Introduction to Miovision Data

Miovision is a traffic data solution firm, which processes video data collected at intersections and roadway segments to produce data reports summarizing volumes and turning movement counts. Miovision customers also have access to an online portal where they can watch the videos, download data reports in various formats, view data collection locations on a map, and share data with other users. Traffic safety groups for the individual Caltrans districts each currently have two Miovision automated video counting devices, which are typically used to collect automobile traffic volumes and intersection turning movement counts. The traffic operations departments of some districts also have Miovision equipment, which are typically used to collect traffic volumes along freeways and at freeway ramps.

The typical process for collecting data is for the Caltrans district "user" to set up the portable Miovision equipment at an intersection or along a roadway segment. After a collection period, the user retrieves the equipment and uploads the video data to the specific Miovision online portal for that district. A username and password are required to access each portal, and information is not publicly available. When uploading the data, the user specifies the location of the study, the name of the study, and the classification type desired. Miovision then processes the data and provides data reports through the online portal.

When collecting bicycle data, the process is similar to and should include the following considerations. The Miovision automated video counting equipment should be set up with a clear view of bicyclists using the study facility. When uploading the data to the Miovision portal, currently the user identifies the location of the facility on a map. However, the user also has the option of entering a "Site Code" for each recorded location. The user should enter the existing TASAS database intersection ID or mid-block location ID as the Site Code. This step is very important to ensure that the data can be appropriately linked to the TASAS database. Finally, when prompted for the "Classification Options," the user should check the boxes, which specify "Count Bicycles on Road" and "Count Bicycles on Crosswalks" as shown in Figure 27.

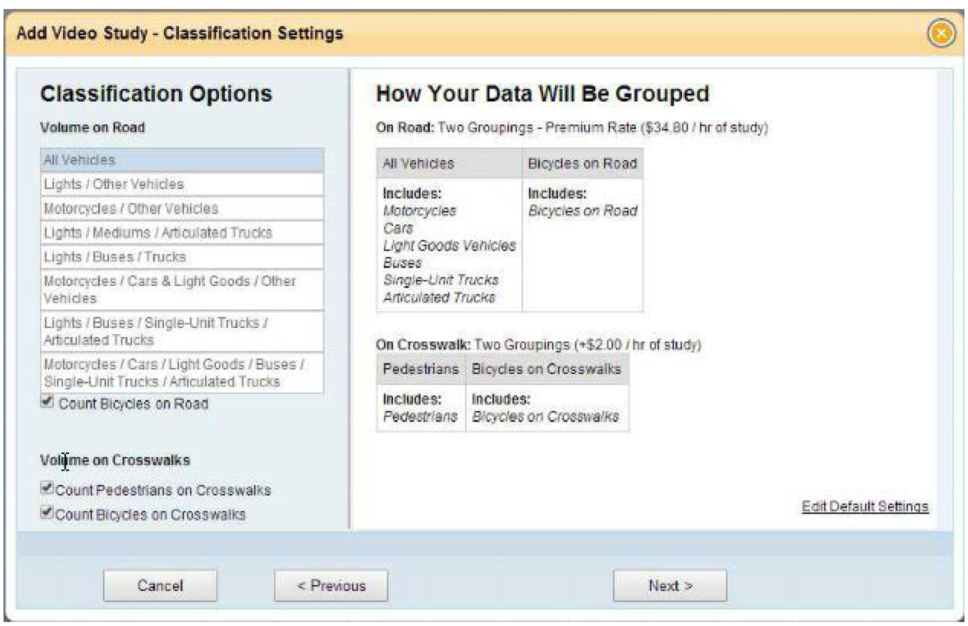


Figure 27. Miovision

Once the data have been processed, the data reports will be uploaded to the online Miovision portal. The user will have the option of downloading the data using various report formats. Under the "Advanced Reporting" option, the format that should be downloaded is "CSV Full." This file can then be used to import the count data into the bicycle volume database.

To further expand the available data pool, Caltrans may wish to coordinate with other Miovision users and "crowd source" data. Any data collected for Caltrans-related projects by other Miovision users can be shared with Caltrans through the Miovision portal. Caltrans can request the data be shared at any time at the discretion of the other party, but this collaboration may be best facilitated by incorporating a request to share data in future project contracts in which other parties are responsible for collecting the data rather than Caltrans. A quality control process would be necessary for implementation of this approach.

5.3.2 Miovision Outputs

Miovision can output the bicycle volume data in any customized format, including full records, and records on a specific bound, etc. Figures 28 shows the full records in csv format.

Study Nan	04-SM-35-26.23-Jun-07-2014																			
Start Date	6/7/2014																			
Start Time	12:00 AM																			
Site Code																				
***NewClass																				
Bicycles on Road																				
	Southbound										Southwestbound									
	Skyline Blvd (SR-35)																			
Start Time	Hard Righ	Right	Bear Right	Thru	Bear Left	Left	Hard Left	U-Turn	Peds CCW	Peds CW	Hard Righ	Right	Bear Right	Thru	Bear Left	Left	Hard Left	U-Turn	Peds	Peds
Movemen	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
12:00 AM		0		0		0		0												
12:30 AM		0		0		0		0												
***NewClass																				
Bicycles on Crosswalk																				
	Southbound										Southwestbound									
	Skyline Blvd (SR-35)																			
Start Time	Hard Righ	Right	Bear Right	Thru	Bear Left	Left	Hard Left	U-Turn	Peds CCW	Peds CW	Hard Righ	Right	Bear Right	Thru	Bear Left	Left	Hard Left	U-Turn	Peds	Peds
Movemen	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
12:00 AM									0	0										
12:30 AM									0	0										
***NewClass																				
Pedestrians																				
	Southbound										Southwestbound									
	Skyline Blvd (SR-35)																			
Start Time	Hard Righ	Right	Bear Right	Thru	Bear Left	Left	Hard Left	U-Turn	Peds CCW	Peds CW	Hard Righ	Right	Bear Right	Thru	Bear Left	Left	Hard Left	U-Turn	Peds	Peds
Movemen	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0

Figure 28. Miovision Output for Intersection Bicycle Volume Data

In these outputs, the intersection legs are labeled as "southbound," "northbound," "westbound," "eastbound" of the intersection. The two opposite directions of bicycle volume in the same crosswalk are labeled as CW/CCW (clockwise/counterclockwise). The logic for the CW/CCW designation is shown in Figure 29.

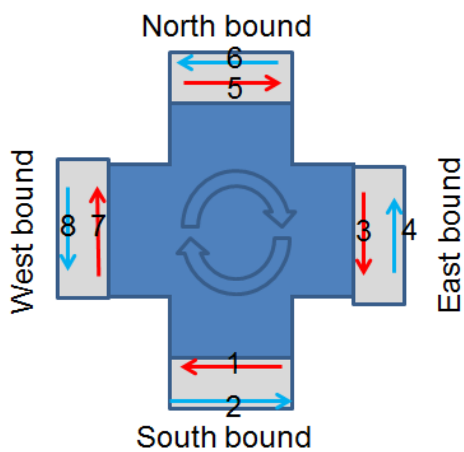


Figure 29. CW/CCW Designation for Bicycle Volume Direction on Crosswalks

For screenline volume on an approach, only the "through" column under one bound (see Figure X) will have count data.

5.3.3 Proposed Bicycle Volume Database

There are two sub-database to store bicycle volume data imported from Miovision data sheet. Figure 30 shows the sub-database for bicycle volume at intersections. Each row records the bicycle volume entering to a specific intersection through or on the crosswalk on a leg in different directions. The volume data in the first row in the table in Figure 30 is illustrated in Figure 31.

	Location						Count on the roadway			Count on the crosswalk		Other			
NVol_ID	N_ID	N_Name	Site_Code	Bound	A_ID	A_Name	Left_Turn	Through	Right_Turn	Clockwise	Counter_Clockwise	Date	StartTime	EndTime	Weather
1		unt/Wil						0				25/02/	15:15	15:30	
2		unt/Wil						1				25/02/	15:30	15:45	
3		(WB)						11				#####	12:00	12:01	

Figure 30. Bicycle Volume Database for Intersections

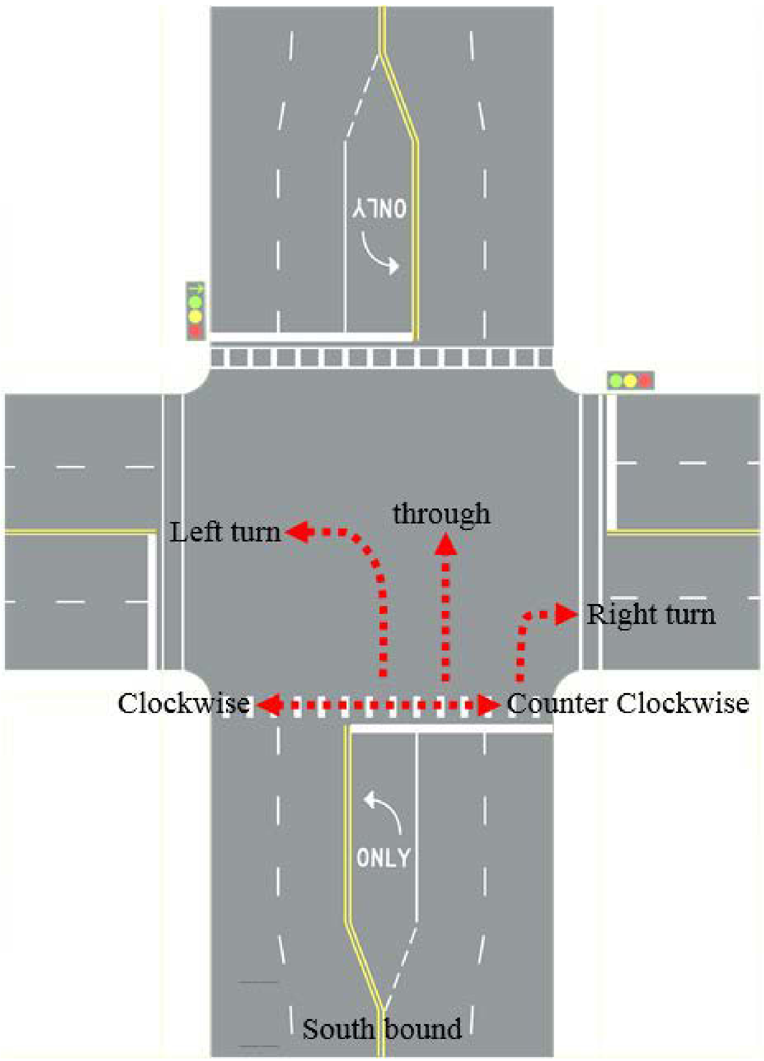


Figure 31. Bicycle Movements Counted at an Intersection

Avol_ID	A_ID	A_Name	SiteCode	Count	Interval	Date	StartTime	EndTime	Weather
1			304-N 305-N		1	####	12:00	12:01	

Figure 32. Bicycle Volume Database for Approaches

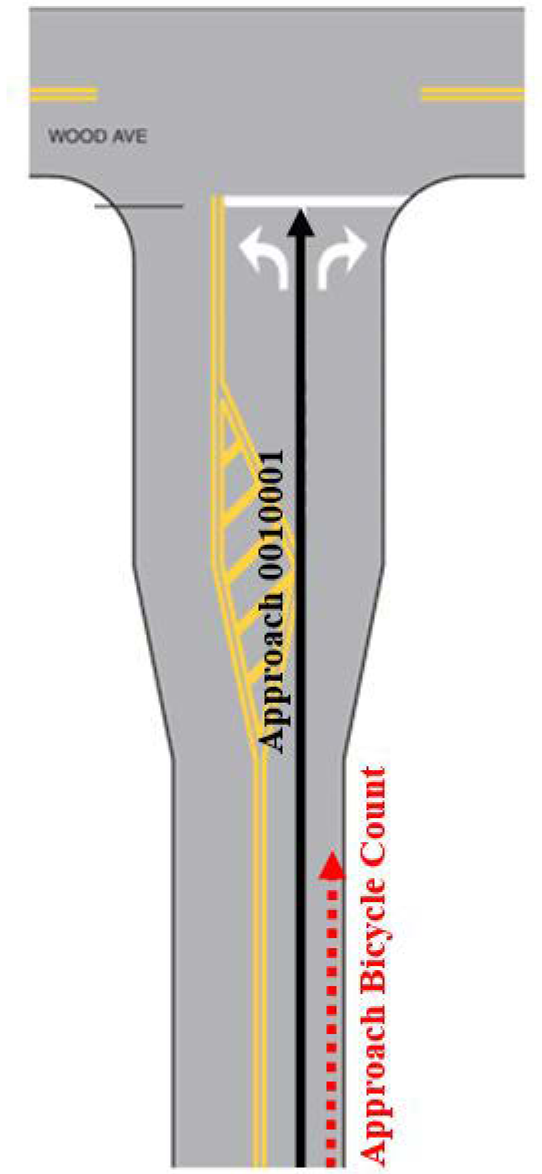


Figure 33. Bicycle Movement Counted at an Approach

6 TIME COST FOR DATA COLLECTION

Note for DRAFT: the estimates below are accurate but we are reviewing some parts of it to make sure the estimates include all of the necessary components for such a data collection effort. This will be reflected in the final draft.

The time cost estimation presented in this chapter details the advantages and disadvantages of computerized and field data collection. While field data collection has traditionally been used and is familiar to many, widely available and free websites have introduced the option of data collection via computer.

I. Pilot Project on Time Estimation

To determine the total estimated time cost for collecting bicyclist facility data across the California State Highway System, the progress of three research assistants collecting data on behalf of the pilot project was monitored. An Excel Macro sheet was used that recorded the time when students clicked ‘start,’ ‘break,’ or ‘end’ on the spreadsheet, as shown in Appendix 4. Each research assistant was assigned specific routes and instructed to collect bicyclist facility data via Google Maps. Each assistant was given verbal instructions, a manual, and an ‘expert’ contact person whom the assistant could consult regarding questions. We were interested in the rate at which data could be collected, which was expected to fluctuate depending on the roadway class and the data collector’s speed of learning.

In summary, we can view the pilot project as an experiment to determine the capabilities of this data collection process. The pertinent variable to monitor is time, as the only significant input to this process is labor.

II. Estimation Procedure

Upon the completion of data collection, we aggregated the time cost and determined the rate of data collection for each route. We classified each route according to one of ten categories. If a certain route changed categories within the route, for example from ‘Urban two lane road’ to ‘Rural two lane road,’ two separate rates were calculated. The mileage for each rate was determined. We took the average rate of data collection per category, and used that to estimate the total time cost for statewide data collection.

Table 12 below shows the route that we selected for our pilot project. For each route, we specify the nodes at which the data collector began and ended, the total mileage of the route, the total number of minutes recorded on the spreadsheet, and the data collector’s average pace in min/mile. The time cost for each route includes time creating map, entering in nodes/approaches, and collecting data using Google Maps.

Table 12. Routes for Pilot Data Collection

Route	Starting Node	Ending Node	Mileage	Time Cost (min)	Rate (min/mi)
1	Usal Rd	Hales Grove	5.8	81	14.0
1	San Geronimo Rd	Harmony Valley Rd	6.7	80	11.9
1	21st	Hinds Ave.	3.6	185.5	51.5
1	Warner Ave.	7th St.	5.0	209	41.8
1	Newland St.	Riverside Ave.	3.8	229	60.3
13*	Mabel St.	Turner Rd	3.0	417	139.0
35	Herbst Rd.	20th Ave.	1.7	265	155.9
36	Pratville Dr	Riverside Rd	2.9	303	104.5
49	Shanghai Way	Lincoln Hwy	1.2	166	138.3
58	Park Hill Rd	Huer Huero Rd	4.9	110	22.4
84	Vellecitos Rd	Kalthoff Common	4.5	112	24.9
84	Portola Rd.	Old Honda Rd.	6.1	119	19.5
84*	Old Niles Canyon Rd	Main St.	2.9	50	17.5
123	Ashby Ave	37th St.	1.9	281	147.9
130	Kincaid Rd	Mt. Hamilton	5.3	46.5	8.8
145	E 9th St	Road 29	3.3	182	55.2
273	Latona Rd	Bruce St	4.3	115	26.7
Total	-	-	66.9	2951.0	-

Note:
*. Field data collection has been conducted on this route.

6.1 COMPUTER DATA COLLECTION

In Table 13 below, we use the results from the pilot project to derive the total estimated time cost for collecting bicyclist facility data. The first column shows the roadway class, in which we categorized each route. The second column shows the total mileage per facility in the California State Highway System. The third column shows the mean rate of data collection per roadway class, and the fourth column shows the minimum and maximum observed rates from our pilot project. We obtained the total time estimation per row by multiplying the mean rate by the total existing mileage. Based on these estimates, the data collection is expected to take approximately 4,500 working hours to complete.

Table 13. Time Cost Estimation From Pilot

Roadway Class	Mileage (mi)	Computer (min/mi) MEAN	Computer (min/mi) MIN&MAX	Total Estimate (hr)
1-Urban freeways	2,355	2.67[a]	1; 4.19[a]	104.80*
2-Urban freeways < 4 lanes	60	2.67[b]	NA	2.67*
3-Urban two lane roads	577	64.09	18.96; 137.30	616.33
4-Urban multilane divided non-freeways	708	68.98	26.74; 152.30	813.96
5-Urban multilane undivided non-freeways	115	112.33	78.75; 265.67	215.30
6-Rural freeways	1,885	2.1[a]	2.10; 2.10[a]	65.98
7-Rural freeways < 4 lanes	187	2.1[b]	NA	6.55*
8-Rural two lane roads	8,461	17.20	8.84; 35.86	2425.49
9-Rural multilane divided non-freeways	782	10.56[c]	NA	137.63*
10-Rural multilane undivided non-freeways	277	17.20[d]	NA	79.41*
Other (Rural one lane roads)	1	17.20[e]	NA	0.29*
Other (Urban one lane roads)	1	64.09[f]	NA	1.07*
Other (multilane L or R highway alignment)	17	2.67[g]	NA	0.76*
Total	15,426	-	-	4470.22*

Notes:
[a]. This value is based on the time cost for pedestrian data collection.
[b] This value is estimated assuming that freeways will have the same time cost regardless of the number of lanes & type of facility (bicycle). This is because there are rarely any bicycle facilities on freeways so the time cost is only for navigating the map along the route, checking for any facilities
[c]. We found that the time cost for urban multilane divided non-freeways is 61.4% of the undivided time cost. Therefore, we used this proportion to estimate this value from the rural multilane undivided non-freeways
[d]. This value is the same as that of 'Rural two lane roads' because they are both in rural areas and the majority of rural two lane roads are undivided
e. We assume that this value is the same as it for Urban two lane roads
f. We assume that this value is the same as it for Rural two lane roads
g. We assume that this value is the same as it for Urban freeways because most of the L or R highway alignment are freeways. Between urban freeways and rural freeways, we chose the one with the bigger time cost to make sure we obtain the safest estimate.
* The value is calculated from specific assumptions.

6.2 FIELD DATA COLLECTION

To compare the time cost of traditional field collection methods with computerized data collection, we also gathered field data on Route 13 (From Old Niles Canyon Rd to Main St) and 84 (Form Shattuck Ave to Claremont Ave). See details in Table 14.

Table 14. Routes for Pilot Data Collection

Route	Starting Node	Ending Node	Mileage	Time Cost (min)	Roadway Class
13	Shattuck Ave	Telegraph Ave	0.4		5
13	Telegraph Ave	Elmwood Ave	0.7		3
13	Elmwood Ave	Claremont Ave	0.12	905.00	5
84	Old Niles Canyon Rd	Main St	2.9	52.00	8

Table 15 below summarizes the rate of data collection on the field, as well as the total estimated working hours required to complete each category. We estimate that the time cost for traditional field data collection will be approximately 25,000 working hours.

Table 15. Time Cost Estimation for the Entire State Highway System

Roadway Class	Mileage (mi)	Field (min/mi)	Field (hr)
1-Urban freeways	3,533	1.00[a]	39.25*
2-Urban freeways < 4 lanes	28	1.00[a]	1.00*
3-Urban two lane roads	868	240.24	1810.15
4-Urban multilane divided non-freeways	1,081	1297.32[b]	3918.66*
5-Urban multilane undivided non-freeways	176	1297.32[c]	636.51*
6-Rural freeways	2,879	1.00[a]	31.42*
7-Rural freeways < 4 lanes	6	1.00[a]	3.12*
8-Rural two lane roads	12,422	17.93	2528.43
9-Rural multilane divided non-freeways	1,125	96.82[c]	420.59*
10-Rural multilane undivided non-freeways	407	96.82[c]	148.98*
Other (Rural one lane roads)	1	240.24[d]	0.30*
Other (Urban one lane roads)	1	17.93[e]	3.14*
Other (multilane L or R highway alignment)	17	1.00[f]	94.09*
Total	15,426	-	24421.89*

Notes:
[a] The freeways in both urban and rural areas are all estimated by dividing 1 mile by speed limit (65 mph). This is because the bicycle facility is very rare on freeways so the time cost is only for driving along the route.
[b] This value is estimated by the assumption that the undivided and divided urban multilane non-freeways will have the same time cost in field.
[c] This value is estimated by the assumption that the time cost of field data collection for multilane non freeways will be 5.4 times (according to time cost estimate for pedestrian data collection) as it for the two lane roads. And then the undivided non freeways will have the same time cost as divided freeways.
d. We assume that this value is the same as it for Urban two lane roads
e. We assume that this value is the same as it for Rural two lane roads
f. We assume that this value is the same as it for Urban freeways because most of the L or R highway alignment are freeways. Between urban freeways and rural freeways, we chose the one with the bigger time cost to make sure we obtain the safest estimate.

*The value is calculated based on specific assumptions.

6.3 COMPARISONS

We estimate that the potential time cost for Google Maps data collection will be lower than that for field data collection. From the results of the pilot project involving three undergraduate UC Berkeley students, we project that the total time necessary to collect data on California state infrastructure will be approximately 4,500 hours, and that that field data collection will take approximately 25,000 hours.

In addition to the time cost, both computer and field data collection present their own advantages and disadvantages:

Advantages of Computerized Data Collection

- Google Maps is cheap and reliable
- No travel cost, less physically demanding

Disadvantages of Computerized Data Collection

- Some data collectors found computer lag to be a distracting problem with online data collection
- Imagery is not necessarily up to date with current infrastructure

Advantages of Field Data Collection

- Measurements can be taken with more certainty, e.g., the edge of the bikeway can easily be located even when in the shadow of a building
- More detailed information can be collected. For example, features such as bikeway surface quality condition and presence of rumble strips can be observed.

Disadvantages of FIELD DATA COLLECTION

- Travel time is substantial, especially for sites that are not near the local Caltrans office
- Measuring in the field can be dangerous, especially along high-speed highways

Because the computer data were gathered by multiple collectors, personal variance undoubtedly exists. The working environment, learning curve, and other day-to-day factors can cause time cost fluctuations even when the data are collected by a single individual. Accordingly, time-cost estimates have been presented as a range. Even when considering the upper end estimate, the time cost for computer collection totals approximately 7500 (Exact number is 7488.22) working hours, which is still substantially lower than the amount of time required for field data collection. Therefore, we can conclude that the computer time cost is no more than 40% of the time cost for field data collection.

In addition, the timer we developed in the Microsoft Excel Spreadsheet can also introduce bias. For example, if the data the collector forgets to press the start/stop button after taking a break in the timing, the recorded time cost will be less than the actual time expended. However, to calculate an estimate, we assume that various instances of bias will balance out.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

This project aims to build a data collection plan for Caltrans to collect bicycle infrastructure and volume data to supplement the TASAS database. After reviewing the existing bicycle inventory, safety studies and relative manuals, a list of items to be collected along the State Highway System was summarized in Chapter 2. In Chapter 3, the research team proposed to develop an "add-on" database, parallel to TASAS with key links to connect the two together. Bicycle infrastructure and volume data will be stored in two separate databases with the same key fields to connect to each other and to the TASAS database. The definitions and measuring methods for all the components are described in detail in Chapter 4.

The database and measuring methods have been tested in a pilot data collection effort. In the pilot, 50 miles of state highways were selected for computer-based data collection, of which approximately one tenth were also used for field data collection. The computer and field data collection procedures are developed and documented in the data collection manual and tutorial (Ch. 4 and 5) to guide data collection work in the future.

For this effort, the databases were developed in Microsoft Excel spreadsheet format to store the bicycle infrastructure data and to import volume data from files produced by Miovision. To estimate the time cost for the two data collection methods, the cost for each measurement was recorded in parallel with the database and is then compared for collecting data from the entire State Highway System. Results indicate that the computer time cost will be approximately 4,500 working hours, which is no more than 40% of the time cost estimated for field data collection.

The following conclusions are based on the analyses conducted during the project:

1. The database developed in this project offers flexibility in its ability to connect to TASAS, is easy to update and maintain, and allows new records and measurements to be added without any changes to TASAS. The procedure for data collection defined in this report will be useful for future implementation of the data collection plan. Caltrans will decide whether the bicycle infrastructure and volume database is going to be merged into TSN or developed as a separate database with links to TSN.
2. The measurements suggested for inclusion in the database adequately cover bicycle related facilities to help Caltrans track facility coverage. In addition, these measurements are useful for bicycle safety analysis and can offer critical information for safety investigations and countermeasure selection.
3. The time estimates for collecting bicycle infrastructure and volume data indicate that the computer data collection is more durable than the field data collection. Use of Google Maps is much less costly (more than 40% less) in terms of time than performing field data collection, even without considering site access time. Although field data collection offers the advantage of data collectors being able to see every corner of a street, the accuracy of the measurements based on computer data collection appears to be fairly high.

7.2 RECOMMENDATIONS

Complete State Highway Network Inventory

The primary recommendation of this project is for Caltrans to initiate construction of the proposed database within TSN and initiate the full infrastructure inventory. As has been discussed, computer-based data collection for the entire state highway network could be completed with approximately 4,500 staff-hours, or approximately 3.0 Full-Time Equivalent (FTE)-years. Additional certainty in data could be achieved by conducting field-based inventory for the urban portions of the state highway system. Alternatively, to a full-fledged data collection effort, Caltrans staff could collect data during routine field visits to enter into the database once constructed, and thereby incrementally populate the database for minimal additional cost.

In either case, the first next step would be for the database to be constructed by HQ to accommodate data collection. Then a prioritized list of locations to start the data collection should be determined. HQ will need to provide the Districts with resources to complete the data collection. Allocation of resources should reflect the approximate expected data collection costs per district. Finally, a protocol should be developed for continual maintenance of the new database, likely mirroring that used for updates of the TASAS database.

Linking to the Existing TASAS-TSN Database

One of the most important improvements to be made to this database is to connect it to the existing TASAS database. The data collection process was designed with this connection in mind, so that existing fields do not have to be re-collected. The connection process will involve making connections between the intersections IDs in TASAS and the node IDs in the new database. One possible key link could be the combined information of intersection connection ID and begin date which are currently used in TSN and TASAS to uniquely identify each intersection. A protocol for merging this link into the infrastructure database is proposed below.

1. All of the intersections in the TSN or TASAS database will be mapped in GIS environment or Google Maps using the location information, including route name, suffix, direction, prefix, county, and post mileage. All of the intersection point data will maintain the information of intersection connection ID and begin date which can connect the list to the data in the TSN/TASAS
2. Data collectors will work directly on the map of TSN/TASAS intersections, and will confirm that the locations of the intersection points are correct and make corrections if necessary by dragging the points to the correct locations.
3. Data collectors will continue work on the confirmed intersection map to label the intersections using the node ID, and insert mid-block crosswalks and other types of nodes into the map. It should be noted that these added nodes do not have to be connected to TSN/TASAS, so long as the intersections are connected with a one-to-one relation.
4. Approaches will be labeled and other data collection processes will be conducted according to this report.

GIS-Based Framework

This database could potentially be implemented as a Geographic Information System (GIS), which would provide spatial references for all of the elements that are collected. Using GIS might make the data entry process more burdensome and difficult, as it requires a specialized set of skills. It would also potentially make connecting to the existing TASAS database more difficult, as TASAS is currently stored in an Oracle database, not geographically. However, using a GIS framework could make analysis of the collected data more straightforward in the long run. Additionally, some information, such as lengths of sidewalks and crossing distances could be automatically calculated based on the geometries of the shapes that are drawn.

Local Jurisdiction Involvement

Local jurisdictions could additionally be trained on the data collection protocol and collect similar data on their streets for comparable analysis. Caltrans could host this database to allow for comprehensive systemic analysis of the statewide road network, including both state highways and local roads.

Implementation of Tablet Computer Interface for Field Data Collection

Field data collection currently relies on a series of paper forms for recording measurements, which are later entered manually into the computer back in the office. This process could be dramatically improved by developing an interface for tablet computers to enter data taken in the field. This could be as simple as creating electronic forms with dropdown menus for entry types, or as elaborate as a Google Maps interface which would allow the user to select highway elements and then enter measurements into a pop-up dialog box, providing geolocation for the data. Additionally, if a tablet with GPS transmittance was used, real-time coordinates could be included with the data as it is collected to simplify the geolocation process.

Hybrid/Computer-Focused Data Collection Process

Based on the pilot data collection project, a hybrid approach between computer and field-based data collection is recommended. Computer data collection should be the core of the process, due to its much faster data collection times and minimal loss of detail/accuracy. However, when Caltrans staffs are in the field, measurements should be taken by hand to validate the computer data collected and to improve the quality of information in the database.

APPENDIX 1. COMMENTS AND RESPONSES ON VARIABLES

1. Please add "Bicycle Loop Detection" and "Regional Bikeway" to the variables, as it would be of great benefit for TASAS to capture this.

> ***"It seems loop detectors can't/won't be examined. So intersection cameras may also fall in this non-examine category. But these items are important so a bicyclist does not get frustrated at a signalized intersection, where the signal won't change (for straight or turns) and proceed illegally. Cameras may be visible from Google Earth Street view. (Otherwise the consultant would have to field examine ALL signalized intersections or query ALL agencies re: signal configurations – an almost infinite task.)"***
>
> **--------------- Jacob Mathew**
>
> ***"Regarding Regional Bikeways: While not all regions in the state will have identified regional bikeways, many do. San Diego and Imperial Counties do and I can provide your team with those. I'm sure the urbanized district bike coordinators can as well at the least."***
>
> **----------- Seth Cutter**

Response:

Bicycle Loop Detection – we agree that this would be a great addition, but we feel that it will be a very difficult variable to capture as loop detectors are not easily visible from Google Maps and cannot be collected consistently. We are however recording bicycle detector pavement markings as part of the pavement markings variable.

Cameras - We are uncertain we will be able to distinguish between different types of cameras – those present for security, versus those present for traffic operations. Do you have a suggestion for how to distinguish? If there is a way to distinguish then we definitely can add it as a variable in our database. We can also label this variable as the one needs to be collected in field instead of on computer.

Regional Bikeway – We can add this variable in our database and label it as the one needs other resources' data.

2. Drain cover presence. What type of drain cover; is it bicycle friendly?

> ***"I think the metric should be "Bicycle Friendly Drainage Inlets", rather that covers. There is a page in the Caltrans Standard Specifications book that identifies these. They can be identified on Google Earth to the trained eye."***
>
> ***---------- Seth Cutter***

Response:

Drain cover presence - we are only recording the presence of drain covers within the bikeway and so are considering all to be "unfriendly." We are not currently distinguishing further whether covers are friendly or unfriendly for bicyclists as this could be difficult to assess from Google Maps. We checked the Caltrans Standard Specification book about drainage lnlets but didn't find any information about drainage inlet cover types. Could you give us the page number of other resources to learn the types?

Collecting data in Google Earth – We agree that Google Earth has better maps than Google Maps. But the reason we chose to use the latter is, we have to use the double screen technique to navigate to a specific node or approach in the bird view of the route map on one screen and at the same time check the street view around that node or approach on another screen. Doing this in

Google Earth is quite challenging and time consuming. We could add Google Earth as a resource for some variables if they are really important for Caltrans to collect.

3. Number of access points. Recommend specifying whether driveways are residential or business.

Response:

We believe it would be difficult to consistently distinguish residential from commercial in many of the more rural areas and so we recommend not adding this distinction.

4. Bicycle parking facility presence. What type is available?

Response:

We are currently collecting information on the type, which includes a standard rack, bicycle lockers, and bike stations.

5. Rumble strip presence. Bicycle friendly or deeper? Are there gaps to allow cyclists to pass through?

Response:

We are currently collecting information on whether the strips are continuous or have gaps (with gaps being more bike friendly).

6. Speed reducing/traffic calming measure presence. What type?

> ***"Suggest also looking at lane width reductions, road diets, presence of pedestrian signalization (HAWK, RRFB)."***
> ***--------- Seth Cutter***

Response:

We are currently collecting information on the following types: curb extensions, speed bumps, special pavement, raised crossing, pedestrian refuge, and roundabouts or traffic circles. We can add lane width reduction as one type. But regarding road diet, we think it is very challenging for collectors to know if there is a road diet project constructed or not because you have to know what the street looks like before. So we recommend not to include the road diet.

7. Vehicle parking type. Do bikes travel on the right of left of the vehicle parking?

> ***"Type of vehicle parking: Is the vehicle parking parallel, diagonal, or back-in diagonal?"***
> ***-------------Seth Cutter***

Response:

Vehicle parking type – vehicle parking is recorded according to whether it is parallel or angled. Bike lane location as opposed to the vehicle parking - we have added a new variable called "Bike lane alignment" to indicate whether bicycles are on the left or right of the parking lane.

8. Pavement marking color. Will this include pavement colorization?

Response:

We are currently collecting both bikeway pavement marking color and bikeway color. Bikeway pavement marking color includes white and yellow. Bikeway color includes green, other, and none.

9. What is an "approach"?
Response:
An approach is defined as a directional road segment between two intersections.

10. Other drainage feature may be relevant – such as curb/gutter or gutter drains (longitudinal) such as E-curb

> ***"On #10, I especially believe presence of curb or gutter within the shoulder is important. Maybe it could be that simple. There are situations where the Highway Log indicates a 4-foot shoulder, but significant stretches include an asphalt dike with accumulated debris in front – rendering the shoulder unavailable for cyclists. On high-volume, high-speed 2-lane conventional highways, this becomes a significant barrier to bicycling (even though on "paper" it will appear that a marginal shoulder exists.)"***
> ***---------------- Aileen Loe***

Response:
We agree this is important, especially the drainage feature within the shoulder. For drainage on the curb, we have the variable called "curb presence" and we consider that all the curbs are not bike friendly. For drainage within the shoulder, we can add a variable called "drainage in shoulder". But if Caltrans requires us to judge different types of drainage, please offer us pictures of different types so that we can add to the manual. The only resource we have to identify different drainage types (or called dikes) is the Highway Design Manual. It is difficult for the collector to understand difference between types only based on the texts. Can Caltrans provide us with an example of each type?

11. Rumble stripes presence. May need to specify centerline or shoulder rumble strips.
Response:
we are currently collecting information on rumble strips on shoulders. Centerline rumble strips are not included. And we have added this distinction to the variable.

12. Median cut through. Is this a crossover? Is it an at-grade intersection through the median on a divided expressway?
Response:
We are currently collecting the facility where it only Allows bicycle traffic to cut through a median or an intersection where automobiles are not allowed.

13. Paved shoulder. Should this be "width of paved shoulder"?

Response:
This is “paved shoulder presence”. It is available in TASAS database as “width of treated shoulder”.
14. Median Presence. Is this specific to a divided expressway or freeway?
Response:
This is not specific to a divided expressway or freeway. It also includes medians on highways, such as the green belt median on Route 123 in Albany, CA.

15. I assume vehicle posted speed limit is already a variable somewhere. ---------Jacob Mathew
Response:
Design speed is available in TASAS, but not the posted speed.

APPENDIX 2. DATEBASE STRUCTURE

PK: Primary Key
FK: Foreign Key, link to the core tables
TSN: Available in TASAS-TSN

Intersection Volume [Intersection Volume Table]

PK	NVol_ID [Node Volume ID]	TEXT
FK1	N_ID [Node ID]	TEXT
FK2	A_ID [Approach ID]	TEXT
	N_Name [Node Name]	TEXT
	A_Name [Approach Name]	TEXT
	Site Code	TEXT
	Bound	TEXT
	Left_Turn [No. of Left Turning Bicycles]	INTEGER
	Through [No. of Through Bicycles]	INTEGER
	Right Turn [No. of Right Turning Bicycles]	INTEGER
	Clockwise [Bicycle Counts on Crosswalks]	INTEGER
	Counter Clockwise [Bicycle Counts on Crosswalks]	INTEGER
	Coll_Date [Collection Date]	TEXT
	Start Time	TEXT
	End Time	TEXT
	Weather	TEXT

Approach Volume [Approach Volume Table]

PK	AVol_ID [Node Volume ID]	TEXT
FK	A_ID [Approach ID]	TEXT
	A_Name [Approach Name]	TEXT
	Site Code	TEXT
	Count	INTEGER
	Start Time	TEXT
	End Time	TEXT
	Weather	TEXT

Node [Node Table]

PK	N_ID [Node ID]	TEXT
	N_Name [Node Name]	TEXT
	N_Type [Node Type]	TEXT
	Inx_Type [Intersection Type]	TEXT
	X_Ctrl [Crossing Control Type]	CHAR
	X_Lane [No. of Lanes on the Crossing Street]	INTEGER
	Coll_Date [Collection Date]	TEXT

Approach [Approach Table]

PK	A_ID [Approach ID]	TEXT
FK1	From_N_ID [From Node ID]	TEXT
FK2	To_N_ID [To Node ID]	TEXT
	Class [Roadway Classification]	INTEGER
	Type of Lane Adjacent to the Outside Lane	TEXT
TSN	Curb [Curb Presence]	TEXT
TSN	Lane [No. of Lanes]	INTEGER
TSN	Width	DOUBLE
TSN	Shoulder [Shoulder Presence]	TEXT
TSN	Paved_Shd [Paved Shoulder Presence]	TEXT
TSN	Median [Median Presence]	TEXT
TSN	Median_Type	CHAR
TSN	ADT	DOUBLE
	Coll_Date [Collection Date]	TEXT

Figure A-1. Approach Bicycle Volume Database Structure

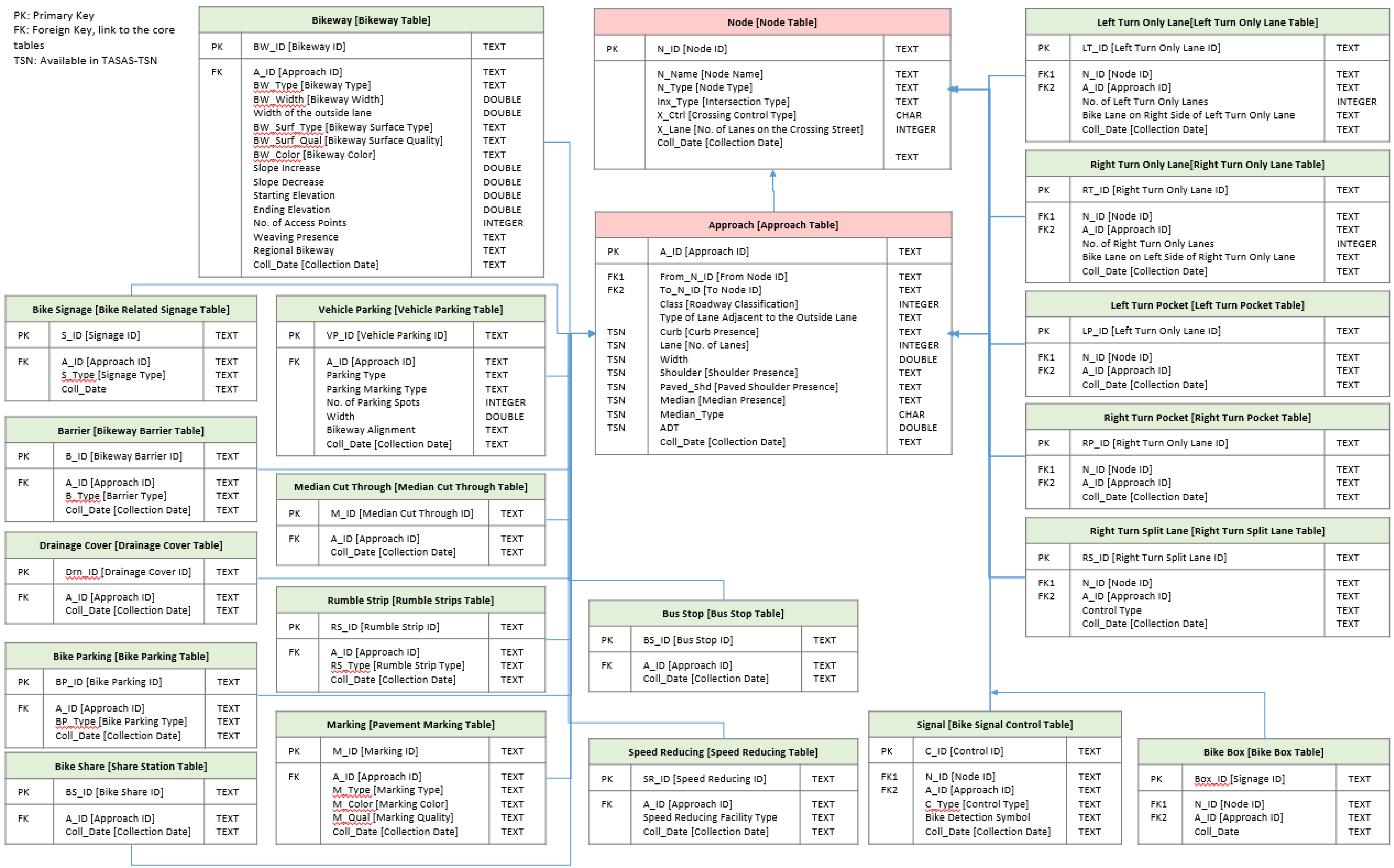


Figure A-2. Intersection Bicycle Volume Database Structure

APPENDIX 3. FIELD DATA COLLECTION PACKET

Field Data Collection Sheets

NAME_______________________ TIME TO COMPLETE________________

#1 NODE, INTERSECTION TYPE

Node ID	Node Type	Intersection Type	# Lanes on Cross street	Type of lane adjacent to outside
	Inter ; midb ; seg	90-3way ; non90-3way ; 4way ; skewed 4way ; Offset ;skewed offset		Opp ; same; Median; 2way turn
	Inter ; midb ; seg	90-3way ; non90-3way ; 4way ; skewed 4way ; Offset ;skewed offset		Opp ; same; Median; 2way turn
	Inter ; midb ; seg	90-3way ; non90-3way ; 4way ; skewed 4way ; Offset ;skewed offset		Opp ; same; Median; 2way turn
	Inter ; midb ; seg	90-3way ; non90-3way ; 4way ; skewed 4way ; Offset ;skewed offset		Opp ; same; Median; 2way turn
	Inter ; midb ; seg	90-3way ; non90-3way ; 4way ; skewed 4way ; Offset ;skewed offset		Opp ; same; Median; 2way turn
	Inter ; midb ; seg	90-3way ; non90-3way ; 4way ; skewed 4way ; Offset ;skewed offset		Opp ; same; Median; 2way turn
	Inter ; midb ; seg	90-3way ; non90-3way ; 4way ; skewed 4way ; Offset ;skewed offset		Opp ; same; Median; 2way turn
	Inter ; midb ; seg	90-3way ; non90-3way ; 4way ; skewed 4way ; Offset ;skewed offset		Opp ; same; Median; 2way turn
	Inter ; midb ; seg	90-3way ; non90-3way ; 4way ; skewed 4way ; Offset ;skewed offset		Opp ; same; Median; 2way turn
	Inter ; midb ; seg	90-3way ; non90-3way ; 4way ; skewed 4way ; Offset ;skewed offset		Opp ; same; Median; 2way turn

NAME_______________________ TIME TO COMPLETE________________

#2 BIKEWAY VARIABLES

Approach ID	Bikeway Type	Bikeway Width*	BW Surface Type	BW Surface Quality	BW Surface Color	# Access Points	Weaving Presence
	Standard; buffered; contraflow; shared		c a g s cr	above below	none; gr other		yes no
	Standard; buffered; contraflow; shared		c a g s cr	above below	none; gr other		yes no
	Standard; buffered; contraflow; shared		c a g s cr	above below	none; gr other		yes no
	Standard; buffered; contraflow; shared		c a g s cr	above below	none; gr other		yes no
	Standard; buffered; contraflow; shared		c a g s cr	above below	none; gr other		yes no
	Standard; buffered; contraflow; shared		c a g s cr	above below	none; gr other		yes no
	Standard; buffered; contraflow; shared		c a g s cr	above below	none; gr other		yes no
	Standard; buffered; contraflow; shared		c a g s cr	above below	none; gr other		yes no
	Standard; buffered; contraflow; shared		c a g s cr	above below	none; gr other		yes no
	Standard; buffered; contraflow; shared		c a g s cr	above below	none; gr other		yes no

*Do not measure width of shared bikeways or any other areas where you feel unsafe.

NAME______________________ TIME TO COMPLETE______________

#3 PAVEMENT MARKING, ETC.

Pavement Marking				Signal Control Midblock		BW Barrier	Drainage
Approach	Type	Color	Quality	Node	Type	Type	Presence
	Bike sym; helmet; words; detector; shared	Y ; W	New; PW; Faded		signal; HAWK; control	F ; Sh ; RB; CB ; St; c, none	Yes no
	Bike sym; helmet; words; detector; shared	Y ; W	New; PW; Faded		signal; HAWK; control	F ; Sh ; RB; CB ; St; c, none	Yes no
	Bike sym; helmet; words; detector; shared	Y ; W	New; PW; Faded		signal; HAWK; control	F ; Sh ; RB; CB ; St; c, none	Yes no
	Bike sym; helmet; words; detector; shared	Y ; W	New; PW; Faded		signal; HAWK; control	F ; Sh ; RB; CB ; St; c, none	Yes no
	Bike sym; helmet; words; detector; shared	Y ; W	New; PW; Faded		signal; HAWK; control	F ; Sh ; RB; CB ; St; c, none	Yes no
	Bike sym; helmet; words; detector; shared	Y ; W	New; PW; Faded		signal; HAWK; control	F ; Sh ; RB; CB ; St; c, none	Yes no
	Bike sym; helmet; words; detector; shared	Y ; W	New; PW; Faded		signal; HAWK; control	F ; Sh ; RB; CB ; St; c, none	Yes no
	Bike sym; helmet; words; detector; shared	Y ; W	New; PW; Faded		signal; HAWK; control	F ; Sh ; RB; CB ; St; c, none	Yes no
	Bike sym; helmet; words; detector; shared	Y ; W	New; PW; Faded		signal; HAWK; control	F ; Sh ; RB; CB ; St; c, none	Yes no
	Bike sym; helmet; words; detector; shared	Y ; W	New; PW; Faded		signal; HAWK; control	F ; Sh ; RB; CB ; St; c, none	Yes no

NAME______________________ TIME TO COMPLETE______________

#4 BIKE PARKING, TRAFFIC CALMING, BUS STOPS

Approach ID	Bike Parking	Bike Share	Bus Stop	Traffic Calming	Bike Box		Median Cut Through	Rumble Strips
	Type	Presence	Presence	Type	Node	Type	Node	Presence
	Std; lock; station	Yes No	Yes No	CE; SB; SP; RC; PR; R/TC		Left Right		Yes No
	Std; lock; station	Yes No	Yes No	CE; SB; SP; RC; PR; R/TC		Left Right		Yes No
	Std; lock; station	Yes No	Yes No	CE; SB; SP; RC; PR; R/TC		Left Right		Yes No
	Std; lock; station	Yes No	Yes No	CE; SB; SP; RC; PR; R/TC		Left Right		Yes No
	Std; lock; station	Yes No	Yes No	CE; SB; SP; RC; PR; R/TC		Left Right		Yes No
	Std; lock; station	Yes No	Yes No	CE; SB; SP; RC; PR; R/TC		Left Right		Yes No
	Std; lock; station	Yes No	Yes No	CE; SB; SP; RC; PR; R/TC		Left Right		Yes No
	Std; lock; station	Yes No	Yes No	CE; SB; SP; RC; PR; R/TC		Left Right		Yes No
	Std; lock; station	Yes No	Yes No	CE; SB; SP; RC; PR; R/TC		Left Right		Yes No
	Std; lock; station	Yes No	Yes No	CE; SB; SP; RC; PR; R/TC		Left Right		Yes No

NAME________________________ TIME TO COMPLETE________________

#5 RIGHT AND LEFT TURNS

Right Turn Only						Left Turn Only				
Approach	**Node**	**#**	**Bikelane on left**	**Pocket presence**	**Split lane control**	**Approach**	**Node**	**#**	**Bikelane on right**	**Pocket presence**
			Y N	Y N	Y N Sig; St; Yi; FB; None				Y N	Y N
			Y N	Y N	Y N Sig; St; Yi; FB; None				Y N	Y N
			Y N	Y N	Y N Sig; St; Yi; FB; None				Y N	Y N
			Y N	Y N	Y N Sig; St; Yi; FB; None				Y N	Y N
			Y N	Y N	Y N Sig; St; Yi; FB; None				Y N	Y N
			Y N	Y N	Y N Sig; St; Yi; FB; None				Y N	Y N
			Y N	Y N	Y N Sig; St; Yi; FB; None				Y N	Y N
			Y N	Y N	Y N Sig; St; Yi; FB; None				Y N	Y N
			Y N	Y N	Y N Sig; St; Yi; FB; None				Y N	Y N
			Y N	Y N	Y N Sig; St; Yi; FB; None				Y N	Y N

NAME________________________ TIME TO COMPLETE________________

#6 VEHICLE PARKING AND BIKE SIGNS

Approach	Parking Type	Parking Marking Type	# of Spots	Width*	Bikeway Alignment	MUTCD Sign #
	Parallel; angled	Stripe; Stall; None			L of park; R of park; None	
	Parallel; angled	Stripe; Stall; None			L of park; R of park; None	
	Parallel; angled	Stripe; Stall; None			L of park; R of park; None	
	Parallel; angled	Stripe; Stall; None			L of park; R of park; None	
	Parallel; angled	Stripe; Stall; None			L of park; R of park; None	
	Parallel; angled	Stripe; Stall; None			L of park; R of park; None	
	Parallel; angled	Stripe; Stall; None			L of park; R of park; None	
	Parallel; angled	Stripe; Stall; None			L of park; R of park; None	
	Parallel; angled	Stripe; Stall; None			L of park; R of park; None	
	Parallel; angled	Stripe; Stall; None			L of park; R of park; None	

***Record width only if you can do so safely**

Field Data Collection Sheets - Key

#1 NODE, INTERSECTION TYPE

NodeID: record based on map

Node Type: Intersection (inter), midblock crossing (midb), segment break (seg)

Intersection Type: If intersection, record type: 90 degree 3-way (90-3way), non-90 degree/skewed 3-way (non90-3way), 4-way (4way), skewed 4-way (skewed 4way), offset (offset), skewed offset (skewed offset)

 # Lanes on Cross Street: count # of lanes at the node; if multi-way, list # of with most lanes

Type of Lane Adjacent to outside lane: outside lane is furthest to the right if you are traveling in the direction of traffic. Opposite direction (opp), same direction (same), median (median), 2way turn (two-way left turn lane)

#2 BIKEWAY VARIABLES

ApproachID: record based on map

Bikeway Type: Standard (standard), buffered (buffered), contraflow (contraflow), shared use (shared)

Bikeway Width: measure the space where bicyclists are guided to ride safely and comfortably. Do not measure width of shared bikeways or any other area where you feel unsafe near traffic.

Bikeway Surface Type: the type of surface that comprises the majority of the bikeway: concrete (c), asphalt (a), gravel (g), stone (s), crushed rock (cr)

Bikeway Surface Quality: the quality of the surface that comprises the majority of the bikeway: above average (above) or below average (below)

Bikeway Surface Color: the color of the bikeway pavement: none (none), green (gr), other (other)

# of Access Points: count driveways and parking lot entries between two nodes (do not count intersections though)

Weaving Area: dashed or gapped are of bike lane for turning vehicles to cross bike lane: yes (yes), no (no)

#3 PAVEMENT MARKINGS, ETC.

Pavement Markings

- **Type:** Bike Symbol (bike sym), helmeted bicyclist symbol (helmet), words, such as "bike lane" (words), bicycle detector pavement marking (detector), shared lane marking (shared)
- **Color:** yellow (y), or white (w)
- **Quality:** the overall condition for majority of approach: new (new), partially worn (PW), faded (faded)

Signal Control (Bicycle) at Intersection and Midblock Crossing: if present, list type. If not present, leave blank - Bicycle signal (signal), Bicycle HAWK Beacon (Hawk), Bicycle Control Sign (control)

Bikeway Barrier: chain link fence (f), dense shrubs (s), raised traffic bars (RB), concrete barrier (CB), steel guardrailing (St), curb (c), none (none)

Drain Cover Presence: only if in the bikeway: yes (yes), no (no)

#4 BIKE PARKING, TRAFFIC CALMING, BUS STOPS

Bike Parking: standard rack (std), bicycle locker (lock), bike stations (station)

Bike Share: yes (yes), no (no)

Traffic Calming - curb extensions (CE), speed bumps (SB), special pavement – such as cobblestone or brick crosswalks (SP), raised crossing (RC), pedestrian refuge (PR), roundabouts or traffic circles (R/TC)

Bike Box - list turning direction – left (left) or right (right)

Median Cut Through - record node according to map only if present

Rumble Strips :yes (yes), no (no)

#5 RIGHT AND LEFT TURNS

Right Turn Only

# of Lanes – record total # of lanes in each direction

Bikelane on leftside of right turn only lane – yes (y) or no (n)

Vehicle pocket presence – yes (y) or no (n)

Vehicle Right Turn Split Lane Control – record yes (y) or no (n). If present, list control type, which includes: signal (sig), stop sign (St), yield (yi), flashing beacon (FB), or none (none) – only list NONE if there is a split lane, but no traffic control

Left Turn Only

# of Lanes – record total # of lanes in each direction

Bikelane on rightside of left turn only lane – yes (y) or no (n)

Vehicle pocket presence – yes (y) or no (n)

#6 VEHICLE PARKING AND BIKE SIGNS

Parking type: parallel (parallel) or angled (angled)

Parking marking type: stripe (stripe), stall (stall) or none (none) – only list none if there is parking, but no marking

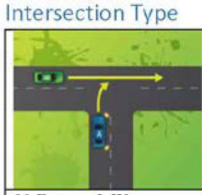
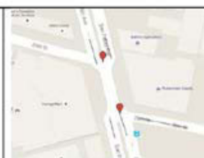
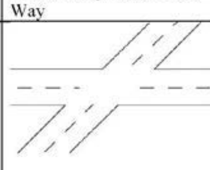
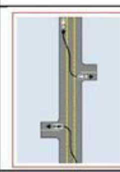
# of parking spots – count if marked, otherwise measure using the wheel

Width – measure using the wheel (only if there are no moving cars and you feel safe)

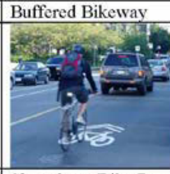
Bikeway alignment – bikeway is left of parking (L of park), right of parking (R of park), or there is no bikeway (none)

MUTCD Sign # - see sign sheet to record types

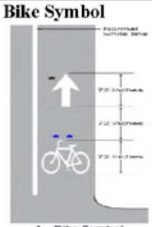
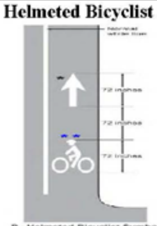
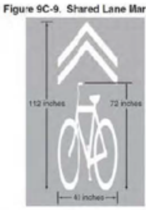
Intersection Type

		
90 Degree 3-Way	Non-90 Degree/Skewed 3-Way	Skewed Offset
		
4-Way	Skewed 4-Way	Offset

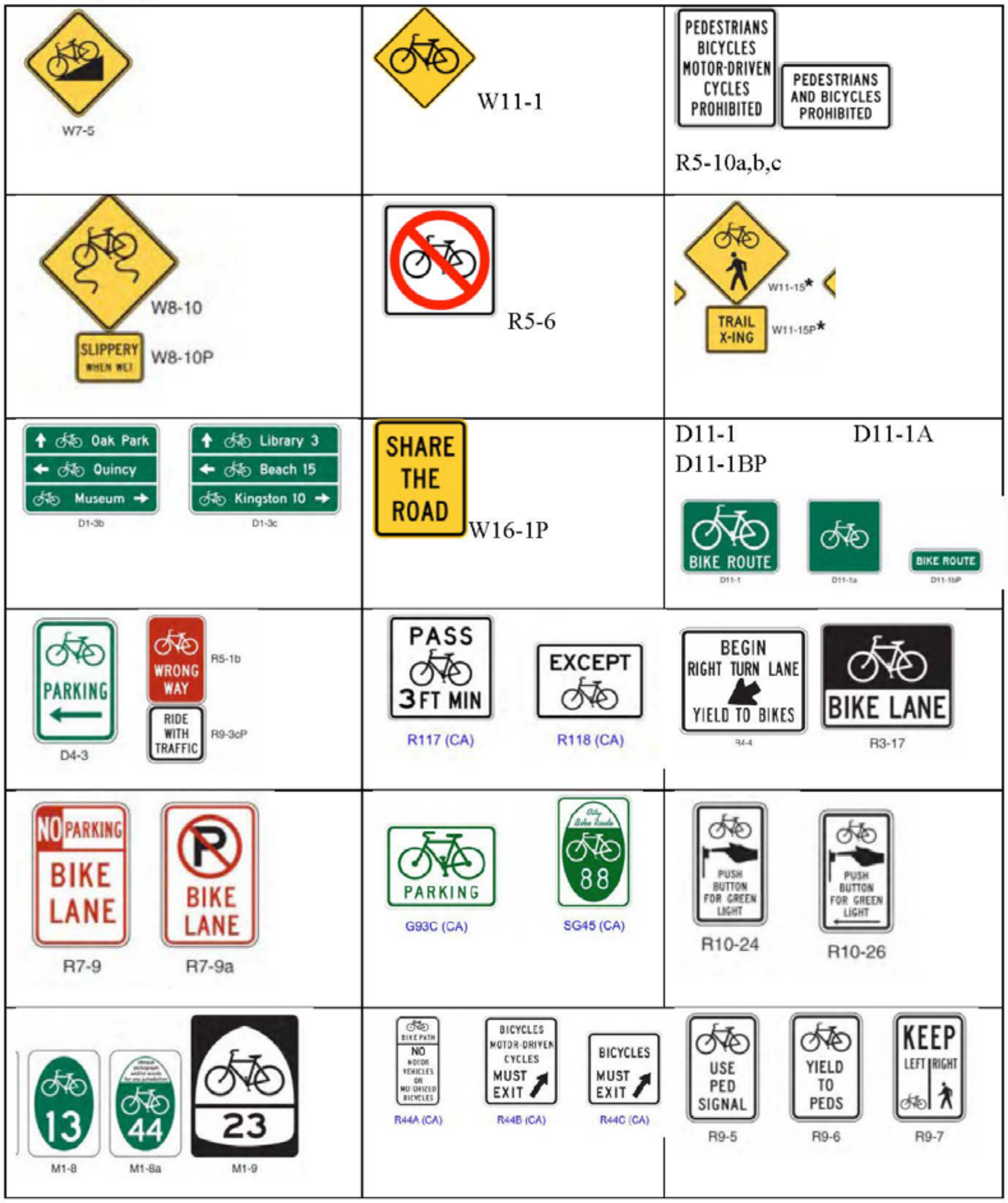
Bikeways

	
Standard Bikeway	Buffered Bikeway
	
Contraflow Bikeway	Shared-use Bike Route

Pavement Marking Type

Bike Symbol  A - Bike Symbol	**Helmeted Bicyclist Symbol**  B - Helmeted Bicyclist Symbol
Words  C - Word Legends	**Bicycle Detector Pavement Marking** 9C-7. Bicycle Detector Pavement Ma   **(Note, this is a small indicator which usually appears at an intersection to let cyclists know where to wait to activate the green light)**
Shared Lane Marking Figure 9C-9. Shared Lane Marking 	

Bike Signage



APPENDIX 4. TIME ESTIMATION SPREADSHEET TOOL

An Excel Macro Tool has been created to store measurements and timing for the data collection process. An image of this spreadsheet is below.

Instructions and Color Codes **Start/Stop and Break/Resume Buttons**

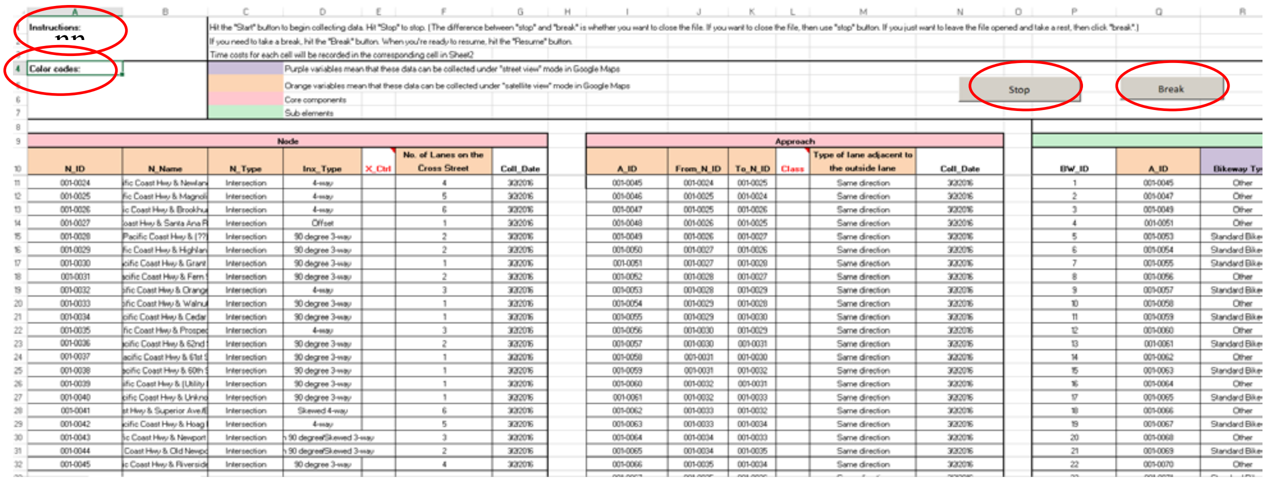


Figure A-4. Screenshot of Macro Tool

The instructions for how to use the macro tool are shown at the top of the sheet. For example, when starting to collect data on the bikeways variables, follow the steps below:

1. Click the “Start Button” (circled in red).
2. Switch to the web browser and conduct the data collection as detailed in the Bikeway Variables.
3. Enter the measurements and information for each variable in the spreadsheet.
4. The time cost will be automatically recorded in a separate sheet titled “Data Collection – Time.”
5. Proceed to the next element.
6. Click the “Stop Button” when you need to close the Excel file. Click the “Break Button” when you leave the Excel file opened and take a break. Then click the “Resume” button to re-start.

Conduct this same process for each of the elements of the selected segments on the highway network.

APPENDIX 5. ROUTES WITH MULTIPLE ROADWAY CLASSIFICATIONS

Begin Post Mile	End Post Mile	Miles	Name of Route	Segments	Class
4	ALA	13	**Mabel St to Turner Road**	From HILLER DR/TUNNEL RD to CLAREMONT AVE	3
				From CLAREMONT AVE to ELMWOOD COURT LT	5
				From ELMWOOD COURT LT to TELEGRAPH AVE	3
				From TELEGRAPH AVE to OTIS ST RT	5
				From OTIS ST RT to Mabel St	4
2	LAS	36	**Pratville to Riverside**	From Pratville Dr Lt to N MESA ST LT/S MESA R	5
				From N MESA ST LT/S MESA R to East Riverside Rd	3
4	SM	84	**Old La Honda Rd to Portola Rd**	Old La Honda Rd to CONN 84 TO/FR 35-LT	8
				From CONN 84 TO/FR 35-LT to Portola Rd	3
6	MAD	145	**E 9th to Road 29**	From 9th St Rt to YOSEMITE AVE	3
				From YOSEMITE AVE to FIG AVE (SOUTH)	5
				From FIG AVE (SOUTH) to AVE 15 1/2	3
				From AVE 15 1/2 to Road 29	8