LINK21

CONNECT NORTHERN CALIFORNIA

MARKET ANALYSIS REPORT

APPENDIX D: TRIP TABLE DEVELOPMENT METHODOLOGY AND VALIDATION

March 2022

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Prepared By:
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ISSUE AND REVISION RECORD

REVISION	DATE	PREPARER(S)	PMC REVIEWER(S) / BART/CCJPA REVIEWER(S)	APPROVER / BART/CCJPA APPROVER	DESCRIPTION/ NOTES
0	09/24/2021	Andrew Desautels, Steer	Elisa Tejedor, Steer	Sudhish Verma, HNTB	Working DRAFT submittal
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1	03/18/2022	Derek Cheah, Steer	Elisa Tejedor, Steer	Sudhish Verma, HNTB	DRAFT submittal
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SHAREPOINT PATH

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ACRONYMS AND ABBREVIATIONS

ACRONYM/ABBREVIATION	DEFINITION
BART	San Francisco Bay Area Rapid Transit
CCJPA	Capitol Corridor Joint Powers Authority
AADT	annual average daily traffic
AC Transit	Alameda-Contra Costa Transit District
AMBAG	Association of Monterey Bay Area Governments
CAHSR	California High-Speed Rail
Caltrans	California Department of Transportation
CTPP	Census Transportation Planning Products
MPO	Metropolitan Planning Organization
MTC	Metropolitan Transportation Commission
NHTS	National Household Travel Survey
OD	origin-destination
PeMS	Caltrans Performance Measurement System
SACOG	Sacramento Area Council of Governments
SACSIM19	Sacramento Activity-based Travel Simulation Model 19
TAZ	transportation analysis zone
TCM	Three-County Travel Demand Model
TNC	Transportation Network Companies
WETA	San Francisco Bay Area Water Emergency Transportation Authority

LINK21 PROGRAM TEAM NAMES

TEAM NAME	TEAM MEMBERS
PMC	The HNTB Team
PMT	BART/CCJPA + PMC
Consultants	Consultants supporting program identification/project selection
Link21 Team	PMT + Consultants

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1. INTRODUCTION

This document provides a detailed description of the methodology used to develop the base and future year Northern California Megaregion (Megaregion)[1] trip tables to be used throughout the market analysis task of the Link21 Program (Link21). It also presents validation results where relevant.

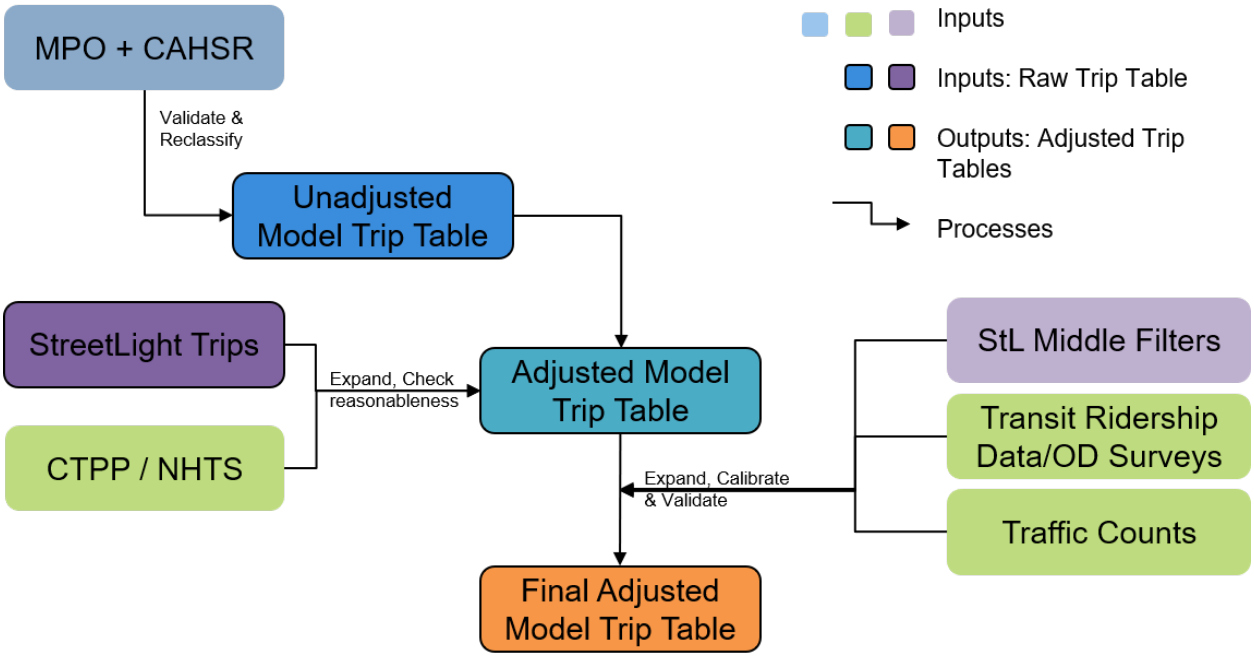
The base year trip table was developed according to the following three steps:

1. Create the unadjusted model trip table by combining base and future year internal trips from the four Megaregion Metropoitan Planning Organization (MPO) models, and inter-MPO trips from the California High-Speed Rail (CAHSR) model.
2. Create the adjusted model trip table by redistributing trips from the unadjusted model trip table according to geographic and time-of-day patterns from StreetLight location-based services data while maintaining mode and trip purpose splits from the unadjusted model trip table on a transportation analysis zone (TAZ) pair basis.
3. Create the final adjusted model trip table by calibrating auto and transit trips from the adjusted model trip table to reflect observed conditions as follows:
    a. **Auto:** Calibrate the county-level origin-destination (OD) pattern of transbay[2] auto trips to approximate the pattern reported by StreetLight and calibrate auto trip volumes by time-of-day crossing selected screenlines to match observed traffic count values.
    b. **Transit:** Scale resulting transbay rail trips to match observed transbay San Francisco Bay Area Rapid Transit (BART) volume and county-level OD patterns from BART's *2015 Station Profile Survey*. Scale transbay non-rail transit trips to match observed total of Alameda-Contra Costa Transit District (AC Transit) and San Francisco Bay Area Water Emergency Transportation Authority (WETA) transbay trips.

Figure 1-1 provides a graphical overview of the process.

[1] The Link21 study area is the 21-county Northern California Megaregion, which includes counties within the San Francisco Bay Area, Sacramento Area, Northern San Joaquin Valley, and Monterey Bay Area.
[2] The term "transbay" is used in this document to refer to trips crossing the San Francisco Bay between the Peninsula and the East Bay (in either direction).

Figure 1-1. Overview of Base Year Trip Table Development Process



Note:
CTPP: Census Transportation Planning Products
NHTS: National Household Travel Survey
StL: StreetLight

The remainder of this document describes in detail each of the data sources used in this process, each of the steps outlined above, the process for developing the final future year trip tables based on the final base year trip tables, and two subsequent refinements that were made to the final trip tables.

2. DATA SOURCES

The following data sources were used in the trip table development:

- Existing travel demand models
- Other data sources
  - StreetLight tour data
  - California Department of Transportation (Caltrans) traffic census counts
  - Caltrans Performance Measurement System (PeMS) data
  - BART 2015 Station Profile Survey data
  - Transit ridership data
  - CTPP/NHTS trip volume data

Each source is described in detail in the following sections.

2.1. Existing Travel Demand Models

2.1.1. MTC Travel Model 1.5

The Metropolitan Transportation Commission's (MTC) Travel Model 1.5 is an activity-based model that covers the nine-county Bay Area region and includes transbay trips. Information from the model's trip tables was used to develop the intra-MTC portion of the combined model trip table. Details of the model's geographic coverage, as well as time periods, modes, and trip purposes represented are included in **Table 2-1**.

Table 2-1. MTC Travel Model 1.5 Details

COUNTIES	TIME PERIODS	TRAVEL MODES	TRIP PURPOSES
▫ Alameda ▫ Contra Costa ▫ Marin ▫ Napa ▫ San Francisco ▫ San Mateo ▫ Santa Clara ▫ Solano ▫ Sonoma	▫ Early AM (3-6 am) ▫ AM peak (6-10 am) ▫ Midday (10 am-3 pm) ▫ PM peak (3-7 pm) ▫ Evening (7 pm-3 am)	▫ Drive alone, not toll eligible ▫ Drive alone, toll eligible ▫ Shared ride 2, not toll eligible ▫ Shared ride 2, toll eligible ▫ Shared ride 3+, not toll eligible ▫ Shared ride 3+, toll eligible ▫ Walk the entire way ▫ Bike the entire way ▫ Walk to local bus ▫ Walk to light rail or ferry ▫ Walk to express bus ▫ Walk to heavy rail ▫ Walk to commuter rail ▫ Drive to local bus ▫ Drive to light rail or ferry ▫ Drive to express bus ▫ Drive to heavy rail ▫ Drive to commuter rail ▫ Taxi ▫ Transportation Network Companies (TNC), single party ▫ TNC, shared (with strangers)	▫ Home ▫ Shopping ▫ Eat out ▫ Other – discretionary ▫ Other – maintenance ▫ Escort ▫ Social ▫ Work ▫ University ▫ At work ▫ School

2.1.2. Sacramento Activity-based Travel Simulation Model

The Sacramento Area Council of Governments' (SACOG) Sacramento Activity-based Travel Simulation Model 19 (SACSIM19) covers the six-county Sacramento Area. Information from the model's trip tables was used to develop the intra-SACOG portion of the combined model trip table. Details of SACSIM19's geographic coverage, as well as time periods, modes, and trip purposes represented are included in **Table 2-2**.

Table 2-2. Sacramento Activity-Based Travel Simulation Model Details

COUNTIES	TIME PERIODS	TRAVEL MODES	TRIP PURPOSES
▫ El Dorado ▫ Placer ▫ Sacramento ▫ Sutter ▫ Yolo ▫ Yuba	**Auto** ▫ 7-8 am ▫ 8-9 am ▫ 9-10 AM ▫ Midday (10 am-3 pm) ▫ 3-4 pm ▫ 4-5 pm ▫ 5-6 pm ▫ Evening (6-8 pm) ▫ Night (8 pm-7 am) **Transit** ▫ Morning peak (start of service-10 am) ▫ Midday (10 am-3 pm) ▫ Afternoon peak (3-6 pm) ▫ Early evening (6-8 pm) ▫ Night (8 pm-end of service)	▫ Drive alone ▫ Shared ride ▫ Commercial ▫ Light rail ▫ Regional rail ▫ Local bus ▫ Walk ▫ Bike	▫ Work ▫ School ▫ Personal business ▫ Shopping ▫ Meal ▫ Social/recreational ▫ Escort ▫ In-home

2.1.3. Three-County Travel Demand Model

The 2015 base version of the Three-County Travel Demand Model (TCM) is a four-step model jointly prepared for the Merced County Association of Governments, San Joaquin Council of Governments, and Stanislaus Council of Governments. The model covers Merced, Stanislaus, and San Joaquin counties, and information from the model's trip tables was used to develop the portion of the combined model trip table that includes trips within these three counties. Details of the model's geographic coverage, as well as time periods, modes, and trip purposes represented are included in **Table 2-3**.

Table 2-3. Three-County Travel Demand Model Details

COUNTIES	TIME PERIODS	TRAVEL MODES	TRIP PURPOSES
▫ Merced ▫ Stanislaus ▫ San Joaquin	**Auto** ▫ AM peak ▫ Midday ▫ PM peak ▫ Night **Transit** ▫ Peak ▫ Off-peak	▫ Drive Alone ▫ Shared ride 2 ▫ Shared ride 3+ ▫ Walk to transit ▫ Drive to transit ▫ Walk ▫ Bike	▫ Home-work ▫ Home-shop ▫ Home-K12 ▫ Home-college ▫ Home-other ▫ Work-other ▫ Other-other ▫ Highway commercial

2.1.4. AMBAG Regional Travel Demand Model

The 2018 Association of Monterey Bay Area Governments (AMBAG) Regional Travel Demand Model is a four-step model that covers the three-county AMBAG Area. Information from the model's trip tables was used to develop the intra-AMBAG portion of the combined model trip table. Details of the model's geographic coverage, as well as time periods, modes, and trip purposes represented are included in **Table 2-4**.

Table 2-4. AMBAG Regional Travel Demand Model Details

COUNTIES	TIME PERIODS	TRAVEL MODES	TRIP PURPOSES
▫ Monterey ▫ San Benito ▫ Santa Cruz	**Auto/Transit** ▫ AM peak (6-9 am) ▫ Midday (9 am-4 pm) ▫ PM peak (4-7 pm) ▫ Evening/night (7 pm-6 am) **Walk/Bike** ▫ Daily	▫ Drive alone ▫ Shared ride ▫ Walk ▫ Bike ▫ Transit ▫ School bus ▫ Other	▫ Home-based work ▫ Home-based shop ▫ Home-based school ▫ Home-based university ▫ Home-based other ▫ Non-home-based work ▫ Non-home-based other ▫ Visitor shop ▫ Visitor tourist

2.1.5. CAHSR Model

Version 3 of the CAHSR Model is a four-step model developed to forecast demand for long-distance intercity trips throughout California. Information from the model's trip tables was used to develop the inter-MPO portion of the combined model trip table and ultimately to distribute inter-MPO trips between modes and trip purposes in the adjusted model trip table. Details of the model's geographic coverage, as well as time periods, modes, and trip purposes represented are included in **Table 2-5**.

Table 2-5. California High-Speed Rail Model Details

COUNTIES	TIME PERIODS	TRAVEL MODES	TRIP PURPOSES
▫ All California counties	▫ Daily	▫ Air ▫ Auto ▫ Conventional rail (includes intercity, commuter, and regional rail, but not BART, subway/metro, or light rail) ▫ High-speed rail	▫ Business ▫ Commercial ▫ Recreation ▫ Other

2.2. Other Data Sources

2.2.1. StreetLight Tour Data

To obtain an up-to-date geographic trip pattern and time-of-day distribution, location-based data on Megaregion travel patterns were purchased from StreetLight. The data are based on cell phone location data from February-April and September-November 2019 throughout the Megaregion and are provided at the census block group level. Data were provided for the following three day types and seven time periods:

- Day types
  - Average day (all days of week)
  - Average weekday (Tuesday-Thursday)
  - Average Saturday
- Time periods
  - All day
  - Early AM (4-6 am)
  - AM peak (6-10 am)
  - Midday (10 am-3 pm)
  - PM peak (3-7 pm)
  - Evening (7 pm-12 am)
  - Night (12-4 am)

Raw StreetLight data were provided on the basis of tours, which are defined as chains of trips connected by gaps shorter than a certain time threshold between adjacent trips. This was done to account for any en route activities, (e.g., brief shopping trips on the way home from work, stopping for food, or refueling on longer trips). Four thresholds (15, 30, 45, and 60 minutes) were initially tested, and 30 minutes was judged to be the

most appropriate, as it is long enough to not split rail trips at transfer points and short enough that the number of truly distinct trips that are unintentionally chained together is small.

StreetLight provided two tour files. One contains indexed tours between all pairs of census block groups in the Megaregion. The other contains indexed tours between all block group pairs containing trips that pass through each of the 87 middle filters (notably including the three transbay bridges), which were defined in order to capture observed OD patterns of trips passing through strategic locations throughout the Megaregion.[3] The data include trips made using all surface modes; however, due to the nature of StreetLight's processing algorithm, it was determined that transit-specific middle filters generally do not produce reliable trip patterns.[4] As a result, only auto-specific middle filters were used in trip table adjustment.

2.2.2. Caltrans Traffic Census Counts

Caltrans Traffic Census[5] counts were collected for several locations judged to be most relevant to transbay flows. These were adjusted based on PeMS data (see Section 2.2.3 below) and used as target volumes in the final adjustment of auto trip volumes. Traffic census counts were chosen as they covered a greater number of the key locations and were judged to be more reliable than PeMS traffic volumes due to issues with missing/questionable PeMS data, but they represent daily bi-directional flows, hence the need to adjust PeMS data.

2.2.3. Caltrans PeMS Data

As mentioned above, data on time of day, day of week, and directional volume splits from the Caltrans PeMS[6] were used to adjust the Traffic Census annual average daily traffic (AADT) counts to reflect the necessary day of week, time of day, and directional volumes required in the auto calibration stage. For locations with no active PeMS stations, adjustments were made based on aggregate Caltrans District 4 (Bay Area) data or based on information from comparable nearby locations as deemed appropriate.

[3] The custom StreetLight data is based on 172 million tours collected from 2.4 million mobile devices.
[4] StreetLight processes data by snapping cell phone "pings" to highway network links where possible and creating a continuous route along the highway network by connecting adjacent pings. Since routes are continuous, all such routes are guaranteed to pass through a middle filter if one exists on one of the traversed links. In cases where pings occur away from highway links (e.g., dedicated rail facilities), no continuous route is created. As a result, these trips are only counted as passing through a middle filter when a ping actually occurs inside the middle filter polygon. Such occurrences represent a small share of trips observed in operator data, and ultimately do not present a reliable picture of travel patterns for trips that actually pass through the area of interest.
[5] More detail on the Caltrans Traffic Census Program is available at: https://dot.ca.gov/programs/traffic-operations/census.
[6] More detail on the Caltrans PeMS is available at: https://pems.dot.ca.gov.

2.2.4. BART 2015 Station Profile Survey Data

Data for transbay trips from BART's most recent *Station Profile Survey*, conducted in 2015, were used in the transit calibration stage to ensure that transbay rail volumes and patterns accurately reflect observed conditions. True origins and destinations were used in this process and not entry and exit stations.

2.2.5. Transit Ridership Data

Ridership data from BART, WETA, and AC Transit were used in the transit calibration stage to ensure that total transbay volumes accurately reflect observed totals of both rail and non-rail transit trips.[7] Ridership data used were from 2019.

2.2.6. CTPP/NHTS Trip Volume Data

County-level trip volume data from the CTPP and the 2017 NHTS California add-on were used to check the reasonableness of both the unadjusted model trip table and the expanded StreetLight trip table prior to the creation of the adjusted model trip table.

[7] Due to a combination of limited service and lack of readily available transbay ridership data, we decided in consultation with BART not to include additional operators of transbay bus service.

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3. COMBINATION OF MPO TRIP TABLES

The first step of the trip table development process was to combine the trip tables from the existing Megaregion travel demand models (MTC, SACOG, TCM, AMBAG, and CAHSR models described previously) to create the unadjusted model trip table. Before tables were combined, it was determined that the combined model zone system should be the union of all internal zones from the MTC, SACOG, TCM, and AMBAG models.[8] In addition, the combined model trip attributes and levels were selected as:

- Year
  - 2015
  - 2040[9]
- Period
  - Peak
  - Off-peak
- Mode
  - Auto
  - Rail
  - Non-rail transit
- Trip purpose
  - Work
  - School
  - Other

Internal trips for each of the four MPO models and the CAHSR model were then converted to person-trips where necessary based on model auto occupancy assumptions, and then mapped to the above categories and levels.[10] Trips in the source model AM and PM peak periods were categorized as peak trips, while all other trips

[8] In consultation with BART, the decision was made to exclude all trips with one or more endpoints outside the Megaregion. The Megaregion was judged to be large enough that trips to/from external locations would not represent a significant volume of trips that would potentially use future Link21 service.

[9] The future year scenarios used for each MPO model are MTC's *2017 Regional Transportation Plan/Sustainable Communities Strategy* (Plan Bay Area 2040), SACOG's *2040 Metropolitan Transportation Plan/Sustainable Communities Strategy*, TCM's *2042 Regional Transportation Plan*, and AMBAG's *2040 Metropolitan Transportation Plan/Sustainable Communities Strategy*. At the time of Link21 trip table development, *Plan Bay Area 2050* model files were not yet available.

[10] It was necessary to make assumptions in some cases about the interaction of trip shares across attributes, (e.g., how mode shares and trip purpose shares overlap). In the absence of further detail, it was typically assumed that attribute shares are distributed across each level of other attributes proportionally to their distribution across total MPO trips. For example, if 35% of total trips are work trips, it is assumed that 35% of auto trips are work trips, 35% of rail trips are work trips, etc.

were categorized as off-peak trips. Truck, taxi, and TNC trips were categorized as auto. Walk-only, bike-only, and intrazonal trips of all modes were dropped as they do not represent potential transbay travelers,[11] and they do not contribute to modeled congestion. If a trip, or either end of a trip, was assigned a school purpose in the base model, it was categorized as a school trip. Otherwise, if a trip, or either end of a trip, was assigned a work purpose in the base model, it was categorized as a work trip. If neither of these applied to a particular trip, it was categorized as an "other" trip.

Since the CAHSR model uses a different zone system, trips from this model were reallocated to the combined model zone system by creating a CAHSR TAZ to a combined model TAZ crosswalk based on the share of CAHSR zone area overlapping with each combined model TAZ, and then allocating trip ends from CAHSR zones to combined model zones according to the relevant shares. Once CAHSR trips were converted to the combined model zone system, trips were mapped to the combined model categories and levels in the same manner as those from the four MPO models.[12]

The recategorized trips from all five models were then combined with the four MPO models serving as the basis for intra-MPO trips and the CAHSR model providing the basis for inter-MPO trips. Inter-MPO trips were only included when one end was within the MTC area, as trips between the SACOG, TCM, and AMBAG areas were deemed to be less relevant to this study.[13]

Finally, in cases where the individual model trip tables correspond to years other than the desired base year of 2015 and future year 2040, interpolation and extrapolation were performed as necessary on a zone-pair basis to translate the relevant volumes to the appropriate year.[14] In these cases, care was taken to constrain volumes to a minimum value of zero. This adjustment was made for the following three cases:

- **SACOG base year:** extrapolated to translate base year trips from 2016 to 2015.
- **CAHSR base year:** interpolated to translate base year trips from 2010 to 2015.
- **TCM future year:** extrapolated to translate future year trips from 2042 to 2040.

At this point, the base year unadjusted model trip table was compared with CTPP (work only) and NHTS trips at the county level for reasonableness. Comparisons of selected intracounty and intercounty flows are shown in **Table 3-1** and **Table 3-2**.

[11] All transbay trips are interzonal, because no single zone spans the bay.
[12] An adjustment was subsequently made to account for short-distance inter-MPO trips, which are not included in the CAHSR model trip tables. See Section 9 for details on this adjustment.
[13] The decision to only include inter-MPO trips with one end in the MTC area was later reversed, and inter-MPO trips between "halo" MPOs were added. See Section 8 for details on this adjustment.
[14] An approach based on growth rates was not possible due to several zone pairs with zero trips in either the base or future year.

Table 3-1. Intracounty Unadjusted Model Trips vs. NHTS/CTPP (Select Counties)[15]

COUNTY	UNADJUSTED MODEL TRIPS	NHTS TRIPS (2017)	UNADJUSTED MODEL TRIPS, WORK ONLY	CTPP WORK TRIPS (2012-2016)
Santa Clara	5.4M	5.5M	1.7M	1.5M
Sacramento	4.5M	5.2M	1.2M	956k
Alameda	3.6M	4.4M	996k	848k
San Francisco	1.9M	3.1M	698k	659k
Contra Costa	2.1M	3.6M	545k	520k
San Mateo	1.4M	2.1M	436k	406k

Table 3-2. Intercounty Unadjusted Model Trips vs. NHTS/CTPP (Select County Pairs)[16]

COUNTY PAIR	UNADJUSTED MODEL TRIPS	NHTS TRIPS (2017)	UNADJUSTED MODEL TRIPS, WORK ONLY	CTPP WORK TRIPS (2012-2016)
Alameda-Contra Costa	611k	623k	243k	286k
San Francisco-San Mateo	516k	508k	281k	269k
San Mateo-Santa Clara	389k	461k	192k	215k
Alameda-Santa Clara	360k	287k	205k	223k
Alameda-San Francisco	351k	386k	234k	244k
Alameda-San Mateo	146k	157k	96k	100k
Contra Costa-San Francisco	135k	202k	96k	130k
Contra Costa-San Mateo	15k	60k	12k	28k
Sacramento-San Francisco	14k	6k	4k	6k
Sacramento-Santa Clara	12k	4k	3k	4k

This process yielded unadjusted model trip tables for base (2015) and future (2040) years. These trip tables include 8,374 zones; peak and off-peak periods; auto, rail, and non-rail transit modes; and work, school, and other trip purposes.

[15] As noted above, model trips do not contain walk, bike, or intrazonal trips (all modes). As a result, model trips are generally expected to be less than NHTS and CTPP trips.

[16] As noted above, model trips do not contain walk or bike trips. As a result, model trips are generally expected to be less than NHTS and CTPP trips.

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4. STREETLIGHT ADJUSTMENT

The second step of the trip table development process involved using OD data from StreetLight to adjust the combined model trip tables.

Prior to the adjustment of the trip tables, an initial expansion was performed to convert StreetLight indices to trip counts. First, 2015 AADT values were collected from the Caltrans Traffic Census for the San Francisco-Oakland Bay Bridge (Bay Bridge), San Mateo-Hayward Bridge, and Dumbarton Bridge. A scaling factor of 1.243 was calculated as the sum of these values divided by the sum of all days, all periods StreetLight middle filter indices corresponding to the same three bridges. All StreetLight index values were then multiplied by this factor to convert to 2015 trips (consistent with the model base year).[17]

The expanded StreetLight trip table was then translated from block groups to TAZs using a similar process to the conversion of trips from CAHSR zones to combined model zones described in Section 3. A block group to TAZ crosswalk was created based on the share of block group area overlapping with each TAZ, and then trip ends were allocated from block groups to zones according to the relevant shares. As with the unadjusted model trip table, intrazonal trips were dropped, as they do not represent potential transbay travelers.

Total interzonal StreetLight trips within each of the four MPO areas were then scaled to match the total number of internal interzonal trips from the corresponding source MPO model, effectively maintaining the trip pattern from the StreetLight data while using the MPO model totals as control totals.[18] The resulting trips were then allocated on a zone-pair basis to modes and trip purposes based on the corresponding shares in the unadjusted model trip table. For zone-pairs that have no trips in the combined model trip table, county pair mode and trip purpose shares were used. At this point, we compared the resulting adjusted model trip table with CTPP (work only) and NHTS trips at the county level for reasonableness. Comparisons of selected intracounty and intercounty flows are shown in **Table 4-1** and **Table 4-2**.

[17] Note that this expanded StreetLight trip table is not considered to be calibrated to observed conditions at this point. A more detailed calibration is performed on the adjusted model trip table and is described in the following section.
[18] Note that these control totals include walk and bike trips since these trips are also captured by StreetLight.

Table 4-1. Intracounty Adjusted Model Trips vs. NHTS/CTPP (Select Counties)[19]

COUNTY	ADJUSTED MODEL TRIPS	NHTS TRIPS (2017)	ADJUSTED MODEL TRIPS, WORK ONLY	CTPP WORK TRIPS (2012-2016)
Santa Clara	4.8M	5.5M	1.6M	1.5M
Sacramento	4.1M	5.2M	1.0M	956k
Alameda	3.5M	4.4M	941k	848k
San Francisco	2.2M	3.1M	756k	659k
Contra Costa	2.1M	3.6M	554k	520k
San Mateo	1.6M	2.1M	511k	406k

Table 4-2. Inter-county Adjusted Model Trips vs. NHTS/CTPP (Select County Pairs)[20]

COUNTY PAIR	ADJUSTED MODEL TRIPS	NHTS TRIPS (2017)	ADJUSTED MODEL TRIPS, WORK ONLY	CTPP WORK TRIPS (2012-2016)
Alameda-Contra Costa	554k	623k	285k	286k
San Francisco-San Mateo	589k	508k	259k	269k
San Mateo-Santa Clara	414k	461k	215k	215k
Alameda-Santa Clara	385k	287k	227k	223k
Alameda-San Francisco	191k	386k	127k	244k
Alameda-San Mateo	164k	157k	111k	100k
Contra Costa-San Francisco	82k	202k	58k	130k
Contra Costa-San Mateo	36k	60k	29k	28k
Sacramento-San Francisco	5k	6k	1k	6k
Sacramento-Santa Clara	4k	4k	800	4k

For the purposes of auto calibration, auto trips were carried through this process in four time periods (AM Peak, Midday, PM Peak, and Night), but were subsequently combined into peak and off-peak to be consistent with transit trips. This process yielded the adjusted 2015 model trip table, which includes trips across the same 8,374 zones, two periods (four for auto, as stated above), three travel modes, and three trip purposes as the unadjusted model trip tables.

[19] As noted above, model trips do not contain walk, bike, or intrazonal trips (all modes). As a result, model trips are generally expected to be less than NHTS and CTPP trips.

[20] As noted above, model trips do not contain walk or bike trips. As a result, model trips are generally expected to be less than NHTS and CTPP trips.

5. AUTO CALIBRATION

To ensure the resulting base year auto travel patterns accurately reflect observed patterns, two separate adjustments were necessary:

- Transbay OD pattern adjustment
- Screenline volume adjustment[21]

For each of these adjustments, Cube travel demand modeling software was used to assign trips from the adjusted model trip table to a Megaregion highway network based on the highway networks for the MTC, SACOG, TCM, and AMBAG models. The assignment was performed for each of the following four time periods which share boundaries with MTC period definitions:

- AM Peak (6-10 am)
- Midday (10 am-3 pm)
- PM Peak (3-7 pm)
- Night (7 pm-6 am)

The network included tolls for the relevant facilities in the MTC model area, and capacity factors of 3.5 (AM/PM peak), 4 (Midday), and 6.5 (Night) were used.[22] For this simplified assignment, all auto trips were assumed to have a single occupant.

The metric used to assess the quality of calibration was the GEH Statistic, which is named for Geoffrey E. Havers. The GEH Statistic is a formula often used to compare two sets of traffic volumes because it enables comparison over a large range of values. The formula for the GEH Statistic is:

$$GEH = \sqrt{\frac{2(modeled - observed)^2}{modeled + observed}}$$

A GEH Statistic less than 5.0 indicates a good match between modeled and observed values. When used for validation, 85% of count locations having GEH Statistic values less than 5.0 are generally considered to be acceptable. This approach is recommended by the *United Kingdom Highways Agency Design Manual for Roads and Bridges* and other prominent references.

[21] The earlier scaling of StreetLight data based on combined transbay bridge volumes was intended to broadly scale StreetLight index values to represent trips and not to address geographic inconsistencies within the data. The adjustment described here is intended to address geographic inconsistencies across the data sources, potentially increasing trips in some areas while decreasing trips in others.

[22] The capacity factor indicates the number of hours of capacity available during the period. This value is typically less than the number of hours in the period to represent temporal peaking.

Consistent with the recommendations above, the goal of the calibration was to ensure that the GEH statistic for observed versus modeled trips is less than 5.0 for 85% of observations for each of the adjustments. Observations correspond to StreetLight transbay county pair volume shares for the transbay OD pattern adjustment and to screenline volumes for the screenline volume adjustment.

To adjust transbay OD patterns, an initial assignment was performed, which included select-link analysis for the transbay bridge links in each direction. Trips in the select link matrices were then aggregated to the county-level, and shares of assigned transbay trips were compared with the corresponding shares of transbay trips from StreetLight (trips crossing the middle filter corresponding to the target bridge). Scaling factors were calculated at the county pair level with the goal of adjusting county pair shares of transbay trips without significantly changing the total transbay trips and were applied to each relevant zone-pair. The adjusted trip table was then reassigned to the network, and the assigned county pair shares were compared with StreetLight county pair shares to ensure that 85% of county pairs yielded GEH Statistics less than 5.0.

Prior to calibration of assigned volumes, a set of screenlines was selected. The following eleven screenlines were chosen to reflect important regional movements, important transbay movements, and geographic balance:

- Bay Bridge
- San Mateo-Hayward Bridge
- Dumbarton Bridge
- Golden Gate Bridge
- Richmond-San Rafael Bridge
- Benicia-Martinez Bridge
- San Francisco/San Mateo County line (I-280/U.S. 101)
- East Bay Hills (I-580/SR-24)
- Alameda/Santa Clara County line (I-880)
- I-80 between Davis and Sacramento
- I-580/I-205 west of Tracy

For each of these locations, AADT values were collected from the 2018 Caltrans Traffic Census and scaled to 2015 based on a global factor calculated from total Caltrans District 4 PeMS vehicle-miles traveled.[23] These counts were then factored based on PeMS time of day/day of week/directional data and aggregated to screenline totals by

[23] Counts from 2018 (the most recent traffic census) were used due to the need to maintain consistency between the observed travel pattern and observed traffic counts since they are related.

direction for each of the four time periods. These volumes served as targets for the screenline calibration.

To adjust screenline volumes, the volumes assigned to each network link corresponding to one of the screenline facilities were scaled by a factor of the total observed screenline volume divided by the total assigned screenline volume. For transbay screenlines, all trips using the screenline were adjusted, but for non-transbay screenlines, only trips unique to the individual screenline were adjusted. The adjusted trip table was then reassigned to the network, and this adjustment process was repeated until the comparison of assigned to observed screenline volumes yielded 85% GEH statistics less than 5.0.

Once the screenline volumes were adjusted, it was necessary to check that the transbay OD patterns still satisfied the validation criteria. Once all auto calibration criteria were met, auto trips were aggregated from the four time periods listed previously to peak and off-peak periods, maintaining the zone-pair purpose splits from the 2015 adjusted model trip table. A summary of the final auto calibration results is presented in **Table 5-1, Table 5-2, Table 5-3**, and **Table 5-4** and in **Figure 5-1** and **Figure 5-2**, and detailed calibration results are presented in Appendix B.

Table 5-1. Transbay Auto OD Calibration Summary by Transbay Bridge[24]

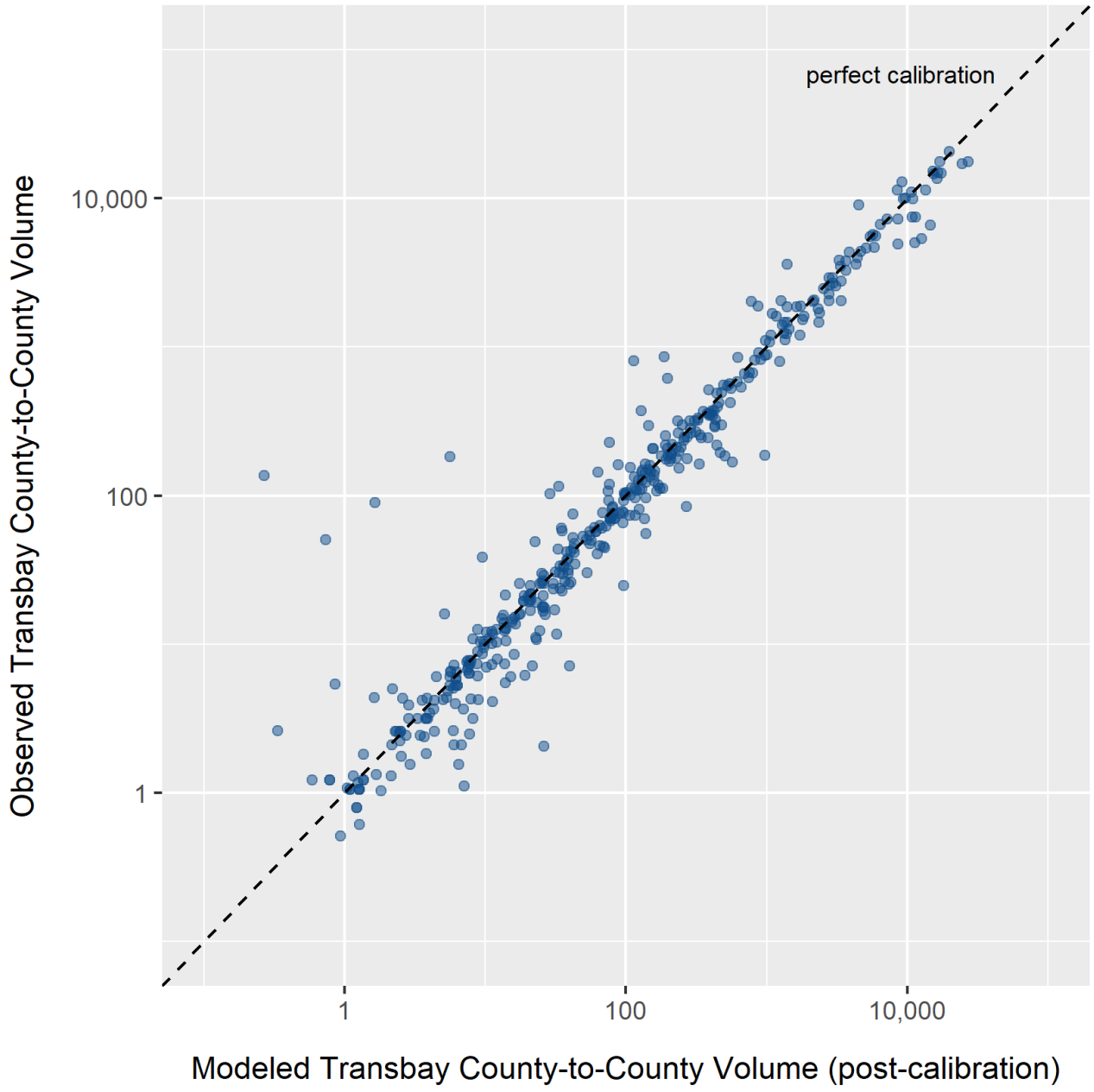
BRIDGE	SHARE OF OBSERVATIONS WITH GEH < 5.0
Bay Bridge	93%
San Mateo-Hayward Bridge	80%
Dumbarton Bridge	89%
All Bridges	**89%**

Table 5-2. Transbay Auto OD Calibration Summary by Period

PERIOD	SHARE OF OBSERVATIONS WITH GEH < 5.0
AM Peak	91%
Midday	89%
PM Peak	88%
Night	89%
All Periods	**89%**

[24] Each observation in the auto OD calibration represents the share of total trips on a specific bridge in a specific time period traveling in a specific direction and that travel between a specific pair of counties.

Figure 5-1. Transbay Auto OD Calibration Plot[25]



[25] Each point in the plot represents a single observation of the volume implied by the share of total trips on a specific transbay bridge in a specific time period traveling in a specific direction and that travel between a specific pair of counties.

Table 5-3. Auto Volume Calibration Summary by Screenline[26]

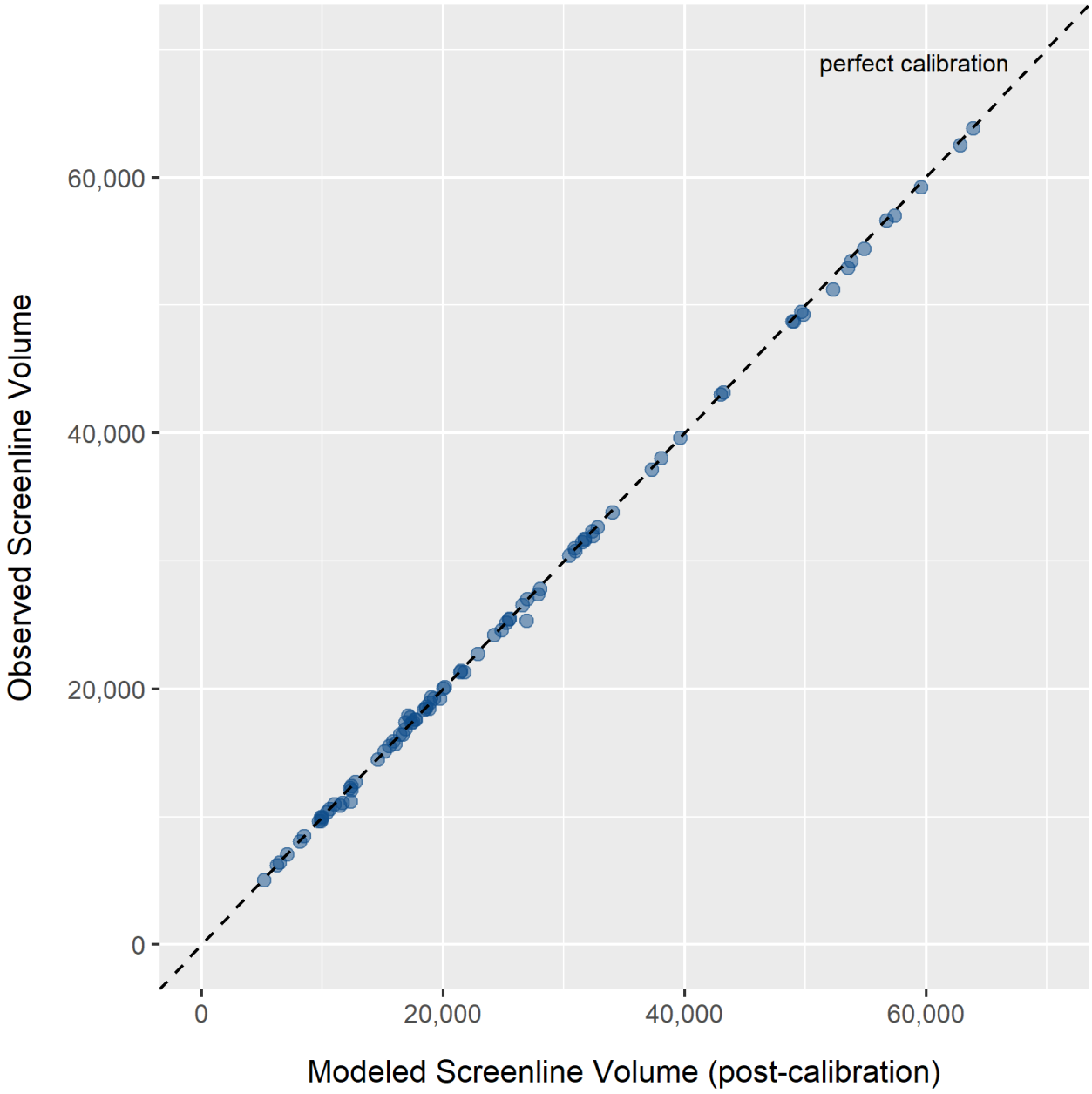
SCREENLINE	SHARE OF OBSERVATIONS WITH GEH < 5.0
Bay Bridge	100%
San Mateo-Hayward Bridge	88%
Dumbarton Bridge	63%
Golden Gate Bridge	100%
Richmond-San Rafael Bridge	100%
Benicia-Martinez Bridge	100%
San Francisco/San Mateo County Line (I-280/U.S. 101)	100%
East Bay Hills (I-580/SR-24)	100%
I-880 at Alameda/Santa Clara County Line	88%
I-80 West of Sacramento	100%
I-580/I-205 West of Tracy	100%
All Screenlines	**94%**

Table 5-4. Auto Volume Calibration Summary by Period (all screenlines)

PERIOD	SHARE OF OBSERVATIONS WITH GEH < 5.0
AM Peak	96%
Midday	96%
PM Peak	91%
Night	96%
All Periods	**94%**

[26] Each observation in the auto volume calibration represents the traffic volume traversing a specific screenline in a specific time period in a specific direction. Since these observations are defined differently than the auto OD calibration observations and are intended to calibrate different attributes of the model, the OD calibration and volume calibration results are different for common locations.

Figure 5-2. Screenline Auto Volume Calibration Plot[27]



These results suggest that we have achieved a good representation of both the transbay OD patterns seen in the StreetLight data and observed screenline volumes. **Table 5-5** illustrates the effects of the OD calibration by comparing the pre- and post-calibration shares of GEH values less than 5, and **Table 5-6** illustrates the effects of the

[27] Each point in the plot represents a single observation of the traffic volume traversing a specific screenline in a specific time period in a specific direction.

screenline calibration by comparing screenline volumes from the adjusted (pre-calibration) trip table and the final adjusted trip table with observed values.

Table 5-5. Comparison of Pre- and Post-Calibration Auto OD Pattern Shares of GEH Statistics Less than 5 by Transbay Bridge and Period

DIRECTION/BRIDGE	PRE-CALIBRATION ADJUSTED MODEL SHARE OF OBSERVATIONS WITH GEH < 5.0	FINAL ADJUSTED MODEL SHARE OF OBSERVATIONS WITH GEH < 5.0
Eastbound (EB) Bay Bridge	52%	90%
Westbound (WB) Bay Bridge	49%	95%
EB San Mateo-Hayward Bridge	53%	80%
WB San Mateo-Hayward Bridge	53%	79%
EB Dumbarton Bridge	82%	94%
WB Dumbarton Bridge	53%	74%
All Bridges	**57%**	**89%**

Table 5-6. Comparison of Pre- and Post-Calibration Screenline Auto Trips with Observed Values, All Day Both Directions

		PRE-CALIBRATION ADJUSTED MODEL		FINAL ADJUSTED MODEL	
SCREENLINE	OBSERVED VOLUME	VOLUME	DIFF. FROM OBSERVED	VOLUME	DIFF. FROM OBSERVED
Bay Bridge	258,147	229,009	-11.29%	258,776	0.24%
San Mateo-Hayward Bridge	122,122	88,060	-27.89%	120,286	-1.50%
Dumbarton Bridge	76,262	82,782	8.55%	79,047	3.65%
Golden Gate Bridge	116,363	117,957	1.37%	116,832	0.40%
Richmond-San Rafael Bridge	77,711	61,940	-20.29%	77,704	-0.01%
Benicia-Martinez Bridge	244,656	197,186	-19.40%	244,556	-0.04%
San Francisco/San Mateo County Line (I-280/U.S. 101)	448,567	505,688	12.73%	451,151	0.58%
East Bay Hills (I-580/SR-24)	371,404	376,125	1.27%	374,109	0.73%
I-880 at Alameda/Santa Clara County Line	206,929	220,593	6.60%	209,411	1.20%
I-80 West of Sacramento	142,291	141,522	-0.54%	142,298	0.00%
I-580/I-205 West of Tracy	153,310	181,045	18.09%	154,846	1.00%

Figure 5-3, **Figure 5-4**, and **Figure 5-5** show a comparison of trip end density between the final adjusted 2015 model trip table and raw StreetLight data for each transbay bridge. Zones are colored according to their percentile rank among all Megaregion zones in order. Note that the number and size of zones differ between the final adjusted model and the StreetLight data. Due to these differences, it is not always informative to compare percentile values at specific locations, but the key point of the figures is that the high-level patterns are generally consistent.

Figure 5-3. Bay Bridge Trip End Density Comparison–Final Adjusted Model (left) vs. StreetLight (right)

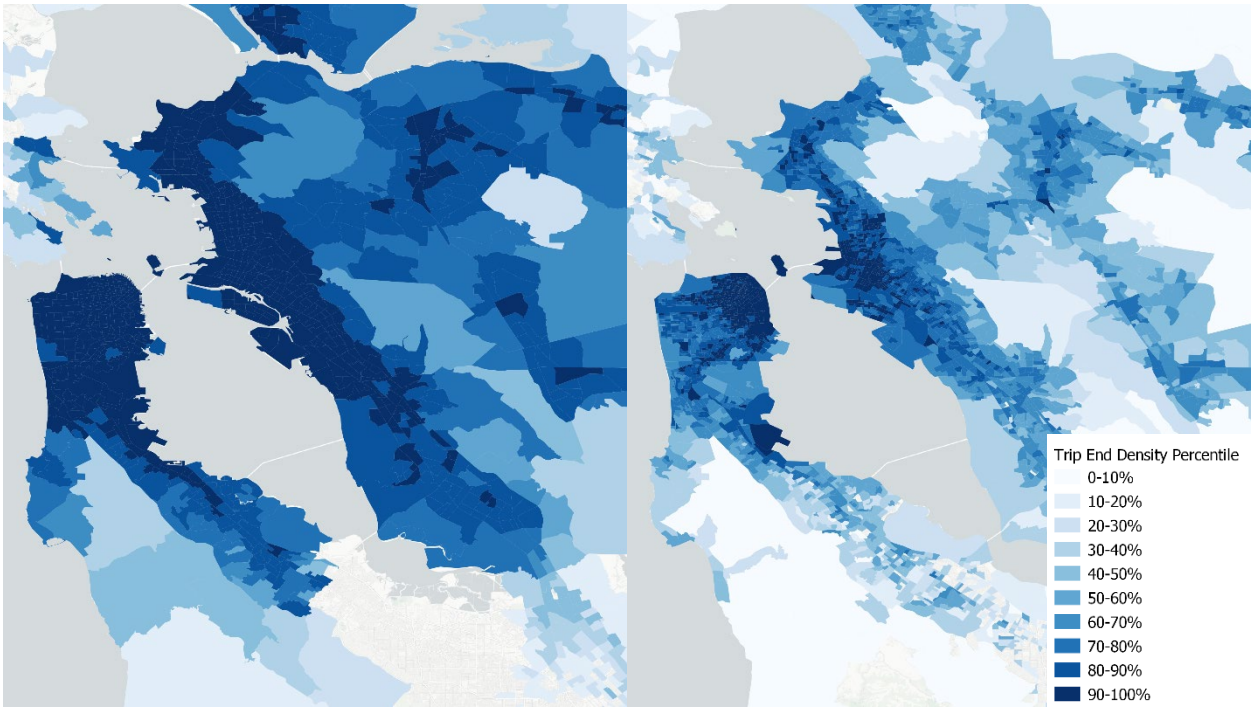


Figure 5-4. San Mateo-Hayward Bridge Trip End Density Comparison–Final Adjusted Model (left) vs. StreetLight (right)

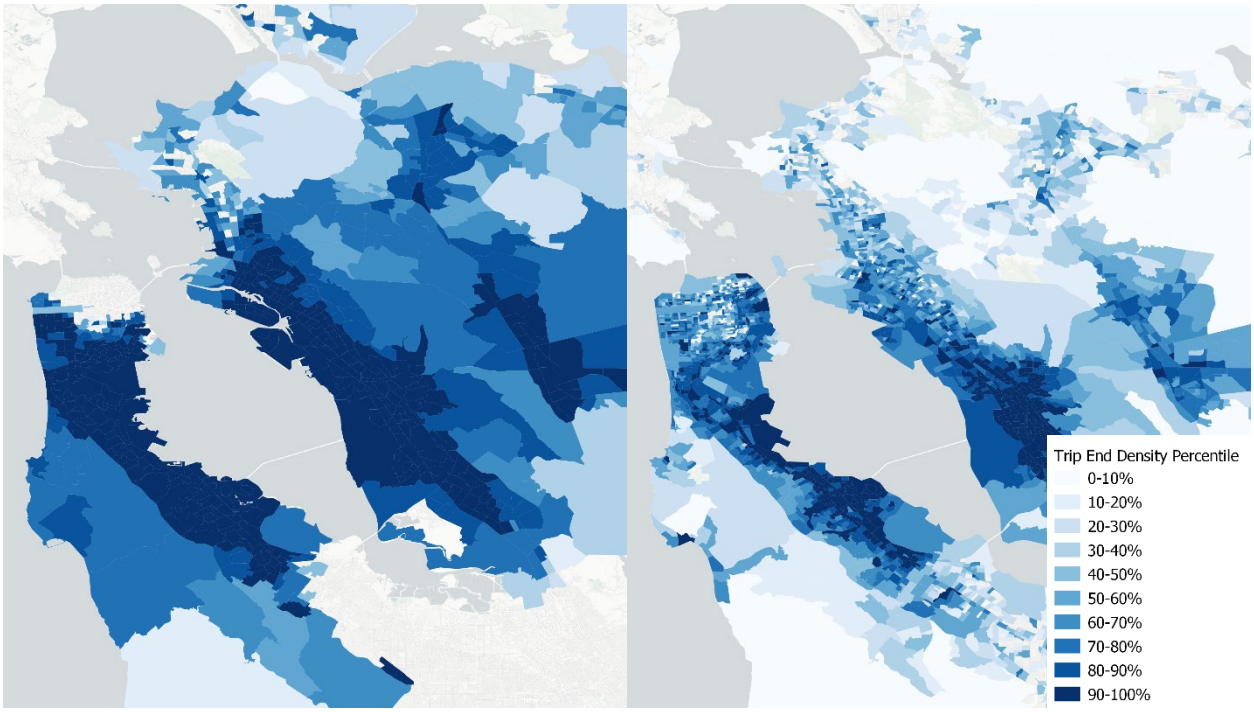
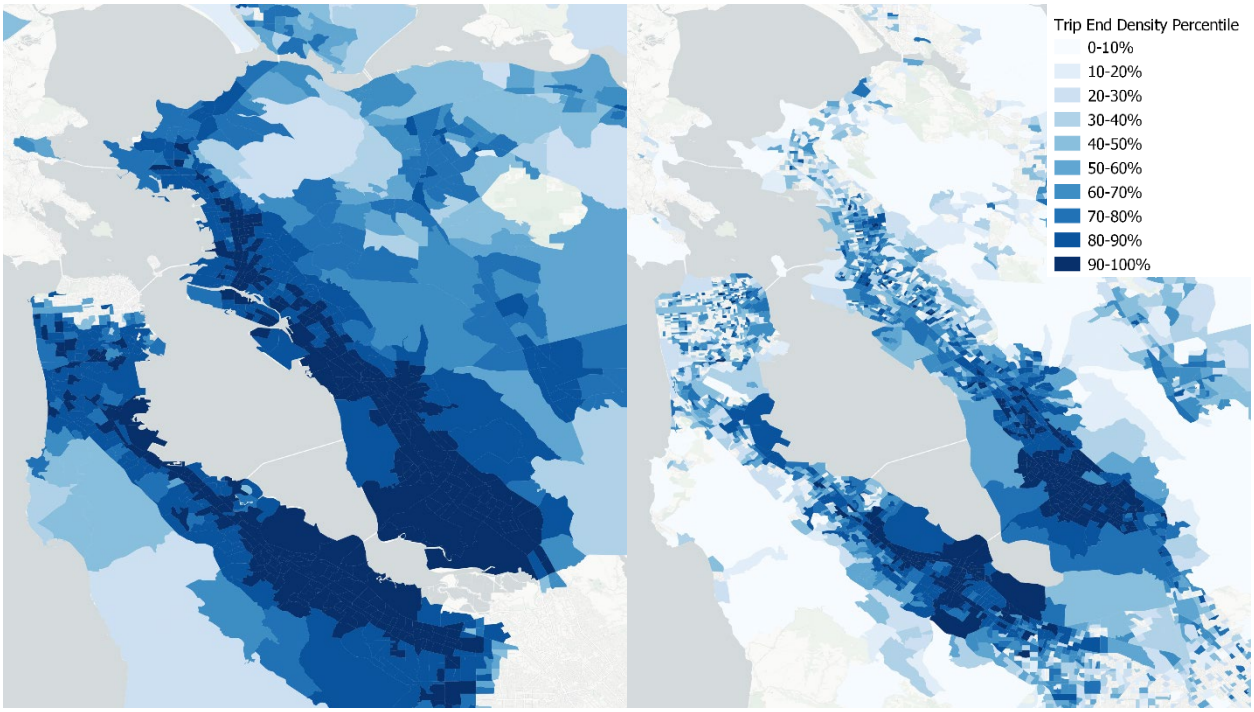


Figure 5-5. Dumbarton Bridge Trip End Density Comparison–Final Adjusted Model (left) vs. StreetLight (right)



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6. TRANSIT CALIBRATION

MPO models are often developed primarily with auto travel in mind, and as a result can be less reliable for use in modeling transit. In addition, StreetLight data includes trips made via all modes, but does not distinguish between them. Due to these shortcomings, we used data for transbay trips from BART's *2015 Station Profile Survey* to further adjust transbay transit trips in the 2015 adjusted model trip table to reflect observed patterns, and 2019 ridership data from BART, WETA, and AC Transit to establish control totals for transbay transit trips.[28]

First, transbay trips from the *Station Profile Survey* were aggregated to the county level based on true origin and destination (as distinct from entry and exit station). Next, transbay rail trips from the 2015 unadjusted model trip table were aggregated to the county level, and a scale factor was calculated for each county pair by dividing aggregated survey trips by aggregated adjusted model trips. A second set of mode-specific scale factors was then calculated by dividing the observed transbay trip totals for rail (BART) and non-rail (WETA/AC Transit) by the total transbay rail and non-rail transit trips in the adjusted model trip table. For rail, zone-pair trips were then multiplied by both of the appropriate scaling factors to ensure total transbay trips match observed totals and transbay trip patterns match those seen in the *Station Profile Survey*. For non-rail transit, no trip pattern information is available, so zone-pair trips are multiplied by the non-rail scaling factor to ensure total transbay trips match observed totals. A summary of the transit calibration is presented in **Table 6-1** and **Table 6-2**.

Table 6-1. Transbay Transit Volume Calibration Summary

VOLUME	TRANSBAY RAIL	TRANSBAY NON-RAIL TRANSIT	ALL TRANSBAY TRANSIT
Observed 2015 Volume	215k	27k	236k
Adjusted (pre-calibration) Model Trips	119k	21k	139k
Scale Factor	1.81	1.34	1.74
Final Adjusted Model Trips	215k	27k	236k

[28] As with observed auto volumes, recent ridership data were used due to the need to maintain consistency between the observed travel pattern (from 2019) and observed transit volumes since they are related.

Table 6-2. Transbay Rail OD Calibration Summary, Share of Transbay Rail Trips by Source (Top County Pairs)

COUNTY PAIR	ADJUSTED MODEL (PRE-CALIBRATION)	BART STATION PROFILE SURVEY	FINAL ADJUSTED MODEL
Alameda-San Francisco	61.7%	65.2%	65.2%
Contra Costa-San Francisco	29.3%	28.2%	28.2%
Alameda-San Mateo	2.2%	3.1%	3.1%
Contra Costa-San Mateo	0.9%	1.4%	1.4%

This step yielded the final 2015 adjusted model trip table. A comparison of the final adjusted model with NHTS and CTPP for selected intracounty and intercounty flows is shown in **Table 6-3** and **Table 6-4**.

Table 6-3. Intracounty Final Adjusted Model Trips vs. NHTS/CTPP (Select Counties)[29]

COUNTY	FINAL ADJUSTED MODEL TRIPS	NHTS TRIPS (2017)	FINAL ADJUSTED MODEL TRIPS, WORK ONLY	CTPP WORK TRIPS (2012-2016)
Santa Clara	4.8M	5.5M	1.6M	1.5M
Sacramento	4.1M	5.2M	1.0M	956k
Alameda	3.4M	4.4M	938k	848k
San Francisco	2.2M	3.1M	756k	659k
Contra Costa	2.1M	3.6M	554k	520k
San Mateo	1.6M	2.1M	510k	406k

[29] As noted above, model trips do not contain walk, bike, or intrazonal trips (all modes). As a result, model trips are generally expected to be less than NHTS and CTPP trips.

Table 6-4. Intercounty Final Adjusted Model Trips vs. NHTS/CTPP (Select County Pairs)[30]

COUNTY PAIR	FINAL ADJUSTED MODEL TRIPS	NHTS TRIPS (2017)	FINAL ADJUSTED MODEL TRIPS, WORK ONLY	CTPP WORK TRIPS (2012-2016)
Alameda-Contra Costa	553k	623k	285k	286k
San Francisco-San Mateo	541k	508k	256k	269k
San Mateo-Santa Clara	414k	461k	215k	215k
Alameda-Santa Clara	359k	287k	210k	223k
Alameda-San Francisco	300k	386k	204k	244k
Alameda-San Mateo	188k	157k	124k	100k
Contra Costa-San Francisco	123k	202k	89k	130k
Contra Costa-San Mateo	40k	60k	32k	28k
Sacramento-San Francisco	5k	6k	1k	6k
Sacramento-Santa Clara	4k	4k	800	4k

A comparison of intra- and intercounty trips at each step of the trip table development process and with NHTS and CTPP is presented in Appendix A.

[30] As noted above, model trips do not contain walk or bike trips. As a result, model trips are generally expected to be less than NHTS and CTPP trips.

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7. FUTURE YEAR TRIP TABLE DEVELOPMENT

Since there are no data available to use for calibration of the future year trip table, an effort was made to strike the appropriate balance between using the StreetLight data and other sources of current travel conditions to inform travel patterns, and appropriately reflecting future changes to transportation infrastructure, demographics, and other factors that may have significant impacts on travel demand in the Megaregion.

With this objective in mind, the adjusted future year trip table was obtained by starting with the final adjusted 2015 model trip table, and scaling zone-pair trips separately by mode by the growth rate for the corresponding county pair between the 2015 and 2040 unadjusted trip tables. A special allowance was made for greenfield development by identifying zones with no trips for a specific mode in the 2015 unadjusted model trip table but trips in the 2040 unadjusted model trip table and setting the corresponding values in the final adjusted 2040 model trip table for trips to and from these greenfield zones to the 2040 unadjusted model trip table values. The county pair growth rates were adjusted prior to their application to 2015 trips to ensure that the total change in trips (including greenfield trips) from 2015 to 2040 reflected the growth rates calculated from the unadjusted trip tables. A summary of growth by mode is presented in **Table 7-1**.

Table 7-1. Future Year Growth by Mode

MODE	2015 FINAL ADJUSTED MODEL TRIPS	2040 FINAL ADJUSTED MODEL TRIPS	PERCENT INCREASE
Auto	30.5M	38.4M	25.7%
Rail	446k	680k	52.6%
Non-rail Transit	1.2M	1.7M	50.3%
All Modes	**32.1M**	**40.8M**	**27.0%**

This process yielded the final 2040 adjusted model trip tables, which will be used along with the final 2015 adjusted model trip table to inform travel demand throughout the market analysis task.

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8. INTER-HALO TRIP ADDITION

As mentioned previously, inter-MPO trips were initially only included where one end is within the MTC area, as trips between the SACOG, TCM, and AMBAG areas were deemed to be less relevant to this study. However, this decision was later reversed, and trips between the SACOG, TCM, and AMBAG areas were added to the trip tables.

Volumes of these "inter-halo" trips were estimated using the same process as in the initial trip table development with the exception of calibration. First, unadjusted model trip tables containing only inter-halo trips were created for the base and future years from the CAHSR model trip tables. Next, the base year unadjusted model trip table was combined with the expanded StreetLight data to produce a base year adjusted model trip table that reflects OD and temporal distributions from StreetLight and mode and purpose distributions from the CAHSR model. Finally, the base year adjusted model trip table was grown to the future year, based on the implied growth rates between the unadjusted model trip tables, and the resulting final adjusted trip table was added to the original final adjusted trip table from which inter-halo trips were omitted.

Since inter-halo trips were expected to have a minimal impact on volumes at the previously selected calibration screenlines and transbay travel patterns, no additional calibration was performed after this adjustment.

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9. SHORT-DISTANCE INTER-MPO TRIP ADJUSTMENT

After the initial trip tables were prepared, it was discovered that the CAHSR trip tables only include trips less than 50 miles within the MTC region but not outside the MTC region, and, as a result, mode and purpose distributions for inter-MPO trips were only based on OD pairs at least 50 miles apart. This had the primary effect of underestimating short-distance work trips that cross MPO boundaries. To rectify this, county-to-county mode and purpose shares were collected from the NHTS California add-on and directly used to redistribute intra-MPO trips less than 50 miles across modes and purposes.

As with the inter-halo trip addition above, minimal impacts on volumes at the previously selected calibration screenlines and transbay travel patterns were expected, so no additional calibration was performed after this adjustment.

9.1. Comparison of Trips by Step of the Trip Table Development Process

Table 9-1 to **Table 9-4** present a comparison of intra- and intercounty trips at each step of the trip table development process and with NHTS and CTPP.[31]

Table 9-1. Intracounty Model Total Trips by Step vs. NHTS (Select Counties)

COUNTY	UNADJUSTED MODEL TRIPS	ADJUSTED MODEL TRIPS (PRE-CALIBRATION)	FINAL ADJUSTED MODEL TRIPS (POST-CALIBRATION)	NHTS TRIPS (2017)
Santa Clara	5.4M	4.8M	4.8M	5.5M
Sacramento	4.5M	4.1M	4.1M	5.2M
Alameda	3.6M	3.5M	3.4M	4.4M
San Francisco	1.9M	2.2M	2.2M	3.1M
Contra Costa	2.1M	2.1M	2.1M	3.6M
San Mateo	1.4M	1.6M	1.6M	2.1M

[31] Model trips do not contain walk, bike, or intrazonal trips (all modes). As a result, model trips are generally expected to be less than NHTS and CTPP trips.

Table 9-2. Intracounty Model Work Trips by Step vs. CTPP (Select Counties)

COUNTY	UNADJUSTED MODEL WORK TRIPS	ADJUSTED MODEL WORK TRIPS (PRE-CALIBRATION)	FINAL ADJUSTED MODEL WORK TRIPS (POST-CALIBRATION)	CTPP WORK TRIPS (2012-2016)
Santa Clara	1.7M	1.6M	1.6M	1.5M
Sacramento	1.2M	1.0M	1.0M	956k
Alameda	996k	941k	938k	848k
San Francisco	698k	756k	756k	659k
Contra Costa	545k	554k	554k	520k
San Mateo	436k	511k	510k	406k

Table 9-3. Intercounty Model Total Trips by Step vs. NHTS (Select County Pairs)

COUNTY PAIR	UNADJUSTED MODEL TRIPS	ADJUSTED MODEL TRIPS (PRE-CALIBRATION)	FINAL ADJUSTED MODEL TRIPS (POST-CALIBRATION)	NHTS TRIPS (2017)
Alameda-Contra Costa	611k	554k	553k	623k
San Francisco-San Mateo	516k	589k	541k	508k
San Mateo-Santa Clara	389k	414k	414k	461k
Alameda-Santa Clara	360k	385k	359k	287k
Alameda-San Francisco	351k	191k	300k	386k
Alameda-San Mateo	146k	164k	188k	157k
Contra Costa-San Francisco	135k	82k	123k	202k
Contra Costa-San Mateo	15k	36k	40k	60k
Sacramento-San Francisco	14k	5k	5k	6k
Sacramento-Santa Clara	12k	4k	4k	4k

Table 9-4. Intercounty Model Work Trips by Step vs. CTPP (Select County Pairs)

COUNTY PAIR	UNADJUSTED MODEL WORK TRIPS	ADJUSTED MODEL WORK TRIPS (PRE-CALIBRATION)	FINAL ADJUSTED MODEL WORK TRIPS (POST-CALIBRATION)	CTPP WORK TRIPS (2012-2016)
Alameda-Contra Costa	243k	285k	285k	286k
San Francisco-San Mateo	281k	259k	256k	269k
San Mateo-Santa Clara	192k	215k	215k	215k
Alameda-Santa Clara	205k	227k	210k	223k
Alameda-San Francisco	234k	127k	204k	244k
Alameda-San Mateo	96k	111k	124k	100k
Contra Costa-San Francisco	96k	58k	89k	130k
Contra Costa-San Mateo	12k	29k	32k	28k
Sacramento-San Francisco	4k	1k	1k	6k
Sacramento-Santa Clara	3k	800	800	4k

9.2. Detailed Auto Calibration Results

Table 9-5 and **Table 9-6** present detailed results of the auto calibration process described in Section 5.

Table 9-5. Transbay Auto OD Calibration Details, Top County Pairs by Bridge/Direction/Period

DIRECTION/BRIDGE/PERIOD	COUNTY PAIR	OBSERVED SHARE	FINAL ADJUSTED MODEL SHARE	GEH[32]
EB Bay Bridge AM Peak	San Francisco-Alameda	53.1%	53.8%	1.51
	San Francisco-Contra Costa	16.8%	17.1%	1.20
	San Mateo-Alameda	12.9%	13.4%	2.22
	San Mateo-Contra Costa	5.2%	5.4%	1.13
EB Bay Bridge Midday	San Francisco-Alameda	45.0%	45.5%	1.46
	San Francisco-Contra Costa	22.1%	22.3%	0.95
	San Mateo-Alameda	7.9%	8.0%	0.92

[32] GEH is calculated on the volumes implied by the shares shown.

DIRECTION/BRIDGE/PERIOD	COUNTY PAIR	OBSERVED SHARE	FINAL ADJUSTED MODEL SHARE	GEH[32]
	San Mateo-Contra Costa	7.0%	7.3%	2.05
EB Bay Bridge PM Peak	San Francisco-Alameda	53.9%	54.7%	2.20
	San Francisco-Contra Costa	23.6%	24.0%	1.75
	San Mateo-Alameda	6.5%	6.2%	1.97
	San Mateo-Contra Costa	5.4%	5.3%	0.69
EB Bay Bridge Night	San Francisco-Alameda	47.6%	48.1%	1.30
	San Francisco-Contra Costa	23.3%	23.5%	0.84
	San Mateo-Contra Costa	8.8%	8.9%	0.51
	San Mateo-Alameda	8.1%	8.1%	0.41
WB Bay Bridge AM Peak	Alameda-San Francisco	57.2%	56.3%	2.62
	Contra Costa-San Francisco	24.1%	23.7%	1.89
	Alameda-San Mateo	6.6%	7.0%	3.04
	Contra Costa-San Mateo	4.8%	4.9%	1.13
WB Bay Bridge Midday	Alameda-San Francisco	51.8%	51.4%	0.95
	Contra Costa-San Francisco	19.7%	19.5%	0.98
	Alameda-San Mateo	8.6%	8.9%	1.62
	Contra Costa-San Mateo	7.3%	7.7%	2.71
WB Bay Bridge PM Peak	Alameda-San Francisco	57.9%	57.6%	0.59
	Contra Costa-San Francisco	17.4%	17.4%	0.07
	Alameda-San Mateo	10.3%	10.5%	1.19
	Contra Costa-San Mateo	4.9%	4.9%	0.42
WB Bay Bridge Night	Alameda-San Francisco	37.6%	37.6%	0.00
	Contra Costa-San Francisco	24.9%	24.9%	0.01
	Contra Costa-San Mateo	10.0%	10.0%	0.03
	Alameda-San Mateo	8.3%	8.3%	0.26
EB San Mateo-Hayward Bridge AM Peak	San Mateo-Alameda	69.4%	68.0%	1.59
	San Francisco-Alameda	15.2%	15.9%	1.50
	San Mateo-Contra Costa	7.2%	7.0%	0.60
	Santa Clara-Alameda	3.2%	3.8%	3.28

DIRECTION/BRIDGE/PERIOD	COUNTY PAIR	OBSERVED SHARE	FINAL ADJUSTED MODEL SHARE	GEH[32]
EB San Mateo-Hayward Bridge Midday	San Mateo-Alameda	63.3%	65.8%	4.06
	San Mateo-Contra Costa	11.6%	13.1%	5.68
	San Francisco-Alameda	10.7%	8.6%	8.43
	San Mateo-San Joaquin	5.0%	6.0%	5.29
EB San Mateo-Hayward Bridge PM Peak	San Mateo-Alameda	75.6%	78.5%	4.72
	San Mateo-Contra Costa	10.1%	11.2%	5.04
	San Francisco-Alameda	6.2%	4.8%	8.69
	Santa Clara-Alameda	3.4%	1.0%	24.04
EB San Mateo-Hayward Bridge Night	San Mateo-Alameda	72.0%	75.1%	3.97
	San Francisco-Alameda	10.5%	7.2%	12.58
	San Mateo-Contra Costa	9.0%	9.6%	2.17
	San Mateo-San Joaquin	4.8%	5.1%	1.79
WB San Mateo-Hayward Bridge AM Peak	Alameda-San Mateo	75.4%	78.1%	4.33
	Contra Costa-San Mateo	10.3%	11.2%	4.03
	Alameda-San Francisco	6.9%	6.7%	1.96
	Alameda-Santa Clara	3.3%	0.0%	36.58
WB San Mateo-Hayward Bridge Midday	Alameda-San Mateo	69.2%	77.2%	10.00
	Alameda-San Francisco	12.3%	7.1%	17.79
	Contra Costa-San Mateo	10.1%	10.0%	0.57
	Alameda-Santa Clara	3.2%	0.0%	26.76
WB San Mateo-Hayward Bridge PM Peak	Alameda-San Mateo	72.2%	72.6%	0.41
	Alameda-San Francisco	14.6%	14.0%	1.44
	Contra Costa-San Mateo	8.2%	8.2%	0.24
	San Joaquin-San Mateo	2.5%	2.7%	1.55
WB San Mateo-Hayward Bridge Night	Alameda-San Mateo	63.3%	66.8%	5.14
	Alameda-San Francisco	13.0%	9.0%	14.08
	Contra Costa-San Mateo	12.0%	12.4%	1.33
	San Joaquin-San Mateo	7.6%	7.6%	0.12

DIRECTION/BRIDGE/PERIOD	COUNTY PAIR	OBSERVED SHARE	FINAL ADJUSTED MODEL SHARE	GEH[32]
EB Dumbarton Bridge AM Peak	San Mateo-Alameda	58.0%	53.8%	3.98
	Santa Clara-Alameda	30.4%	35.2%	6.03
	San Francisco-Alameda	4.3%	3.7%	2.27
	San Mateo-Contra Costa	2.7%	2.2%	1.92
EB Dumbarton Bridge Midday	San Mateo-Alameda	42.9%	45.4%	4.37
	Santa Clara-Alameda	42.3%	39.5%	4.96
	Santa Clara-Contra Costa	3.3%	2.9%	2.19
	San Mateo-Contra Costa	3.0%	3.4%	2.30
EB Dumbarton Bridge PM Peak	San Mateo-Alameda	47.8%	47.1%	1.79
	Santa Clara-Alameda	44.8%	42.1%	6.65
	San Francisco-Alameda	1.7%	3.6%	19.74
	San Mateo-Contra Costa	1.6%	1.9%	2.87
EB Dumbarton Bridge Night	San Mateo-Alameda	49.5%	51.1%	2.36
	Santa Clara-Alameda	39.1%	36.3%	4.66
	Santa Clara-Contra Costa	3.0%	3.1%	0.51
	San Francisco-Alameda	2.4%	3.0%	3.39
WB Dumbarton Bridge AM Peak	Alameda-San Mateo	54.4%	59.6%	10.72
	Alameda-Santa Clara	40.4%	35.0%	13.90
	Contra Costa-San Mateo	1.8%	1.8%	0.04
	Alameda-San Francisco	1.6%	1.9%	3.55
WB Dumbarton Bridge Midday	Alameda-San Mateo	57.1%	75.9%	19.94
	Alameda-Santa Clara	36.2%	18.5%	29.39
	Alameda-San Francisco	3.7%	1.7%	10.64
	Contra Costa-San Mateo	2.8%	3.8%	4.69
WB Dumbarton Bridge PM Peak	Alameda-San Mateo	61.5%	61.1%	0.34
	Alameda-Santa Clara	29.9%	30.3%	0.59
	Alameda-San Francisco	4.8%	4.7%	0.34
	Contra Costa-San Mateo	2.4%	2.4%	0.21

DIRECTION/BRIDGE/PERIOD	COUNTY PAIR	OBSERVED SHARE	FINAL ADJUSTED MODEL SHARE	GEH[32]
WB Dumbarton Bridge Night	Alameda-San Mateo	53.3%	97.6%	45.57
	Alameda-Santa Clara	37.8%	0.0%	77.76
	Alameda-San Francisco	4.8%	2.4%	46.04
	Contra Costa-San Mateo	4.1%	0.0%	25.77

Table 9-6. Auto Volume Calibration Details

SCREENLINE/DIRECTION	PERIOD	OBSERVED VOLUME	FINAL ADJUSTED MODEL VOLUME	GEH
Bay Bridge EB	AM Peak	21,409	21,456	0.32
	Midday	32,656	32,800	0.80
	PM Peak	31,618	31,711	0.52
	Night	43,038	43,008	0.15
	All Day	**128,721**	**128,975**	**0.71**
Bay Bridge WB	AM Peak	30,785	30,949	0.94
	Midday	33,812	33,999	1.01
	PM Peak	25,182	25,209	0.17
	Night	39,647	39,644	0.02
	All Day	**129,425**	**129,801**	**1.04**
San Mateo-Hayward Bridge EB	AM Peak	8,049	8,142	1.03
	Midday	17,415	16,896	3.96
	PM Peak	17,917	17,118	6.04
	Night	17,781	17,256	3.97
	All Day	**61,162**	**59,411**	**7.13**
San Mateo-Hayward Bridge WB	AM Peak	19,351	18,988	2.62
	Midday	15,934	15,858	0.60
	PM Peak	9,991	9,980	0.11
	Night	15,684	16,049	2.90
	All Day	**60,961**	**60,875**	**0.35**

SCREENLINE/DIRECTION	PERIOD	OBSERVED VOLUME	FINAL ADJUSTED MODEL VOLUME	GEH
Dumbarton Bridge EB	AM Peak	5,026	5,146	1.67
	Midday	10,875	11,451	5.46
	PM Peak	11,189	12,344	10.65
	Night	11,104	11,669	5.30
	All Day	**38,194**	**40,610**	**12.17**
Dumbarton Bridge WB	AM Peak	12,084	12,412	2.96
	Midday	9,950	9,872	0.79
	PM Peak	6,239	6,226	0.17
	Night	9,794	9,927	1.34
	All Day	**38,068**	**38,437**	**12.17**
Golden Gate Bridge NB	AM Peak	9,635	9,852	2.19
	Midday	16,451	16,633	1.42
	PM Peak	18,352	18,364	0.09
	Night	14,496	14,556	0.50
	All Day	**58,934**	**59,404**	**1.94**
Golden Gate Bridge SB	AM Peak	18,603	18,593	0.07
	Midday	15,526	15,529	0.02
	PM Peak	12,706	12,712	0.06
	Night	10,594	10,594	0.00
	All Day	**57,429**	**57,428**	**0.00**
Richmond-San Rafael Bridge EB	AM Peak	6,435	6,445	0.13
	Midday	10,986	10,992	0.06
	PM Peak	12,256	12,262	0.05
	Night	9,681	9,686	0.05
	All Day	**39,358**	**39,385**	**0.14**
Richmond-San Rafael Bridge WB	AM Peak	12,424	12,403	0.18
	Midday	10,369	10,366	0.02
	PM Peak	8,485	8,474	0.12
	Night	7,075	7,075	0.00
	All Day	**38,353**	**38,319**	**0.17**

SCREENLINE/DIRECTION	PERIOD	OBSERVED VOLUME	FINAL ADJUSTED MODEL VOLUME	GEH
Benicia-Martinez Bridge NB	AM Peak	30,431	30,441	0.06
	Midday	31,015	30,908	0.61
	PM Peak	24,202	24,206	0.03
	Night	38,035	38,034	0.00
	All Day	**123,683**	**123,589**	**0.27**
Benicia-Martinez Bridge SB	AM Peak	25,437	25,434	0.02
	Midday	31,722	31,709	0.08
	PM Peak	32,314	32,325	0.06
	Night	31,501	31,500	0.00
	All Day	**120,974**	**120,967**	**0.02**
San Francisco/San Mateo County Line (I-280/U.S. 101) NB	AM Peak	48,765	48,939	0.79
	Midday	57,007	57,368	1.51
	PM Peak	53,476	53,813	1.45
	Night	62,532	62,830	1.19
	All Day	**221,780**	**222,950**	**2.48**
San Francisco/San Mateo County Line (I-280/U.S. 101) SB	AM Peak	54,406	54,869	1.98
	Midday	59,255	59,597	1.40
	PM Peak	49,290	49,824	2.40
	Night	63,836	63,910	0.29
	All Day	**226,787**	**228,200**	**2.96**
East Bay Hills EB	AM Peak	31,981	32,388	2.27
	Midday	51,256	52,291	4.55
	PM Peak	52,949	53,548	2.60
	Night	48,738	49,039	1.36
	All Day	**184,924**	**187,265**	**5.43**
East Bay Hills WB	AM Peak	56,651	56,747	0.40
	Midday	49,499	49,630	0.59
	PM Peak	37,161	37,264	0.54
	Night	43,168	43,202	0.16
	All Day	**186,480**	**186,844**	**0.84**

SCREENLINE/DIRECTION	PERIOD	OBSERVED VOLUME	FINAL ADJUSTED MODEL VOLUME	GEH
I-880 at Alameda/Santa Clara County Line NB	AM Peak	22,740	22,844	0.69
	Midday	27,039	26,937	0.62
	PM Peak	24,580	24,805	1.44
	Night	25,480	25,492	0.08
	All Day	**99,839**	**100,079**	**0.76**
I-880 at Alameda/Santa Clara County Line SB	AM Peak	25,328	26,909	9.78
	Midday	27,808	27,999	1.14
	PM Peak	26,570	26,566	0.03
	Night	27,383	27,858	2.86
	All Day	**107,090**	**109,332**	**6.82**
I-80 West of Sacramento EB	AM Peak	15,136	15,160	0.20
	Midday	20,045	20,032	0.09
	PM Peak	18,910	18,890	0.15
	Night	17,459	17,464	0.04
	All Day	**71,550**	**71,546**	**0.01**
I-80 West of Sacramento WB	AM Peak	16,856	16,871	0.12
	Midday	20,133	20,120	0.09
	PM Peak	17,334	17,350	0.12
	Night	16,419	16,410	0.06
	All Day	**70,742**	**70,752**	**0.04**
I-580/I-205 West of Tracy EB	AM Peak	17,606	17,643	0.28
	Midday	21,323	21,751	2.92
	PM Peak	19,252	19,718	3.33
	Night	18,474	18,576	0.76
	All Day	**76,655**	**77,688**	**3.72**
I-580/I-205 West of Tracy WB	AM Peak	17,606	17,712	0.80
	Midday	21,323	21,388	0.45
	PM Peak	19,252	19,250	0.02
	Night	18,474	18,808	2.45
	All Day	**76,655**	**77,158**	**1.81**