TRANSPORTATION IMPACT ANALYSIS GUIDELINES

APPENDIX F
TRAVEL DEMAND

San Francisco Planning

Appendix F
Travel Demand Memorandum

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Prepared by:	Daniel Wu and Sherie George
Reviewed by:	Wade Wietgrefe
RE:	**Transportation Impact Analysis Guidelines Update, Travel Demand**

INTRODUCTION

In 2015, the department and the San Francisco Municipal Transportation Agency (SFMTA) hired a consultant to assist with an update to the travel demand methodology and estimates within the Transportation Impact Analysis Guidelines. For those prior travel demand estimates, the department relied on a series of sources, such as Citywide Travel Behavior Surveys and Institute of Transportation Engineers Trip Generation rates, from the 1980s through the 2000s. The consultant's specific tasks were to review the existing methodology and data; conduct primary data collection and analysis; derive updated parameters including trip generation rates, way people travel (also known as mode split), common origins and destinations (also known as trip distribution), and loading demand rates; and review the current geographic analysis structure. In addition to the department, the SFMTA and San Francisco County Transportation Authority (SFCTA) also provided feedback on this effort.

This memorandum updates the guidance provided in the prior guidelines for the travel demand topic. The department prepared this memorandum in consultation with stakeholders (e.g., city and county agencies, consultants). The department will issue memoranda that provide updates to other topics (e.g., transit, loading) within the guidelines. When the department issues a memorandum about a topic, it will supersede existing guidance regarding that topic. This travel demand memorandum informs the analysis of other transportation topics. This memorandum provides specific guidance on the methodology for conducting a travel demand analysis. However, summary guidance on the typical methodology for this topic is provided in the guidelines.

The guidance provided herein assumes a typical land use development project including residential, office, retail, and hotel that requires a transportation study. The "Other" subsection provides guidance on other types of projects. The department may use this guidance for multiple projects, but the department has discretion on applying the guidance on a project by project basis.

The organization of the memorandum is as follows:

1) Travel Demand (typical projects)
2) Loading Demand
3) Other (covers different types of projects)

Attachments are under separate cover. The department may update the attachments to the memoranda more frequently than the body of the memoranda.

TRAVEL DEMAND

The section identifies the approach to calculate travel demand, including describing typical geography, period, and methodology for typical projects.

Basics

Geographic Unit of Analysis

There are two travel demand geographic units of analysis – neighborhoods and place type (defined below). Neighborhoods consist of a collection of transportation analysis zones, which are units used by planners as part of transportation models and for other planning purposes. The San Francisco County Transportation Authority manages San Francisco's transportation model and developed boundaries for 12 neighborhoods (nine in San Francisco proper, and three external districts – north bay, east bay, and south bay). Figure 1 in Attachment A shows these neighborhoods and districts.

This methodology sorts each of nine San Francisco neighborhoods developed into one of three place types based on each neighborhood's auto mode share. Figure 2 in Attachment A shows the three place types based on the nine neighborhoods, including an overlay of the neighborhood boundaries. These place types are "urban high density" (place type 1), "urban medium density" (place type 2), and "urban low density" (place type 3).

Period

In San Francisco, the weekday extended p.m. peak period (Tuesday, Wednesday, or Thursday, 3 p.m. to 7 p.m.) is typically the period when the most overall travel happens.[1] Although a substantial amount of travel occurs throughout the day and impacts from projects would typically be less during other periods, the methodology should typically focus on this period (including limiting the hours within the extended p.m. peak period) as changes in travel demand would be acute during these periods compared to other times of the day and days of the week. However, the methodology should also use the weekday daily time period as a unit of analysis to examine the overall daily activity travel patterns and behavior of a project in its entirety. The loading, construction, and vehicular parking memoranda provide specific guidance on the appropriate period of study for those transportation topics.

Methodology

The typical methodology consists of four steps: 1) trip generation, 2) ways people travel, 3) common origins and destinations, and 4) trip assignment. The following subsections summarize each of these steps. Attachment B summarizes the data collection and analysis used to develop the methodology described below. The department developed a tool for travel demand analysis; Attachment C provides details on how to use the tool to implement the methodology described below.

Step 1. Trip Generation

Trip generation refers to the number of estimated trips people would take to and from the project, regardless of the way they travel (see step 2 below). The following methodology refers to these trips as

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[1] Examples that illustrate this statement: within the San Francisco County Congestion Management Program network transit and vehicular travel speeds are lower during the p.m. peak period (4:30-6:30 p.m.) than during the a.m. peak period (7-9a.m.) as documented in San Francisco County Transportation Authority, *Congestion Management Program*, December 2015; demand at transit stations is consistent and generally higher throughout the p.m. peak period relative to demand at transit stations during the a.m. peak period, as documented in the Metropolitan Transportation Commission, *Core Capacity Transit Study Briefing Book*, July 2016; the weekday peak period for for-hire vehicles occurs from 6:30 p.m. to 7p.m., as documented in San Francisco County Transportation Authority, *TNCs Today: a Profile of San Francisco Transportation Network Company Activity*, June 2017.

person trips. The methodology applies person trip rates, accounting for the size and type of land use, to estimate the number of project person trips. Table 1 shows the estimated daily and p.m. peak hour person trip generation rates by typical land use type.

The department developed these trip generation rates for daily and pm peak hour based on data collection in spring 2017 at 65 typical office, retail, residential, and hotel sites throughout San Francisco. The trip generation rates below include pass-by trips or trips people make en-route two primary locations, such as home and work.[2]

Table 1 – Person Daily and P.M. Peak Hour Trip Generation Rates by Land Use

Land Use	Unit of Land Use	Trip Generation Rate	
Residential	Per Bedroom	Daily	4.5
		PM Peak	0.4
Office	Per 1k square feet of land use	Daily	15.7
		PM Peak	1.4
Retail – General	Per 1k square feet of land use	Daily	150
		PM Peak	13.5
Retail – Supermarket		Daily	297
		PM Peak	21.7
Eating Restaurant	Per 1k square feet of land use	Daily	200
		PM Peak	27
Eating Composite		Daily	600
		PM Peak	81
Hotel	Per Hotel Room	Daily	8.4
		PM Peak	0.6

The department caps residential trip generation rates at the 3-bedroom rate, meaning that a 4-bedroom unit has the same estimated daily and p.m. peak hour number of person trips as a 3-bedroom unit.

Step 2. Ways People Travel

Ways people travel, also known as mode split, refers to the estimated way or method people travel. This methodology defines five methods: automobile modes (driving alone or with passengers), taxi/TNC, walking, public transit (such as bus, light rail, BART, or Caltrain), and bicycling.[3] Figure 1 summarizes extended p.m. peak mode split by one of the three place types and land use. Each place type displays

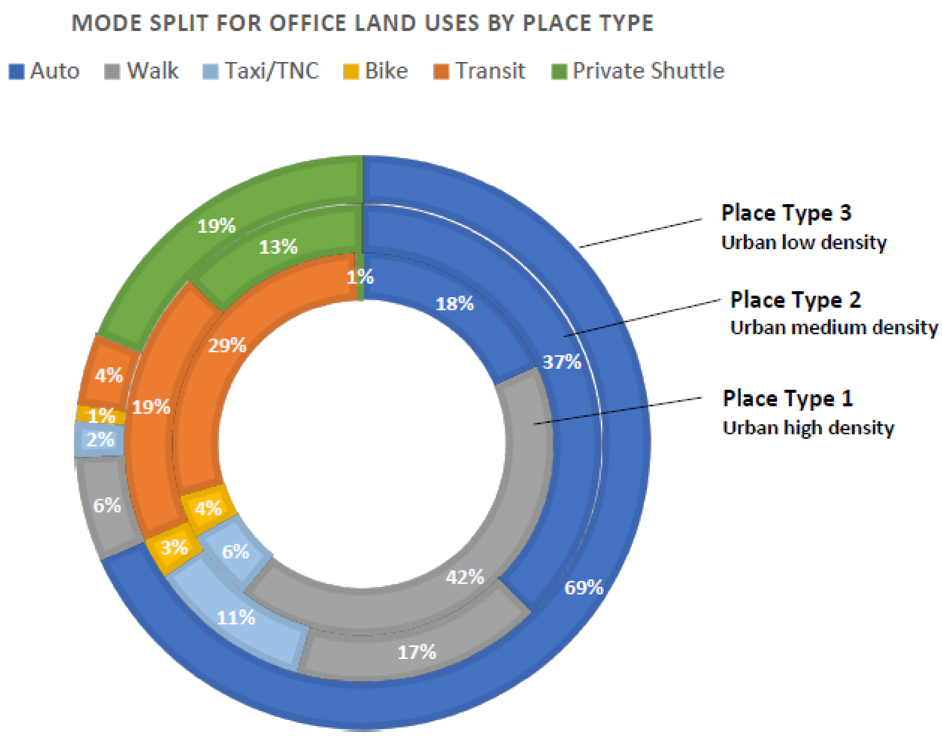
[2] Therefore, models (e.g., California Emissions Estimator Model) should generally assume 0 percent for pass-by trips when inserting projects trips.

[3] While private transit trips are included as a percentage of the observed total person trips, the department excludes private transit from impact analysis. Therefore, private transit is not mentioned as a method although it is shown in figure 1.

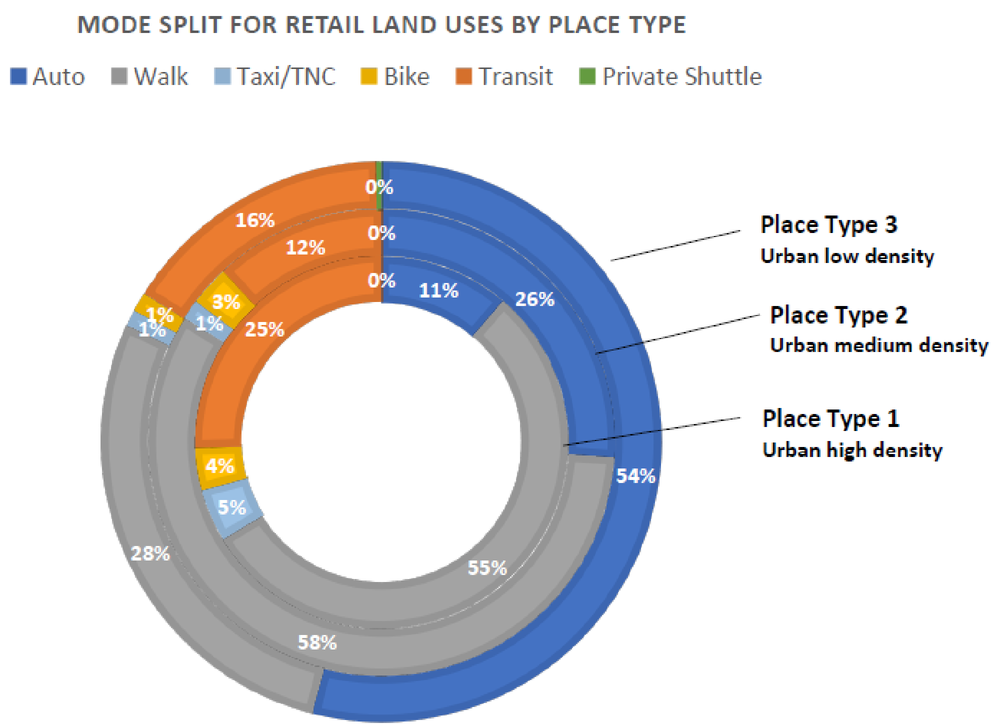
different mode split ratios due to factors that influence travel behavior, such as transit accessibility, walkability, roadway and transit infrastructure.

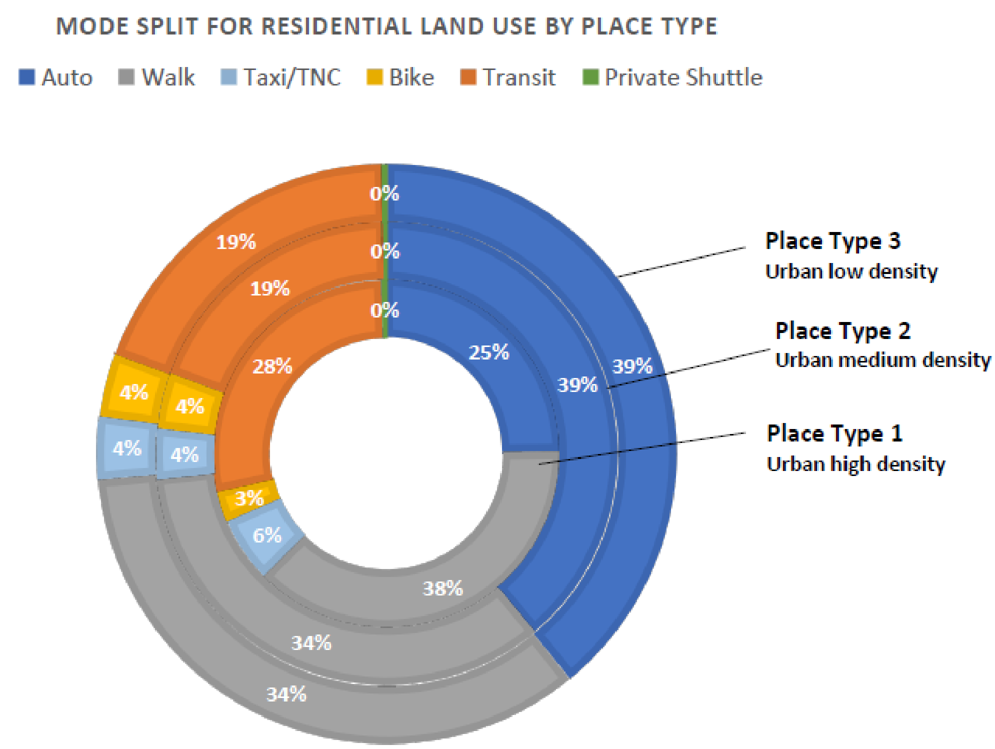
The methodology will typically assume the extended p.m. peak period mode splits would apply to both daily and p.m. peak hour person trip generation to determine person trips by mode.

The department developed mode splits[4] based on data collection in spring 2017 at 65 typical office, retail, residential, and hotel sites throughout San Francisco. Attachment B provides more details on this data collection effort.



[4] The department calculated mode splits based on intercept survey data collected during the PM peak period (3:00-7:00pm);


MODE SPLIT FOR RETAIL LAND USES BY PLACE TYPE
Auto
Walk
Taxi/TNC
Bike
Transit
Private Shuttle
Place Type 3
Urban low density
Place Type 2
Urban medium density
Place Type 1
Urban high density
0%
0%
0%
16%
12%
25%
11%
26%
54%
1%
1%
3%
1%
4%
5%
28%
58%
55%


MODE SPLIT FOR RESIDENTIAL LAND USE BY PLACE TYPE
Auto
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Taxi/TNC
Bike
Transit
Private Shuttle
Place Type 3
Urban low density
Place Type 2
Urban medium density
Place Type 1
Urban high density
0%
0%
0%
19%
19%
28%
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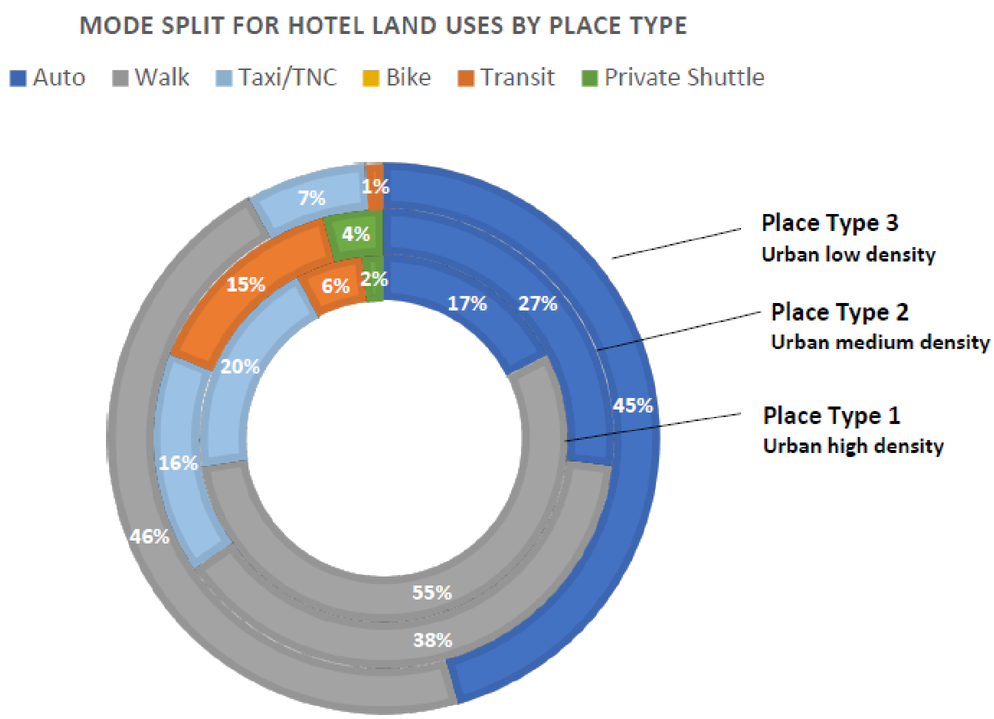

Figure 1 Mode Split by Land Use Type and Place Type

Step 3. Common Origins and Destinations

Common origins and destinations, also known as trip distribution, refer to the estimated number of trips people would take to (inbound) and from (outbound) the project and another place (e.g., another neighborhood). Common origins and destinations consist of locations in the nine San Francisco neighborhoods, east bay, north bay, and the south bay.

The methodology uses the aforementioned travel demand analysis tool to distribute a project's person[5] and vehicle[6] trips to/from a project site's neighborhood district or place type to the 12 neighborhood districts based on the following categories:

- Origin/destination (residential, office, or retail[7])
- Trip purpose (work or non-work)
- Mode (drive alone, shared ride, and transit)

[5] The department does not distribute walk and bicycle as the impact analysis for walking/accessibility, and bicycles assume these trips to be localized and not traveling between different neighborhoods. The department does not evaluate impacts to private transit.

[6] To calculate vehicle trips, the methodology uses vehicle occupancy rates, defined as the number of passengers in a vehicle during a trip, and calculated as vehicle person trips divided by vehicle drive trips from the California Household Travel Survey trips records between different neighborhood districts. Each neighborhood district's land use type has its own unique vehicle occupancy rate. Vehicle person trip is the sum of carpool (two occupants), carpool (three of more occupants), and drive alone in the Travel Survey. Vehicle drive trips are vehicle person trips divided by assumed vehicle occupancy of 2 for carpool (two occupants), 3.5 for carpool (three or more occupants), and 1 for drive alone tripsperson(s).

[7] The California Household Travel Survey does not provide hotel or visitor trip patterns. The methodology distributes hotel or visitor trips using retail trip patterns based on the department's comparative assessment of retail trip patterns with neighborhoods visited according to the San Francisco Travel Association's 2017 San Francisco Visitor Profile.

- Directionality (inbound or outbound)

The department with the SFCTA developed trip distribution tables, stratified by the above four categories, based on the California Household Travel Survey data; this data includes 5,000 trip records starting or ending in San Francisco. Using the relative weight of these trips, per each of the four categories, the methodology provides a better granularity to assign trips to roadways and transit routes in the subsequent step as described below. See Attachment C for more details and instructions for accessing and using the tool.

The department developed recommendations on whether a project should use auto or transit trip distribution based on the project's neighborhood or place type as shown in Table 2 Recommended Level of Trip Distribution below. The department developed these recommendations by analyzing the number of California Household Travel Survey trip records available for each given neighborhood, land use type, and mode of travel (auto versus transit); the recommended geographic level of distribution below reflects the department's assessment of whether the number of trip records for a given neighborhood and mode of travel is sufficient; if it is not, then a project would use place type level of trip distribution.

Table 2. Recommended Level of Trip Distribution

Mode	Recommended Level of Trip Distribution	Example
Auto	Projects should distribute by neighborhood district, except for: • Projects in SoMa (distribute by place type), or • Projects with office in urban medium or urban low place types (distribute by place type for all project land use types)	Project with 500,000 square feet of office and 400 residential units in the Mission (a district in urban medium place type) would use place type trip distribution for the project's office and residential components
Transit	Projects should distribute by neighborhood district, except for: • Projects in urban low place type (distribute by place type), or • Projects with office in urban medium place types (distribute by place type for all project land use types)	Project with 150 residential units and 5,000 square feet of retail in the Sunset (a district in urban low place type) would use place type level trip distribution for project's residential and retail components

Step 4. Assignment

Assignment refers to the location or assignment of project vehicle trips to different streets, on-street loading zones, and driveways, and project transit trips to specific transit routes. In other words, assignment uses the results of step 2: number of project trips by different ways of travel, and step 3, percentages of those projects trips to and from common origins and destinations, to place project vehicle and transit trips onto physical locations. Roadway assignment between an origin or destination and the project site can be based on factors such as consideration for one-way versus two-way streets, access to on and off-ramps, or prohibited movements in the study area intersections. Transit assignment between an origin and destination can be based on factors such as transit travel time, number of transfers, and location of transit stop.

The methodology will multiply the percentage of taxi/TNC trips calculated from the total estimated number of vehicle trips by two to account for separate vehicle trips both to and from a site (one as the vehicle arrives, and one as the vehicle departs). The methodology will assign taxi/TNC vehicle trips to the nearest study intersection(s). At the intersection, the methodology will assign taxi/TNC vehicle trips to critical movement to the extent applicable.[8] This same methodology will apply for parent/guardian vehicle trips (pick-up/drop-off) to and from childcare and schools to the extent applicable.

FREIGHT AND PASSENGER LOADING DEMAND

The section identifies the approach to calculate loading demand, including a description of geographic unit by the study area, period, and methodology for a typical project. Refer to the loading memorandum for further guidance.

Basics

Geographic Unit of Analysis

The methodology will typically focus on the streets, including alleys, adjacent to the project site, and on-street and off-street passenger and commercial loading (and potential shared loading) zones within convenient locations of the project site, which is typically 250 linear feet of the project site.[9] The project will use the nine San Francisco neighborhoods and three place types units as described under the travel demand geographic unit of analysis subsection.

Period

For loading demand, the period will differ depending upon the land use and type of loading activity. The periods defined below assume residential, office, and commercial land uses and commercial or passenger loading. For other land uses and other loading activities, the department will determine the appropriate period that loading demand and activity should be analyzed.

For commercial vehicle loading, such as freight and delivery service vehicles, the weekday mid-day is the peak period (Tuesday, Wednesday, or Thursday from 11 a.m. to 2 p.m.).

For passenger vehicle loading, consisting of private and for-hire vehicles, the weekday p.m. hours are the peak period (Wednesday, Thursday, or Friday, from 5 p.m. to 8 p.m.).

Methodology

Loading demand analysis represents how the estimated number of loading trips will affect the use of available loading facilities. The methodology calculates demand for freight and delivery, and passenger loading.

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[8] The department data collection effort in spring 2017 estimated the number of person trips by mode generated by a development. While there is limited information regarding the distribution of TNCs across the surrounding street network beyond an immediate block face, the methodology above intends to appropriately account for the vehicle trips produced by TNCs to adequately analyze their effects on localized issues (e.g., passenger loading, localized safety).

[9] For the purposes of this memorandum, “convenient” refers to locations that meet people’s loading and unloading needs, including people with disabilities. Convenient generally is within 250 linear feet of the project site, but depends on contextual characteristics such as proximity to an alley, curb lane, or ADA curb ramp; distance and type of intersections in relation to the project site; and directionality of project frontage roadways.

Freight and Delivery Loading

Freight and delivery loading demand represents the number of spaces generated by a particular land use during the peak hour throughout the average weekday peak period. Table 3 presents freight and delivery loading daily demand rates.

The department bases these rates on a 1980 study of goods movement activity in San Francisco.

Table 3. Freight and Delivery Daily Trip Demand Rates per 1,000 Square Feet of Floor Area by Land Use

Land Use	Rate per 1,000 square feet
Office	0.21
Retail (Composite)[10]	0.22
Restaurant/Bar	3.60
Services	
Hotel	0.09
Institution	0.10
Warehousing	0.46
Manufacturing	0.51
Light Industry	0.65
Residential	0.03

Source: Center City Pedestrian Circulation and Goods Movement Study (Wilbur Smith & Associates for San Francisco Department of City Planning). September 1980.

The freight and delivery loading demand calculation formula is:

Number of spaces per 1,000 GSF = $\left[\frac{(1.25)(R)}{9}\right]/(2.4)$

Where,

R = Daily truck trip demand rates per 1,000 GSF of use from Table 3;

1.25 = Peak hour deliveries at 25% higher rate than other hours;

9 = Number of hours deliveries are made (8:00 a.m. – 5:00 p.m.); and

2.4 = Assuming average truck delivery/pick up of 25 minutes, 2.4 trucks could be accommodated per hour.

Round up the demand calculation to the nearest whole number of loading spaces (e.g. 1.4 spaces would round up to two spaces).

[10] Retail includes but not limited to personal services, wholesale, apparel, drug store, and specialty shops.

Passenger Loading

Passenger loading demand is expressed as the required number of loading spaces generated by the land use during any one minute of the peak hour throughout the average peak period or if the project site is located along a non-center running public transit rapid network route or unprotected bicycle facility (e.g., no safe hit post, parking/loading in between, or raised sidewalk), then calculate demand for any one minute of the peak 15 minutes of the average peak period.

Passenger loading demand is calculated by using the mode split percentage of all person trips going to a particular project site that would involve a passenger loading instance occurring at the curb near the project site. These percentages (also known as passenger loading percentage), are shown in Table 4 by land use and place type. These passenger loading percentages are calculated using the planning department's intercept survey data collection in spring 2017.

Table 4. Curb Loading-type p.m. Peak Period Mode Splits by Land Use and Place Type Geography

Land Use	Geography	Number of Sites	Taxi/TNC%	Private Vehicle Drop-off (50% of HOV Passenger Mode)	Passenger Loading %
Office	Place Type 1	8	6.1%	1.2%	7.3%
	Place Type 2	7	11.0%	2.4%	13.4%
	Place Type 3	3	2.0%	5.1%	7.1%
Retail	Place Type 1	4	4.6%	0.9%	5.5%
	Place Type 2	10	1.4%	1.6%	3.0%
	Place Type 3	7	1.0%	4.2%	5.2%
Residential	Place Type 1	4	6.0%	2.8%	8.8%
	Place Type 2	9	3.5%	3.7%	7.2%
	Place Type 3	2	4.2%	2.7%	6.9%
Hotel	Place Type 1	4	19.6%	2.2%	21.8%
	Place Type 2	5	15.6%	4.1%	19.7%
	Place Type 3	2	7.5%	6.0%	13.5%

Note: Because survey respondents were not asked to specify if they were dropped off or simply part of a group arriving in single vehicle, the methodology assumed a 50 percent factor for HOV trips for purposes of loading analysis.

The passenger loading demand calculation formula is as such:

$$\text{Peak hour spaces of passenger loading demand} = \left[\frac{P*L*D}{60}\right]$$

Where,

P = Person trip generated by the land use during the p.m. peak hour based on the land use type's trip generation rate as shown in Table 1 and the amount of land use;

L = Loading mode type percentage (mode split of all person trips going to a project site involving passenger loading occurring at the curb) as shown in Table 4 for the land use and place type; and

D = The average stop duration is assumed to be 1 minute.

Peak 15 minutes spaces of passenger loading demand = $[\left(\left(\frac{P*L}{2}\right)*D\right)/15)]$

Where,

P = Person trip generated by the land use during the p.m. peak hour based on the land use type's trip generation rate as shown in Table 1 and the amount of land use;

L = Loading mode type percentage (mode split of all person trips going to a project site involving passenger loading occurring at the curb) as shown in Table 4 for the land use and place type;

2 = Assumes that half of peak hour loading demand occurs during the peak 15 minutes; and

D = The average stop duration is assumed to be 1 minute.

Round up the demand calculation to the nearest whole number of loading spaces (e.g. 1.4 spaces would round up to two spaces). For projects that consist of more than one building, the methodology should calculate passenger loading demand for the lobby entrance at each individual building.

OTHER

The guidance provided in this memorandum assumes a typical land use development project. This section describes the type of additional or different information that may be necessary to calculate travel demand for the following circumstances: atypical land use, cumulative, an area plan, and substantial rezoning outside of area plans.

Atypical Land Use

This section applies to projects that are not typical land use types (e.g. residential, office, retail, or hotel) or do not have the same travel behaviors as these typical land use types.

Project Description

The project description must include the physical features to the extent applicable to calculate trip generation. Examples include:

- For student housing, number of rooms [text, table]
- For entertainment uses, number of seats and/or standing capacity (maximum occupancy) [text, table]
- For schools and child care facilities, capacity by age and number of teaches and employees [text, table]

Period

In some instances, the most overall trips people would take to and from a proposed project, may occur at different periods (a.m., midday, post p.m. peak, and/or weekend) for smaller geographic areas (e.g., a segment of a street) in existing conditions or as a result of the project, or the project may result in substantial disparity in travel demand at different periods (e.g., special events). In these instances, the methodology may substantiate the use of different periods in addition to or other than the weekday p.m. peak. The methodology should also use the weekday daily time period as a unit of analysis to examine the overall daily activity travel patterns and behavior of a project in its entirety. Trip generation rates to estimate the number of project person trips during an atypical peak period must be justified and in consultation with the department. Refer to Chapter 6 of Attachment B for a.m. peak hour trip generation rates based on the department data collection in spring 2017.

Counts

The methodology should include counts of people approaching and leaving sites with similar characteristics (e.g. project size and use) and location as those of the proposed project in order to estimate trip generation. The methodology may include prior counts collected from other studies or sources combined with (e.g., an average of three different dates with counts at sites with similar characteristics) or counts collected specifically for the project. To conduct a full accounting of person trips to and from individual sites, the methodology may conduct video counts of all access and egress points to a site (e.g. pedestrian entryways to garages and pedestrian doors with exterior access). Refer to Chapter 3 of Attachment B for an example of the department's effort to conduct video counts collection. The use of prior counts or the counts collection approach must be justified and in consultation with the department.

Intercept Survey

The intercept survey should gather two key pieces of information: how an individual arriving at the survey site traveled to that site and where they traveled from. In the case of individuals intercepted while leaving the site, the survey should ask how they are traveling to their next destination and location of that destination. These data points allow for an assessment of both mode split and trip distribution at the site level. Refer to Chapter 3 of Attachment B for an example intercept survey.

Methodology

The methodology to calculate demand for freight and delivery, and passenger loading could vary for atypical land uses. In those instances, the department will determine the appropriate methodology.

Cumulative

For certain projects, reasonably foreseeable projects in the study area may affect mode split for the project. Examples include major transit projects such as new or increased service or a significant change in density nearby. In these cases, trip generation and trip distribution assumptions would remain the same as existing conditions. However, the analysis could consider changes to the mode split under cumulative conditions derived through approaches such as modeling future travel behaviors with SFCTA's travel demand model or based on policy goals.

Area Plans

For area plans, the methodology would require running a travel demand model with the project's proposed land use and/or infrastructure improvement to estimate trip generation, mode split, and trip distribution. The planning department will determine whether to use a list –based, projections-based, or modified approach to identify a list of cumulative projects in the project study area to include in the cumulative model run. Refer to the guidelines for direction on developing a list of and or modeling reasonably foreseeable projects.

Substantial Rezoning Outside of Area Plans

On occasion, project sponsors may propose redevelopment of large areas consisting of multi-structure, multi-phased development. The methodology to estimate travel demand for these rezoning projects would mostly remain the same as the typical land uses, except that these rezoning projects shall also account for the number of person trips that may remain inside the project area, also known as trip internalization. Trip internalization is mostly relevant to large, mixed-use developments that include various land uses that would produce a significant number of trips that remain within the development. Refer to Attachment D for an example steps on how to estimate trip internalization.

As noted above, should the travel demand methodology choose to substantiate the use of periods in addition to or other than the weekday p.m. peak, the methodology must also substantiate how to estimate these different period's trip generation rates. Examples include using Chapter 6 of Attachment B, the existing *Institute of Transportation Engineers Trip Generation Manual* to calculate a.m. percentage of daily trip rates, or if a land use has a majority of outbound trips in the a.m. peak period and a majority of p.m. inbound trips in the p.m. peak period, such as a residential use, the methodology may choose to reverse the distribution of the p.m. peak period to estimate a.m. peak distribution. The department will determine the appropriate approach based on the characteristics of the project.

ATTACHMENT A

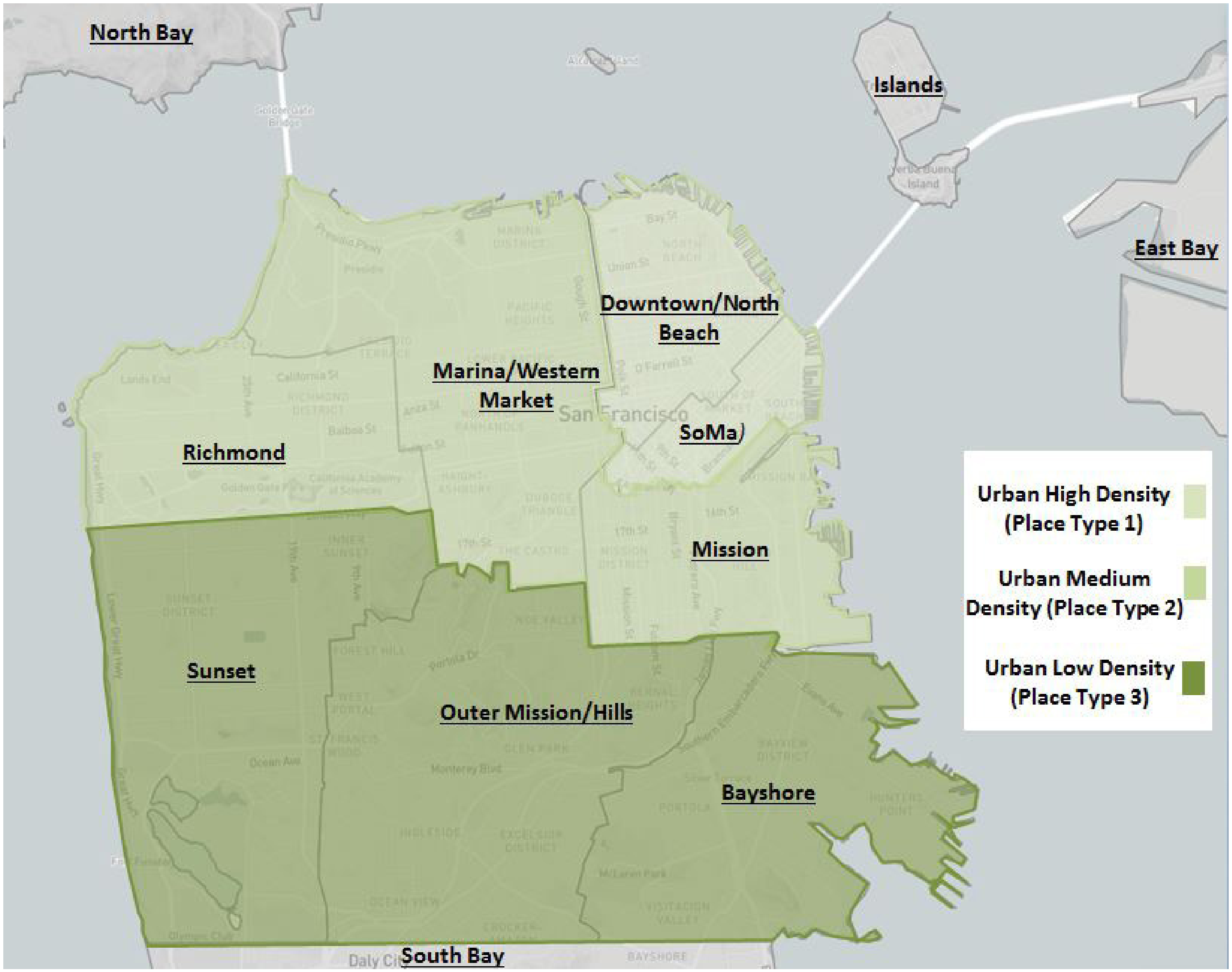
Travel Demand Geographic Unit of Analysis Maps

FIGURE 1

Neighborhood District Boundaries Map

FIGURE 2

Placetype Map



ATTACHMENT B

San Francisco Travel Demand Update: Data Collection and Analysis

Prepared for

San Francisco
Planning
Department

Prepared by

FEHR & PEERS

332 Pine Street, Floor 4
San Francisco, CA 94104

San Francisco Travel Demand Update:

Data Collection and Analysis

SF15-0864

June 29, 2018

Table of Contents

List of Figures

List of Tables

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Chapter 1. Introduction

In 2015, the San Francisco Planning Department ("SF Planning") hired Fehr & Peers to assist with an update to the trip generation, trip distribution, mode-split and loading demand methodologies contained within SF Planning's Transportation Impact Analysis Guidelines for Environmental Review ("SF Guidelines"). The current SF Guidelines were published in 2002, and the data on which they are based date to the 1980s and 1990s. The specific tasks were to update the existing SF Guidelines with new data (including primary data collection and analysis); derive updated parameters including trip generation rates, trip distribution tables, mode splits, and loading demand rates; review the current geographic analysis structure; and examine whether any major assumptions built into the SF Guidelines need revisiting. In addition to SF Planning, the San Francisco Municipal Transportation Agency and San Francisco County Transportation Authority also provided feedback on this effort.

This report summarizes the data collection and analysis methodologies used in this process, and provides the results of the data analysis in the form of tables addressing trip generation, mode split, trip distribution, and loading demand. The report discusses the data collection plan (Chapter 1), analytical framework (Chapter 2), and data collection methodology, including site selection (Chapter 3). Data sources beyond the newly collected data are discussed (Chapter 4), and the pros and cons of a range of geographic analysis units are considered (Chapter 5). The details and results of the data analyses are presented for both travel demand (Chapter 6) and loading demand (Chapter 7), and conclusions and next steps are discussed (Chapter 8).

This report largely presents the methodology and data results in a stand-alone fashion for initial review and informational purposes; it is intended to be a succinct presentation of both process and findings. It does not directly address the degree of change these rates represent compared to the existing SF Guidelines except in the case of trip generation, nor does it present detailed policy recommendations. Planning Department staff have separately prepared case studies showing how updates to travel demand rates, mode split percentages, and trip distribution could affect analysis for hypothetical projects.

1.1 General Approach

Fehr & Peers worked with SF Planning staff to identify key areas of concern and data points in need of updated information. The scope of work for this effort (included as **Appendix A**) was developed in order to efficiently provide quantitative backing for updates to the most common land uses among new development considered in San Francisco both now and in the future.

The overall approach to this data collection effort was to focus on updating information regarding the following analysis categories:

- **Trip Generation**, or the number of person trips to and from a project, per unit of land use;
- **Mode Choice**, or the method by which people travel to and from a project;
- **Trip Distribution**, or where people are traveling to or from; and
- **Loading Demand**, or how much passenger and freight loading activity is associated with a project, per unit of land use.

The first three elements above are used in travel demand analysis to calculate vehicle trips (including for-hire vehicles, such as taxis and Transportation Network Company[1] a.k.a TNC trips), transit trips (both public transit and private transit, such as employer shuttles), walk trips, and bike trips, including those trips' common origins and destinations. This process forms the backbone of transportation impact analysis under the current SF Guidelines.

The overall approach to updating these data points was to collect direct data from sites that represent typical development in San Francisco, via a combination of 24-hour video counts and in-person intercept surveys during an extended PM peak period (3:00 to 7:00 PM).[2] The video counts provide a full accounting of the number of people entering or exiting an individual development, while the intercept surveys provide insight into how and where people travel to and from the site. This direct data collection allows for a recent, targeted look at travel patterns specifically at a building level. Where appropriate, secondary data sources, including census data and household travel survey data, were integrated into the analysis to supplement initial findings.

In order to focus the data collection effort, emphasis was placed on updating the most frequently used rates, and capturing the types of development that reflect ongoing development patterns in San Francisco. A secondary emphasis was placed on identifying land uses where common sources for trip making behavior (such as census journey-to-work data) were unable to fully capture trip-making patterns, as is the case for hotel uses, which are primarily visited by non-residents of San Francisco. This resulted in the identification of four key land use categories for which new travel data were collected.

[1] Transportation Network Companies (TNCs) are regulated by the California Public Utilities Commission and act as dispatchers of large numbers of private cars in taxi-like operation that are hailed via phone or phone/ computer application.

[2] The rationale for selecting an extended PM peak period of 3:00 to 7:00 PM is discussed in section 1.1.2.

1.1.1 Land Uses Included

Four land uses were identified as most frequently being included in development applications: office, retail, residential, and hotel. While many sites in San Francisco include more than one land use, this study looked only at single land uses with individual access points. This decision was made to help focus solely on single uses; future policy direction and analysis may determine how travel demand for multi-use projects should be calculated from single-use rates.

Office

The office land use category consists of traditional office buildings, i.e. buildings whose space is used primarily for administrative, clerical, consulting, or other professional service work. Office land uses are concentrated in downtown San Francisco, particularly the Financial District and SoMa, but large and small office land uses can be found throughout the city. Two typical office data collection sites are shown in **Inset Figure 1**.

Inset Figure 1: Two typical office data collection sites. Left: 535 Mission Street; right: 221 Pine Street. Source: Google Street View, 2017.

The office land use category is also often used as a proxy for less traditional employment uses (such as to calculate travel demand for employees at schools, for instance, or for non-traditional work spaces such as co-working space or live-work units). Traditionally, travel demand for office uses has been calculated based on thousand square feet of development area (ksf), with supplementary information on how many square feet are provided per employee. This data collection effort continues to analyze office trip generation on the basis of trips per thousand square feet, and has not updated the assumed number of square feet per employee.[3]

Retail

The retail land use category consists of general shops, pharmacies, department stores, convenience stores, laundromats, dry cleaners, and some types of restaurants (such as coffee shops). A 'typical' retail use is a store that sells goods or services directly to visitors, however the term is generally used as an umbrella category, particularly in development applications where specific retail tenants have not yet been identified. Given that there are many different types of retail uses, this umbrella category encompasses a wide array of potential uses. The most common type of retail varies by city neighborhood; in the Financial District, there may be a higher rate of convenience stores, small pharmacies, and formula retail, while in more residential neighborhoods like the Sunset or Balboa Park there may be more stand-alone facilities and locally serving commercial. Two typical retail data collection sites are shown in **Inset Figure 2**. Traditionally, travel demand for retail uses has been calculated based on thousand square feet of development area (ksf).

Inset Figure 2: Two typical retail data collection sites. Top: 535 Valencia Street; bottom: 3001 Taraval Street. Source: Google Street View, 2017.

Most trips generated to retail sites are made by visitors, though a substantial number of trips may also be made by employees. However, many of the most readily available secondary sources of information on transportation mode are focused on employee trips only. As such, intercept surveys represent an opportunity to collect more information that is not available through secondary sources, particularly for

[3] Historically, some applicants have chosen to adjust parking demand if they suspect their employee density, or number of employees per thousand square feet, is noticeably higher or lower than the assumptions in the Guidelines. We have opted to focus on observed trips per ksf rather than rates based on number of employees, as it represents the most easily analyzed unit at the environmental analysis stage, when office tenants are often not yet identified; additionally, employee counts were not available for many of the study locations. Other studies have found that employee densities may be around 8 to 9 percent lower than current estimates used in the SF Guidelines (October 2017 Report to Planning Commission on Jobs-Housing Capacity & Growth; http://commissions.sfplanning.org/cpcpackets/Jobs%20Housing%20Capacity%20Informational%20Oct2017_FINAL.pdf)

retail uses that tend to generate a high share of "pass-by" trips, i.e. trips that are made en route between two primary locations, such as home and work.

Residential

The residential land use category includes single family and multifamily homes, including houses, apartments, townhomes, and condominiums. The residential sites that were the focus of the present data collection effort were multifamily sites, as it would be inefficient to collect video count and intercept survey data at single-family homes, and single-family developments do not represent the typical construction type subject to transportation review. Two typical residential data collection sites are shown in **Inset Figure 3**.

Fehr and Peers has expressed residential land use intensity in terms of dwelling units (du) and the number of bedrooms in each du, which serves as a proxy for household size. Section 6.1.3 discusses how trip generation rate results differed between these analysis units in greater detail.

Inset Figure 3: Two typical residential data collection sites. Top: 1998 Market Street; bottom: 55 Chumasero Street. Source: Google Street View, 2017.

Hotel

The hotel category includes hotels, motels, and any other use where rooms are provided on a nightly or weekly basis directly to visitors. Two typical hotel data collection sites are shown in **Inset Figure 4.**

Travel demand for hotel uses is analyzed on a per room basis. Because most hotel users are visitors to San Francisco, it can be difficult to accurately express trip mode and distribution due to a lack of secondary sources (for instance, census data would not capture hotel visitors who do not live in San Francisco). As such, intercept surveys and direct data collection represent the best potential source of data for travel patterns among hotel guests.

Inset Figure 4: Two typical hotel data collection sites. Top: 1500 Sutter Street; bottom: 1234 Great Highway. Source: Google Street View, 2017.

1.1.2 Time Period for Mode Choice

Intercept survey data collection occurred during the extended PM peak period, defined as the window from 3:00 to 7:00 PM. This window was selected because it includes the default analysis period for transportation impact analyses in San Francisco (i.e., the PM peak hour, which is the hour falling between 4:00 and 6:00 PM with the highest traffic volumes) as well as including the PM Peak period reported in runs of SF-CHAMP, the City's activity-based travel demand model.[4]

SF Planning typically requires transportation analysis to analyze patterns during the PM peak hour because it represents the period when the transportation network is most congested across modes. This includes crowding on SFMTA transit service as well as congestion on local roadways. As the amount of travel activity within San Francisco continues to increase, congested conditions may occur outside the traditional PM peak

[4] SF-CHAMP, the San Francisco Chained Activity Modeling Process, is discussed in greater detail in section 0. The PM period analyzed in SF-CHAMP runs from 3:30 PM to 6:30 PM.

hour. A focus on the extended PM peak period helps ensure that intercept survey data are relevant to changing travel patterns.

1.2 Data Collected

As discussed in section 1.1, the emphasis of this data collection effort was to identify and collect data that were not readily available through other sources. The primary challenge in adapting other data sources is that they typically are not presented at a building level; that is, they may show overall choices in travel mode, or travel patterns, but do not represent a rate of trip making for one specific building or land use. They may also only capture a subset of trip types; for instance, census data asks only about commute trips, which represent only around one quarter to one third of all trips in the Bay Area, as estimated by the MTC travel model.[5]

1.2.1 Person Trip Generation

Person trip generation is the total number of person trips associated with a given amount of a land use; for instance, the number of people entering and leaving an office expressed as a rate per 1,000 square feet (ksf). In order to collect person trip data, Fehr & Peers contracted with data collection firm IDAX Data Solutions ("IDAX"). Using video technology, all trips in and out of doorways and driveways were tallied for each site. Trips via doorways are expressed directly in person trips, as access is on foot, while trips via driveways are expressed in vehicle trips. Person trips are calculated from vehicle trips via assumptions regarding average vehicle occupancy for each use; these assumptions are based on data from the California Household Travel Survey and calculated via methods described in section 4.1.1.[6]

1.2.2 Mode Choice

Mode choice represents the ways people travel from place to place. Historically, the SF Guidelines have represented these transportation modes as auto modes (driving alone or with passengers, taking a taxi, or riding a motorcycle), walking, transit (such as bus, light rail, BART, or Caltrain), and all other modes (which includes bicycling). Alternatively, mode choice can be thought of by the categories of private auto trips (driving alone or with passengers), taxi/TNC trips, public transit trips, private transit trips (such as private shuttles), walk trips, and bike trips; these categories provide a slightly higher level of nuance simply based on expanding the categories currently in use

[5] Data taken from estimations of regional trip purposes from MTC Travel Model One, v0.6.
[6] Direct observations of vehicle occupancy at driveways were not used due to difficulty in accurate assessment of the number of vehicle occupants from the level of quality found in data collection cameras.

Individuals choose a mode based on a wide array of factors, including the modes available to them for a certain trip (e.g., whether they have access to a car or bike, and whether the nearest bus travels to where they want to go), travel time for each mode, comfort, and the cost and convenience of each mode. Additionally, individuals may value time, cost, comfort, and convenience at different levels depending on a wide array of socio-economic factors or travel purpose; these values ultimately factor into their choice of mode for a given trip.

Mode choice is an input into determining how an individual person trip may affect the overall transportation system by indicating what vehicle, right-of-way, and termini that an individual may use.

1.2.3 Origins and Destinations

Origins and destinations represent where people traveled from immediately before arriving at a site (origin) and where they are traveling to immediately after leaving a site (destination). In combination with an individual's mode choice, knowing origin and destination helps to determine which transportation facilities they may use. For instance, if some individuals are identified as taking transit to a site in the San Francisco Financial District from the East Bay, they are likely using BART or AC Transit Transbay service. Knowing the individuals' specific origins and destinations (especially their proximity to BART stations) would enable a better assumption about which transit service they would likely use. In other cases, a large number of options may exist (such as driving trips along the high-connectivity urban street grid) and it may not be feasible to identify which transportation facilities would be used for such trips.

Knowing the origin or destination of individuals who drive or use other vehicle modes also provides the information necessary to estimate vehicle miles traveled (VMT) on a site basis. VMT provides a simple method for translating travel demand for a site into the amount and distance a project may cause people to drive[7].

1.2.4 Loading Demand

Loading demand represents how the trips generated by a site will affect the use of available loading space. This loading space may be off-street, such as in a loading dock or driveway, or it may be on-street and occur at the curb. Off-street loading activity may involve deliveries or larger service vehicles, while on-street

[7] The above statement applies to a trip-based method of calculating VMT, in which a site's vehicle trip generation is multiplied by the average vehicle trip length. This is the most rudimentary way of calculating VMT, as it does not account for differences in whether the site is producing trips or attracting trips, how many of the trips are "pass-by" or diverted trips, or whether development of the site affects travel behavior at other sites. More complicated VMT calculation methods often involve producing new model runs to reflect how land use changes affect all trip-making behavior in the vicinity.

loading activity may be either deliveries or passenger loading (such as when an individual is dropped off or picked up). Loading demand is expressed in terms of a number of expected loading instances during peak hours, along with an average expected length of stay. The loading analysis largely involves inspection of curb occupancy data, data from other sources, and some use of doorway intercept survey data. A full discussion of the loading data collection and analysis effort is presented in Chapter 7.

Chapter 2. Overview of Data Sources

Two primary data collection methods were used to collect the data points discussed in Chapter 1: video counts, which were used to capture person trip generation, and intercept surveys, which were used to collect information on individual travel behaviors. In addition, time lapse photography was used to collect loading observations and assess general occupancy levels of loading zones adjacent to study sites.

To conduct a full accounting for person trips to and from individual sites, Fehr & Peers contracted with IDAX to conduct video counts of all access and egress points to a site. If a site had direct access from a garage (e.g. interior doorways or elevators opening on to an indoor parking garage), cameras were directed at pedestrian entryways and at garage doors / driveways. If a site did not have direct access from a garage, cameras were directed at only pedestrian entryways from the street level.

Counts were collected at both pedestrian entryways and driveways over a 24-hour period using video cameras directed at each doorway, driveway, or other entrance. Sites identified for video counts of person trips were visited, and data collection sheets were provided to the count firm conducting the video counts (a sample data request sheet is included as **Appendix B**). The key limitation to the use of video counts for doorways is that they may capture multiple "non-trips" (such as employees taking breaks, people making multiple trips to carry a delivery, or other cases where someone is neither leaving nor arriving at the location in question) that still involve entering or exiting the building. By reporting the share of responses to surveys that indicated that no trip was being made, we can infer for each land use roughly how many of these cordon crossings were not the start or end of a trip.

Pedestrian Door Counts

For pedestrian doors with external access at all sites, individuals entering or exiting the door were counted in 15-minute increments. These counts included all individuals that crossed the doorway screenline as marked on the data request sheets provided to the data collection firm.

Garage Door Counts

At sites with garages that provide direct access to buildings, counts were also performed for driveways to ensure that all trips were counted; to avoid double counting at these sites, no person trip data were collected at interior doorways, such as those connecting a garage to a building lobby. The same principles for pedestrian doors were applied to garage doors, but counts were split into three modes: automobile, bike, and walk; person trips by walking had the associated mode split from corresponding intercept surveys applied to them. This was done to accurately record trips for modes that could not be easily surveyed, such as those arriving via car and proceeding directly to a private garage. This methodology was used only for sites where a full cordon could not be established without conducting garage/driveway counts; i.e., those that had direct access from a garage to the building interior.

Vehicle trips counted at garage doors and driveways were translated into person trips by multiplying by an average vehicle occupancy (AVO) figure. This AVO depended on the site's land use type and its geographic location within San Francisco. AVO ranged from 1. 13 to 2.31[8] persons per vehicle, and had an average of 1.61 persons per vehicle overall.

Intercept Surveys

The intercept survey instrument was intended to gather two key pieces of information: how an individual arriving at the survey site traveled to that site, and where they traveled from. In the case of individuals intercepted while leaving the site, the survey instead asked how they were traveling to their next destination, and where that destination was located. These data points allowed for an assessment of both mode split and trip distribution at the site level.

Intercept surveys were conducted by individual surveyors. Each site was subject to one day of surveying during the extended PM peak period of 3:00 to 7:00 PM. During this time, surveyors were instructed to engage individuals entering or exiting the site for a brief survey.

For the surveys, the instructions for which are provided in **Figure 1**, the basic procedure involved intercepting as many individuals entering and exiting the site as possible, asking about their primary mode of travel to and from the site, and recording their responses or marking them as 'No Response'. If a respondent answered with multiple modes or asked for clarification, it was specified that the respondent should give their most recent mode of travel from their previous destination or their expected travel mode to the next destination, excluding walking.[9] These responses were recorded in 15-minute intervals. In addition to the initial mode question, individuals who drove or had a package were asked if they were making a delivery. Additionally, individuals responding that they drove were asked if they had driven alone or if they had passengers; the former was recorded as 'Drive Alone' while the latter was recorded as 'HOV Driver.'[10]

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[8] See section 4.1.3 for a detailed discussion of how this parameter was derived from California Household Travel Survey data.

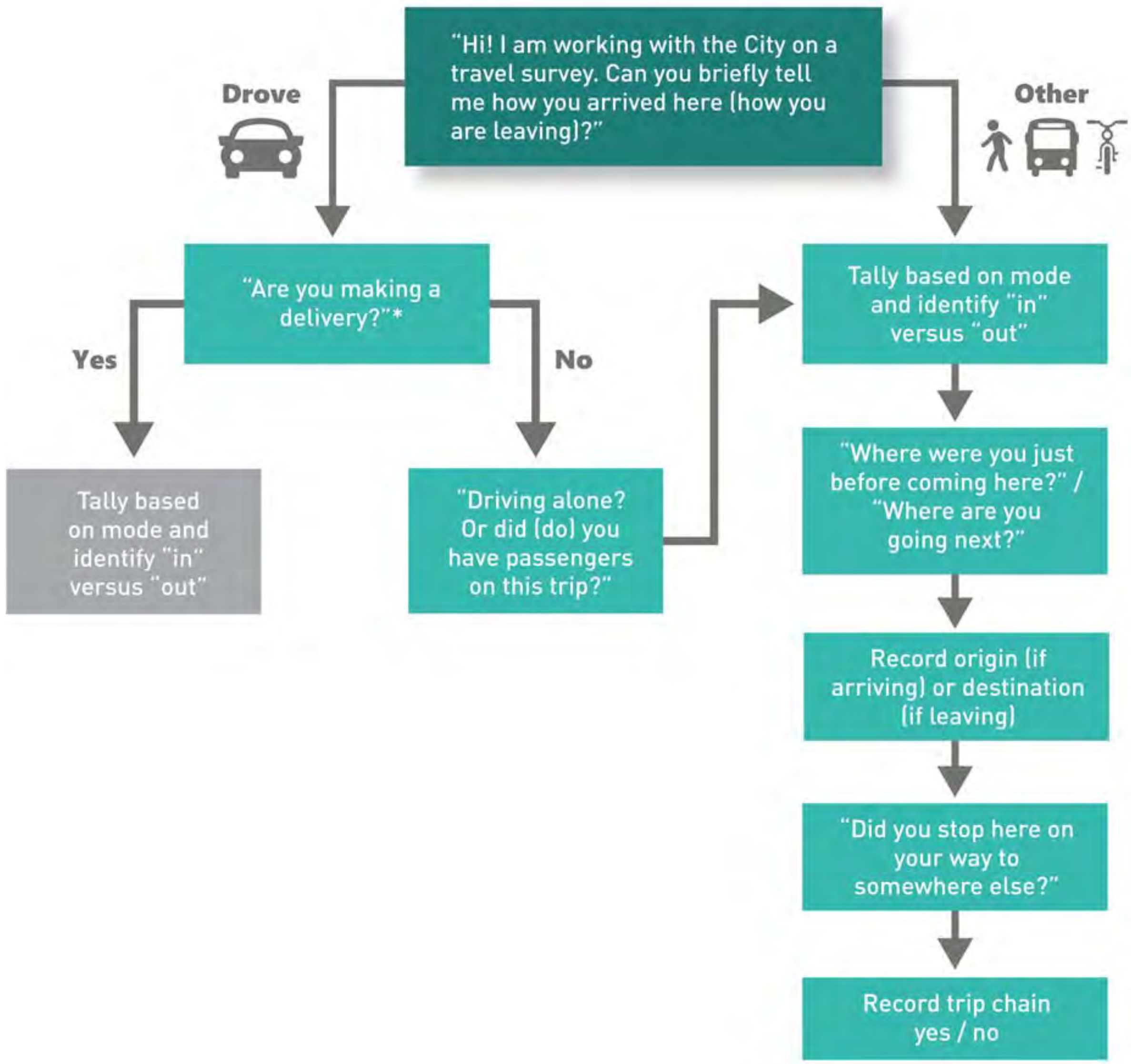
[9] The exception to this was if the entire trip was taken on foot. In such cases, 'Walk' was recorded as the mode of travel.

[10] At sites with driveways, the calculated AVO was applied to driveway trips to estimate the share of individuals arriving as solo drivers, HOV drivers, and HOV passengers.

Following the mode question, respondents were then asked where they came from immediately before arriving at the site (if they were making an inbound trip) or where they were travelling to immediately after leaving the site (if they were making an outbound trip). Surveyors were instructed to collect information based on an address or cross-street if possible, with the next highest priority being a neighborhood (if within San Francisco) or a city (if outside of San Francisco). Finally, respondents were asked whether they stopped at the site on their way to another location, allowing for estimation of what share of trips occurred as part of a larger trip chain (i.e., stopping at the store on the way home from work).

Responses were recorded on data collection sheets, with one response per line. These data collection sheets were then transferred into a Google spreadsheet for analysis at the person trip or site level. An example of the retail survey data recording sheet can be found in **Appendix C**.

Figure 1: Survey Instructions



*This question was also asked to non-drivers who were carrying a parcel, package, or food delivery. As such, some "delivery" trips were also flagged as bicycle or walk trips. The delivery flag serves as an additional indicator, and delivery trip mode was included in the sample based on the survey response.

Chapter 3. Data Collection

This chapter details the data collection process, including reconnaissance of sites and site identification and selection, preparations in advance of data collection, and notes on the data collection process itself.

3.1 Site Selection

Fehr & Peers worked in partnership with SF Planning staff to identify sites for data collection. Site selection began with a list of recently constructed buildings, based on a query of SF Planning records. Additional sites were identified through a combination of further permit database queries and manual examination of existing buildings to attempt to identify enough sites in a given category. In sum, a total of 199 potential sites for data collection were identified, of which 118 were deemed suitable for one or more methods of data collection, based on site reconnaissance. Ultimately, data were collected at 82 sites, with some sites having person trip data collected, some having interviews collected, and some having both collected.[11] **Appendix D** provides a full list of sites selected, including type of data collected, address, land use, and overall size.

Separate sets of sites were considered for the three data collection categories: person trip generation (i.e., counts), intercept surveys, and loading observations. Generally, sites were selected due to the potential to collect all three data elements at each site; however, following site reconnaissance, it was common to discover that a site's context made one or more of the data elements difficult to collect accurately. As an example, a site may have doorways situated such that person counts are easy to collect, but not have an easily visible loading zone adjacent to the site.

3.1.1 General Considerations for Data Collection Sites

Sites were selected using the following guidelines:

[11] Not all sites deemed suitable for data collection were ultimately selected for data collection. In some instances, there were more suitable sites than necessary for a given combination of land use and geography. In other instances, sites that initially appeared suitable proved to be infeasible upon further inspection or during data collection.

- Taken together, sites should provide adequate geographic coverage of the City
- Sites should represent a range of parking supply rates that are typical for the use in question
- Sites should represent a range of building sizes, including multi-family buildings with under 50 dwelling units or less than 10ksf of retail space
- Sites should be roughly generalizable to future development in terms of unit type, share of affordable housing, building age, and parking supply
- Sites should not have a shared parking garages[12]
- Sites should not contain multiple uses, or direct access between multiple uses (such as an office building with direct access from a café)
- Site entrances should be visible from and/or accessible from the public right-of-way when possible
- If possible, permission to survey should be provided by the property owner or property manager[13]

After this initial screening and prior to conducting counts and surveys, a site reconnaissance was conducted to confirm the viability of the sites. This was typically performed during the AM and/or PM peak period, so that pedestrian traffic volumes would be approximately consistent with the extended PM peak period, when surveys would be conducted (AM peak period site reconnaissance was limited to sites where we expected substantial trip-making in both the morning and evening; i.e., non-retail sites). The information collected during site reconnaissance included:

- General assessment of overall pedestrian traffic volumes, to determine appropriate surveyor staffing levels[14]
- Identification/verification of access points
- Identification of recommended surveyor and counter 'standing locations'

[12] Such sites were rejected because auto trips for the use in question could not be distinguished from auto trips generated by other uses, such as ground floor retail.

[13] For each site, we identified the property owner or manager via a combination of City records and web search and attempted to contact them via phone call. In addition, letters were provided to surveyors stating the general purpose of the surveys and providing contact information for City staff in the event of questions or concerns raised on the day of surveying.

[14] In particular, it was determined whether multiple surveyors would be needed due to a high volume of pedestrian activity.

- Observation of any other ambient circumstances or peculiarities of the site which would not be conducive to site surveying[15]

A sample of the data collected during site reconnaissance can be found in **Appendix E**. An excerpt of a completed site reconnaissance form is shown in Error! Reference source not found..

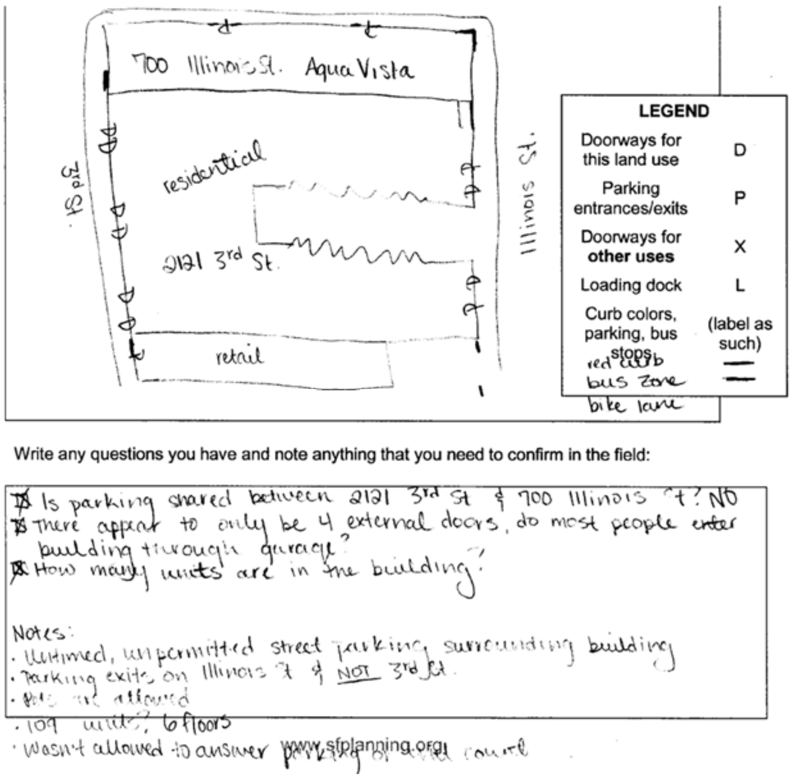
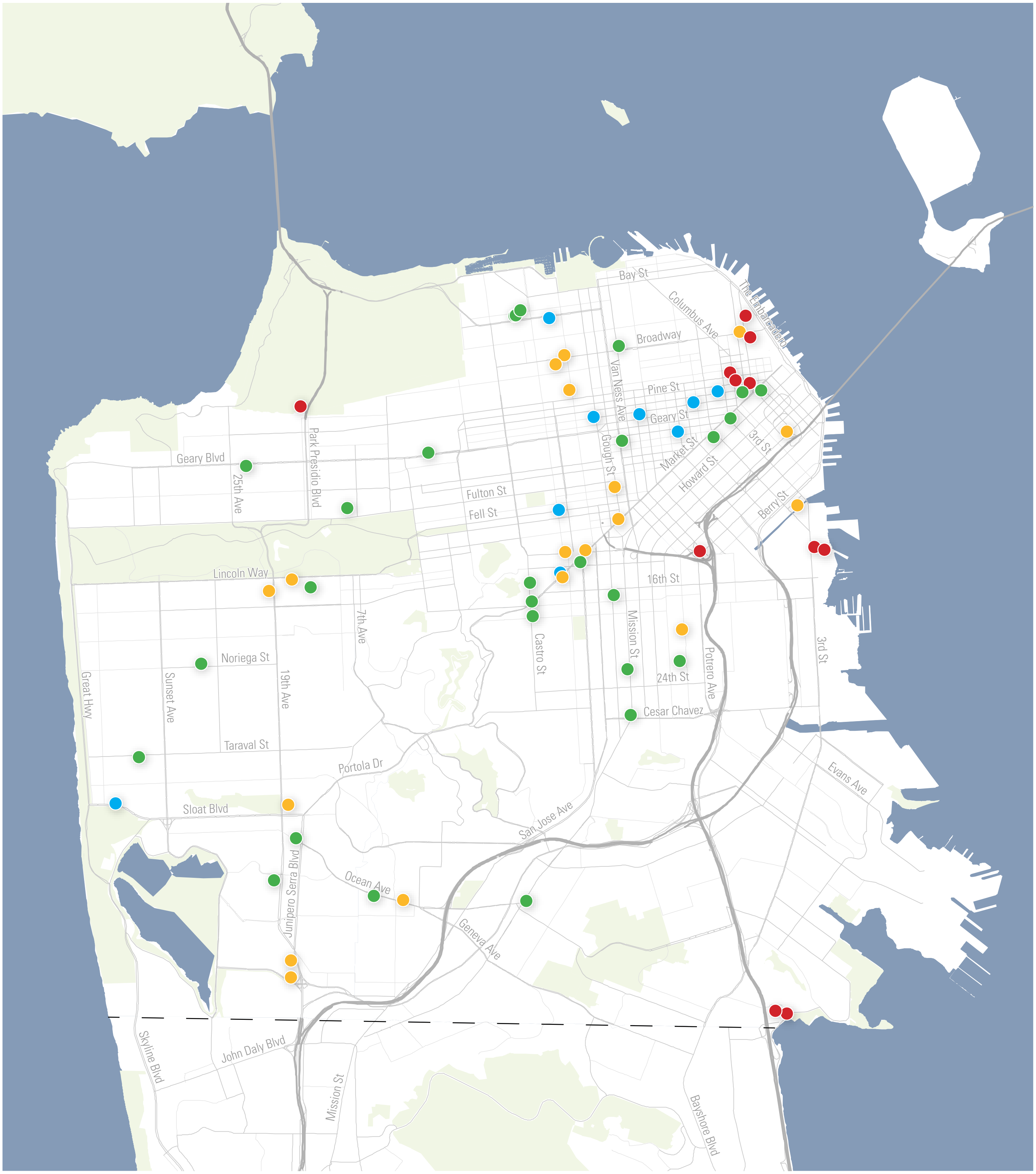


Figure 2: Excerpt of site reconnaissance form for 2121 3rd Street (site not ultimately included in data collection).

3.1.2 Site Selection: Person Trip Generation

In addition to the above considerations for data collection, sites selected for person trip generation data collection were required to have a clear line-of-sight of all access points from the public realm. This was to facilitate placement of cameras to conduct video counts at doorways and driveways. In total, 65 sites were selected for person trip generation data collection; their locations are shown in **Figure 3**.

[15] This could include construction activities, concerns for surveyor safety, or identification of additional doorways unsuitable for conducting counts.



Data Collection Sites by Land Use

- **Office** (11 sites)
- **Retail** (27 sites)
- **Residential** (19 sites)
- **Hotel** (9 sites)

Miles 0 1 2

NORTH

Figure 3

Sites with Person Trip Generation Data

3.1.3 Site Selection: Intercept Surveys

In addition to the above considerations for data collection, sites selected for intercept surveys were required to have direct access from the public right of way that included adequate space for a surveyor to stand and intercept pedestrians. Additional consideration was given to whether the building owner or primary tenant would allow surveyors site access and garage access when applicable to conduct surveys during business hours. This was of special concern for sites that provided direct access to the land use being studied from the garage. Because the intercept surveys collected origin and destination information in addition to mode, if surveyors did not have access to the garage the resulting distribution information would be biased away from driving patterns. While this concern was partially addressed through the integration of additional data sources, as discussed in section 4.1, efforts were made to choose data collection sites where direct surveying of individuals using the garage was feasible.

Additionally, due to the personal nature of intercept surveys, Fehr & Peers prioritized sites that had given permission for surveyor access at public doorways, or, at a minimum, sites where surveyors were able to reach a property manager or owner and inform them of survey efforts. The outreach effort included identifying property owners from City records as well as property managers or primary tenants via web search or direct contact (e.g.., asking at a retail store to speak with a manager during site reconnaissance). While there were several sites where we were unable to contact a representative, in most instances individuals were informed of survey efforts prior to the day of the surveys.

In total, 65 sites were selected for intercept survey data collection; their locations are shown in **Figure 4**.

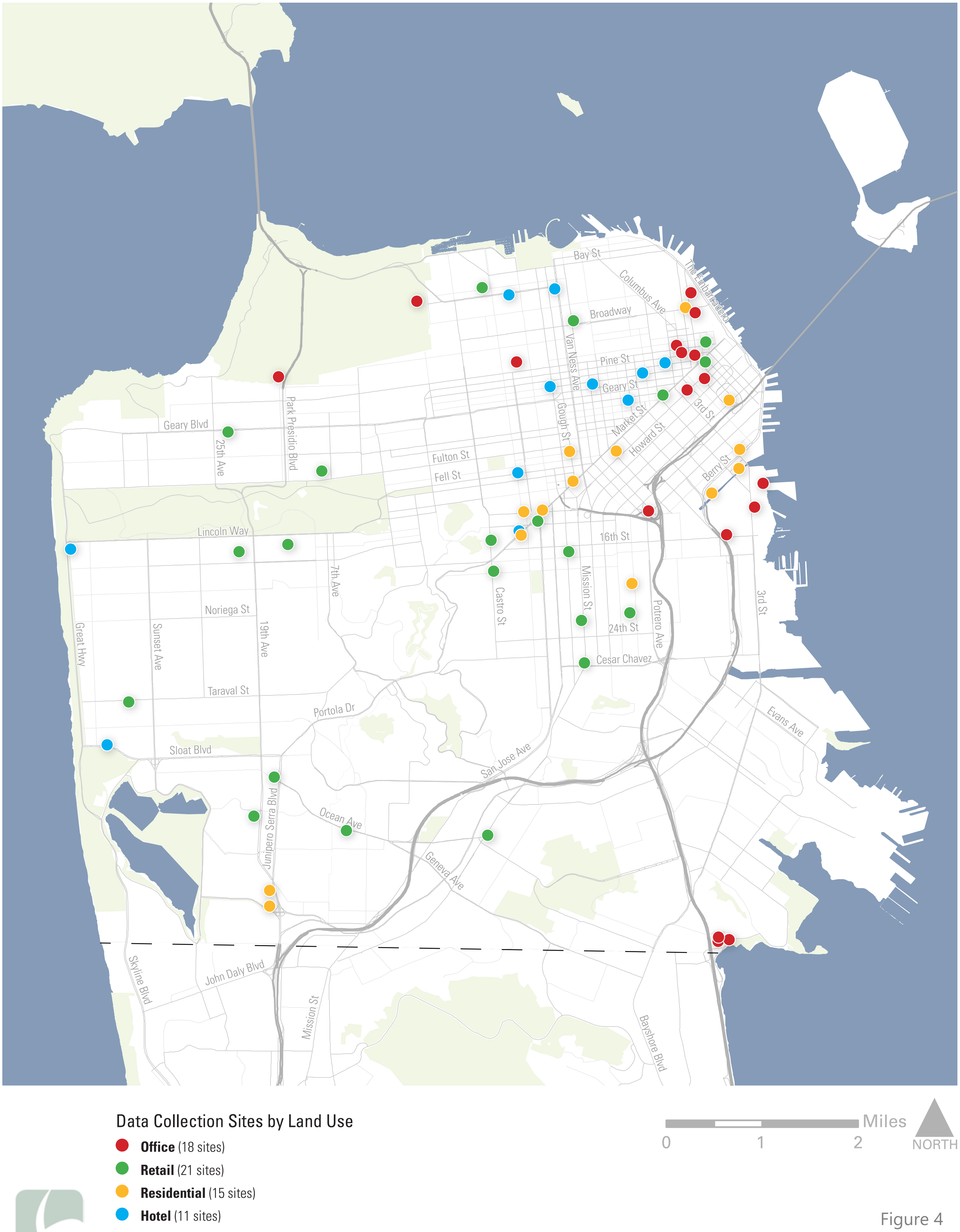


Figure 4

Sites with Intercept Survey Data

3.2 Video Data Collection

Video data collection occurred in spring 2017 and was conducted by IDAX. This included both loading observations and doorway and driveway counts at the sites selected for each. In two cases, counts were unable to be used for analysis due to construction activity blocking the camera. Person counts were deliberately collected on days other than when surveys occurred. This was to insure that surveyors did not block the screenline or affect individual movement patterns in the immediate vicinity of each doorway; as such, there is some risk that travel patterns differed between the dates of the surveys and the dates of counts.

Following data collection, data were processed by IDAX and provided to Fehr & Peers in spreadsheet format for each site. Fehr & Peers then performed basic quality checks on the data and aggregated the spreadsheets to allow for further analysis.

3.3 Intercept Surveys

Intercept surveys were conducted in two waves. The first occurred in fall 2016, consisted of 27 sites, and was performed by temporary staff managed by Fehr & Peers. The second wave occurred in spring 2017, consisted of 38 sites, and was performed by data collection firm Corey, Canapary & Galanis Research.

All survey staff in both waves were required to attend a training to ensure they had a thorough understanding of any data collection role they were performing. Training involved the following key elements:

- Ensuring surveyors have a proper understanding of the goal of the project – to determine total person counts, mode splits, and trip distribution
- Training surveyors on how to approach and engage the survey subject
- Emphasizing that minor variations of the survey questions were acceptable to render them more natural for each surveyor
- Acting out the survey process to identify any uncertainties new surveyors had
- Ensuring that the surveyors read all pertinent information by reviewing each sheet in the survey packet carefully
- Stressing the importance of clear documentation

Survey packets were created for each survey site the week before surveying occurred and were subsequently distributed to each surveyor by providing a link to a cloud-based storage system. The intention of the survey packets was to provide all surveyors with all instructions, information, and materials necessary to carry out their duties; an example survey packet is provided for reference in **Appendix F**. Each survey packet contained:

1. Cover sheet with information about:
    a. Name and phone number of all surveyors and supervisors
    b. Roles and timeslots for each surveyor and supervisor
    c. Building contact and instructions for day-of check-in if necessary or requested
2. Key instructions and reminders
3. List of survey packet contents and supply checklist
4. Diagram of site with:
    a. Numbered entrances/exits and garage doors
    b. Suggested surveyor standing positions
5. Materials relevant to recording data:
    a. Relevant data recording sheets
    b. Flowcharts and tables of survey procedure for each type of role
    c. Examples of completed sheets for each type of role
6. Post-survey instructions

After selecting survey sites and identifying the number of staff required to conduct the surveys, the sites were entered into a schedule where staff members were assigned shifts; scheduling was required to adhere to certain conditions, described in the section below, to ensure data quality and consistency. Once chosen, survey dates were also finalized with building or property managers, where possible.

In recognition of the fact that many events can impact travel choices, this effort took care to:

1. Conduct data collection only on Tuesdays, Wednesdays, and Thursdays. Mondays and Fridays were avoided because travel schedules on these days are more variable and less comparable to mid-week days
2. Avoid weeks with holidays
3. Avoid days with street fairs, sporting events, or parades that may affect the travel patterns on and around the site
4. Watch for anticipated severe weather and change data collection days accordingly

Data collection was planned for the extended PM peak period, from 3:00 PM to 7:00 PM, as discussed in section 1.1.2.

Common issues that arose during the surveying process include:

- Concerns from property owners, security guards, and managers. Efforts were made to contact representatives from each site prior to the survey date; however, if permission was not secured in advance, survey staff were instructed to politely inform concerned individuals that surveys were being conducted in the public right-of-way, but to cease surveying if the individual continued to express concerns. Property manager concerns resulted in a total of two sites being removed from the survey schedule.
- Language barriers. At some locations, there were larger populations of individuals who were not comfortable responding to English-language surveys. These populations may have different travel patterns than English-speakers; however, this analysis does not include responses provided in a language other than English.
- Unresponsive populations. Some sites had higher response rates than others, and may therefore be oversampled. The response rate represents the number of individuals asked to take the survey who completed it over the number of all individuals arriving at or leaving the site.
    - Overall, an average response rate of 67% was achieved. Individual sites' response rates ranged from 34% (Trader Joe's, 265 Winston Drive) to 100% (1600 Market Street and 1234 Great Highway).
    - The average survey response rate at retail sites (59%) was lower than at hotel (72%), office (73%), or residential sites (76%).
    - Because no demographic data were collected, it is not possible to examine whether individuals' sociodemographic affiliations affected their likelihood of responding to the intercept survey or analyzing their travel demand characteristics.
- Weather. While effort was made to avoid surveying on rainy days, late 2016 to early 2017 were uncharacteristically rainy, which affected the survey schedule (due to canceled surveys from inclement weather) as well as potentially affecting travel patterns (on days with light rain when surveys were conducted).

Chapter 4. Supplemental Data Sources

In addition to the video trip counts, intercept surveys, and time-lapse loading data collected for the Travel Demand Update as summarized in Chapter 3, the California Household Travel Survey (CHTS) was used as a means of filling in gaps in the survey data and providing additional context due to a wider breadth of applicability. Because the overall data collection effort detailed in Chapter 3 was focused on individual sites, there was the potential that more generalized travel patterns common to existing San Francisco residents may not be captured. This was especially pertinent for items captured via survey response, such as origin and destination for trips, trip chaining behaviors, and mode choice. By incorporating the larger data set of the CHTS, which included 12,094 trips made to, from, or within San Francisco, Fehr & Peers was able to provide a higher level of confidence in this data source.

4.1 California Household Travel Survey

The California Household Travel Survey (CHTS) is a statewide dataset of multi-modal travel behavior and household demographics. Historically, the CHTS is conducted by Caltrans approximately every ten years. The most recent CHTS ("2012 CHTS") was initiated in 2010 and concluded in 2013, with the majority of data being collected during 2012.

The 2012 CHTS includes data from a total of 42,430 households, collected using telephone surveys and Global Positioning System (GPS) devices from all counties in California. The dataset consists of individual trip entries, each of which includes an identifier for the individual making the trip, travel purpose, duration, travel distance, travel time, origin, destination, and mode choice. Demographic data are also available for each individual making the trip; these data include household size, income, vehicle availability, and household members' ages. Data are provided for 331,540 trips statewide, of which 12,094 (3.6%) have at least one trip end in San Francisco.

Fehr & Peers staff have prepared a modified version of the 2012 CHTS, which has been cleaned and processed for use on multiple projects. The cleaning process was used to address the following items:

1. Identify and repair unreasonable or missing trip distances.
2. Identify and consolidate transit trip chains.
3. Identify trip purposes.
4. Impute missing household income data.
5. Recode certain variables.

6. Attach Metropolitan Planning Organization and Census Designated Place information to trip and household records.
7. Aggregate information about persons in the household to the household record.
8. Attach person-level data to the trip records.

Details on these data cleaning steps are provided in **Appendix G**.

Fehr & Peers incorporated 2012 CHTS data into the Travel Demand Update for three reasons. First, as discussed in section 4.1.1, CHTS data supplemented newly collected survey data for calculating trip distribution; the data filled potential gaps in new survey coverage, most notably including residential sites. Second, as discussed in section 4.1.3, the CHTS data provided a large-sample-size basis from which vehicle occupancy parameters necessary for analysis of the newly collected data could be derived. Third, as discussed in section 4.1.4, analysis of CHTS data provided a comparison point to validate new residential trip generation rates.

4.1.1 Trip Distribution

CHTS data were used to supplement newly collected intercept survey data in calculating trip distribution tables for each land use type. As presented in section 6.3 below, trip distribution tables were developed using three methods: new survey responses alone, CHTS trip records alone, and a blend of CHTS and new survey data. This process enabled Fehr & Peers to assess the reasonableness of the newly collected data, as well as supplement the new data with additional records. Adding CHTS data to the newly collected survey data most notably helped address small sample sizes from certain land use/geography types, and residential sites in Place Type 3.

Intercept surveys were conducted between 3:00 and 7:00 PM. To enable an apples-to-apples comparison, CHTS data were limited to trip records whose departure time was between 3:00 and 7:00 PM, a total of 3,982 records (3,968 of which were able to be associated with the geographic regions used in the trip distribution analysis).

The Fehr & Peers processed CHTS dataset includes seven trip purpose categories; these categories were associated with “office-type,” “retail-type” and “residential-type” flags in order to facilitate the combination of CHTS and new survey data. **Table 1** shows the seven trip purpose categories and their association with the three “land use-type” flags.

Table 1: CHTS Trip Purposes and Land Use-type Flags

Trip Purpose	Office-type	Retail-type	Residential-type
Home-based College (HBC)			Yes
Home-based K-12 School (HBK)			Yes
Home-based Other (HBO)			Yes
Home-based Shop (HBS)		Yes	Yes
Home-based Work (HBW)	Yes		Yes
Non-home-based (NHB)		Yes	
Work-based Other (WBO)	Yes		

Source: CHTS, 2012; Fehr & Peers, 2018.

For each of the land use-type flags, a PivotTable was prepared in which trips' sample weightings were summed by origin and destination geographies.

The sum of the sample weightings of CHTS trip records relevant to PM extended peak trip distribution (4,265)[16] was similar to the number of survey responses with valid origin/destination locations (4,712). Therefore, the CHTS and new survey data were combined in a simple 1:1 fashion, in which the sum of CHTS sample weightings for a given origin/destination (O/D) pair was added to the count of new survey responses for that O/D pair to produce the blended trip distribution tables.

Limitations

Because Home-based Shop and Home-based Work trips are included in multiple land use-type tables, these trips are double-counted in the CHTS analysis. Of the 3,982 trip records included in this analysis, 326 (8.2%) were double-counted as Residential-type and Retail-type, and 712 (17.9%) were double-counted as Residential-type and Office-type. No records were triple-counted.

[16] Fehr and Peers used a statistical sample weighting to balance the CHTS survey sample to match county-level percentages for several variables (e.g. household income, number of workers per household) as reported in the 2012 American Community Survey to account for population groups that might over or underrepresent in the survey sample.

4.1.2 Trip Distribution by Mode

In addition to checking overall trip distribution against CHTS, SFCTA staff provided an assessment of neighborhood-to-neighborhood trip distribution by mode of travel, based on the full CHTS data set. This analysis, as prepared by the SFCTA, stratifies all trips between districts based on whether they were work trips or non-work trips, and by the mode used. Additional information on this analysis method is included as **Appendix H.**

Limitations

CHTS data stratified by both trip purpose (specifically work and non-work) as well as by origin-destination pairing results in small sample sizes for several O-D pairs and several modes of travel. This largely reflects that there is limited daily travel between certain districts of San Francisco, and that some districts have lower population levels than others (and thus fewer recorded total trips in the CHTS). Nonetheless, extrapolating from the CHTS sample may necessarily result in findings of zero percent distributions for certain O-D pairs.

4.1.3 Vehicle Occupancy

Five parameters pertaining to vehicle occupancy were extracted from CHTS data. These parameters were based on all trips beginning or ending in San Francisco and made by a private vehicular mode (Drive Alone, Drive Shared 2, Drive Shared 3, Drive Shared 4+). There were 6,385 trip records matching these criteria. These trip records were then de-duplicated in order to ensure that each vehicle trip appeared only once in the dataset. Approximately 1,400 trip records took place in the same vehicle as other records; most of these "duplicate" trips involved multiple members of the same household making the same vehicular trip. Records were de-duplicated by comparing the concatenation of household ID, trip start time (hour/minute), and trip end time (hour/minute).

The parameters below were used to supplement the newly collected data, particularly with regards to vehicle occupancy, which was not available through the data collection process due to limitations with video data collection.

- **Average vehicle occupancy (AVO)** was needed in order to transform driveway vehicle counts into person-trip counts for the trip generation analysis.

  - For each combination of land use[17] and geographic area,[18] AVO was calculated as the weighted average of all records' occupancy counts, weighted according to each trip's sample weight as calculated in the CHTS dataset.
  - The range of AVOs thus derived is shown in **Table 2** below.
    - Because hotel trips are not significantly represented in CHTS, the overall average AVO of 1.61 was used for all hotel sites.
- **Percentage of vehicle trips with one occupant (SOV %)** was needed to calculate the percentage of *person trips in vehicles* that are single-occupancy-vehicle (SOV) drivers, high-occupancy-vehicle (HOV) drivers, and HOV passengers.
  - SOV % was calculated as the weighted proportion of de-duplicated trip records that were Drive Alone trips.
  - SOV % was thus derived as 61.1%. In other words, 61 percent of vehicle trips are SOV trips.
- **Percentage of person trips in vehicles with one occupant (SOV Driver %)**, **percentage of person trips in vehicles that are high-occupancy vehicle driver (HOV Driver %)**, and **percentage of person trips in vehicles that are HOV passenger (HOV Pax %)** were needed in order to determine detailed mode splits for person trips observed at sites' driveways, when driveway/garage survey data were unavailable.
  - SOV Driver % was calculated as the weighted proportion of vehicle person trips that were Drive Alone. using AVO and SOV %:
    - $SOV\ Driver\ \% = \frac{SOV\ \%}{AVO} = \frac{0.611}{1.61} = 0.380 = 38.0\%$
  - HOV Driver % was also calculated using AVO and SOV %:
    - $HOV\ Driver\ \% = \frac{1-SOV\ \%}{AVO} = \frac{1-0.611}{1.61} = 0.242 = 24.2\%$
  - The remainder of person trips in vehicles were therefore HOV passenger trips:
    - $HOV\ Pax\ \% = 1 - SOV\ Driver\ \% - HOV\ Driver\ \% = 1 - 0.380 - 0.242 = 0.378 = 37.8\%$

  These data indicate that among all person trips in private vehicles, 38 percent are made by SOV drivers, and 62 percent are made by HOV drivers and passengers (i.e., carpools) combined.

These parameters were used in the mode split analysis to translate the count of person trips in vehicles into counts of person trips by SOV and HOV modes.

[17] This analysis used the same land use-type flags as the trip distribution analysis discussed in section 4.1.1 above.
[18] See section 5.6 below for a discussion of the geographic units used for this analysis.

Table 2: Average Vehicle Occupancy by Land Use-type and Geography

Geography	Land Use-type			
	Residential-type	Office-type	Retail-type	All
Place Type 1	1.45	1.25	2.05	**1.63**
Place Type 2	1.56	1.24	1.80	**1.61**
Place Type 3	1.56	1.22	1.71	**1.60**
North Bay	1.35	1.25	2.27	**1.55**
East Bay	1.66	1.44	2.31	**1.79**
South Bay	1.44	1.13	1.89	**1.51**
All	**1.53**	**1.23**	**1.85**	**1.61**

Source: California Household Travel Survey, 2012; Fehr & Peers, 2018.

Limitations

While AVO was calculated for each combination of land use-type and geography, the other parameters (SOV %, SOV Driver %, HOV Driver %, and HOV Pax %) were based on all CHTS auto-type trip records with at least one end in San Francisco. In other words, only one, citywide value was calculated for these parameters. In actuality, these parameters would vary across land uses and geographic areas; however, this variation would be relatively minor. Furthermore, the downstream applications of these parameters are themselves relatively minor, such that using a citywide value for these parameters does not materially affect the outputs of the analysis in question (mode split).

4.1.4 Residential Trip Generation

The 2012 CHTS dataset was used to validate the new residential trip generation rates calculated for the Travel Demand Update. Specifically, the average number of home-based trips per household was calculated. This metric was developed because it is analogous to daily residential trip generation.

Similar to the categorization of CHTS trip records in section 4.1.1 above, trips were coded as "home-based" (i.e. "Residential-type" as shown in Table 1) or not home-based. The CHTS "trips" table was used to calculate the count of home-based trips per household and weighted to obtain the average number of home-based trips per San Francisco household (HBT_{avg}) as follows:

$$HBT_{avg} = \frac{\sum(hb\_trips\_num \times hhweight^{19})}{\sum hhweight}$$

To ensure parallelism with the video data collected for the Travel Demand Update, which were collected on Tuesdays, Wednesdays, and Thursdays, the CHTS "households" table was filtered to include only households whose "trip day" (i.e. the day of the week for which household members reported trip activity) was Tuesday, Wednesday, or Thursday.

The above procedure was applied to daily, AM peak hour, and PM peak hour trips. To calculate the approximate number of AM and PM peak hour home-based trips, it was necessary to identify the AM and PM "peak hours" in the CHTS dataset. These peak hours (7:30-8:30 AM and 5:00-6:00 PM) were identified by taking the sum of trips (weighted based on sample weights for each household) for (1) home-based trip records (2) with at least one end in San Francisco (3) recorded on a Tuesday, Wednesday, or Thursday (4) whose departure times fell within the trailing hour for each 15-minute period of the day. This analytical methodology enabled the identification of "peak hours" that are closely analogous to how peak hours are identified in a typical transportation analysis.

To enable an apples-to-apples comparison, CHTS data were limited to trip records whose departure time was between 3:00 and 7:00 PM, a total of 3,982 records (3,968 of which were able to be associated with the geographic regions used in the trip distribution analysis). This total is similar to the number of residential survey responses received; as such, the CHTS and new survey data were combined in a simple 1:1 fashion.

[19] hb_trips_num represents the number of recorded trips by a household, while hhweight indicates the sample weight to account for demographic factors.

Chapter 5. Geographic Analysis

Any transportation analysis methodology must define some set of geographic units for its use. This chapter discusses several geographic units that were considered for the San Francisco Travel Demand Update, presents maps of those units, considers their advantages and disadvantages, and recommends a set of units for use in the future.

5.1 Superdistricts

Planners in the San Francisco Bay Area have developed and maintained a set of Transportation Analysis Zones (TAZs) for use in transportation analysis. Of the 2,245 TAZs used by SF-CHAMP, 981 are within San Francisco. Historically, SF Planning has used "superdistricts" as its major geographic unit for transportation impact analysis. These four large aggregations of TAZs roughly divide the city into four quadrants, whose boundaries approximately follow Van Ness Avenue, Golden Gate Park, Townsend Street, Market Street, and the crest of the several hills that run south from Twin Peaks. The four superdistricts are shown in **Figure 5**.

Figure 6 shows three regions outside of San Francisco: the North Bay, East Bay, and South Bay. These regions, which encompass the nine-county San Francisco Bay Area, remain the same across all the sets of geographic units under consideration.

5.1.1 Advantages and Disadvantages

The traditional superdistricts have three advantages as geographic zones for transportation analysis. First, they are currently in use for transportation impact analysis, so their use in the future would ensure continuity and reduce the level of effort required to publicize a change in geography. Second, the low number of zones (four San Francisco zones, plus three regions outside the city) presents a reasonable burden for staff (within the City Family and among consultants; the most frequent users/consumers of the current system) preparing transportation impact analyses: that is, a lower number of zones can correspond to a lower number of zone-to-zone pairs. Finally, a rough geographic direction is generally clear from zone to zone. For example, the entirety of Superdistrict 2 (SD2) lies to the west of SD1, so it is clear that a SD1-SD2 trip must be an east-west trip. This can help clarify trip assignment, including transit trip assignment.

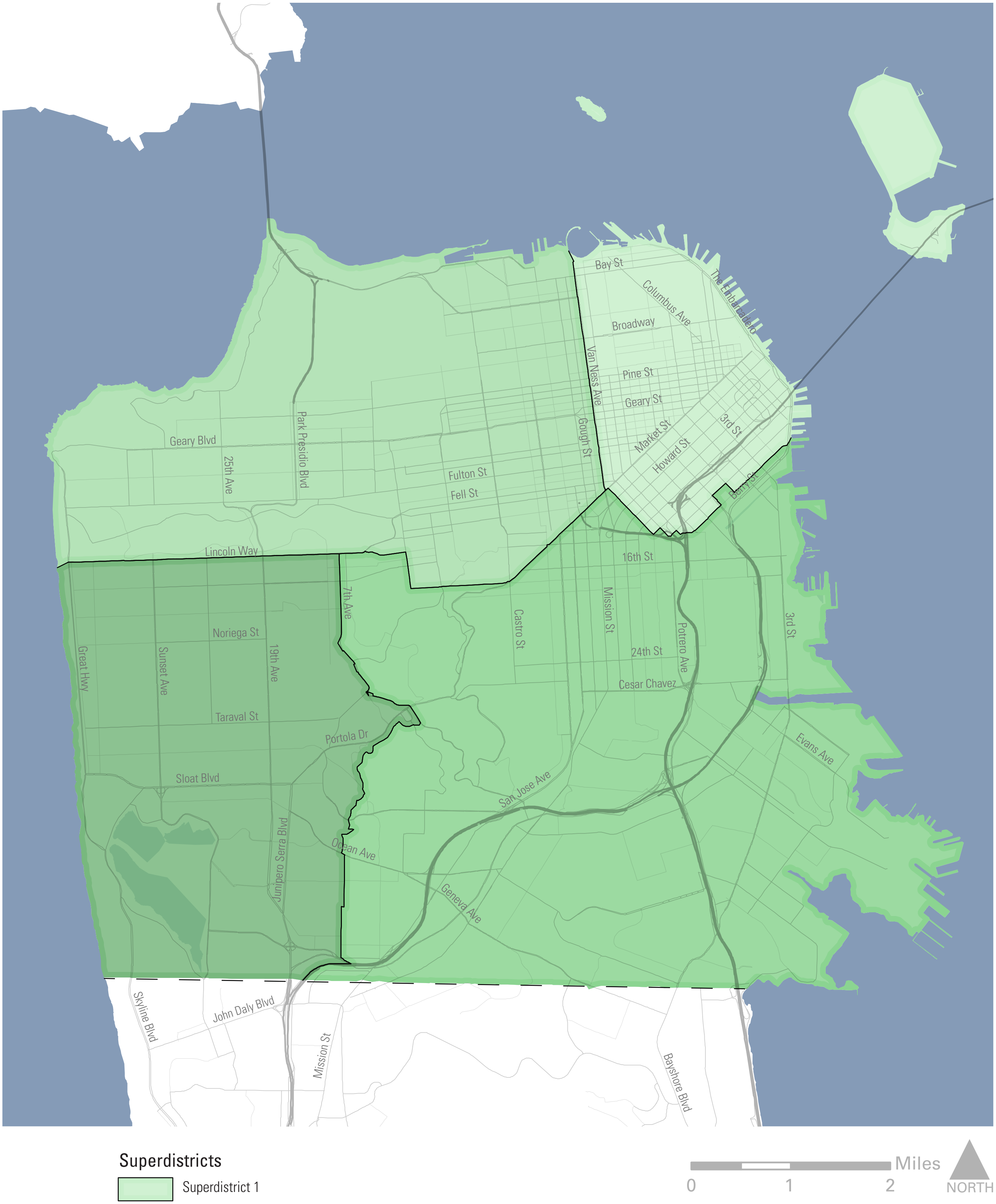


Figure 5

Superdistricts

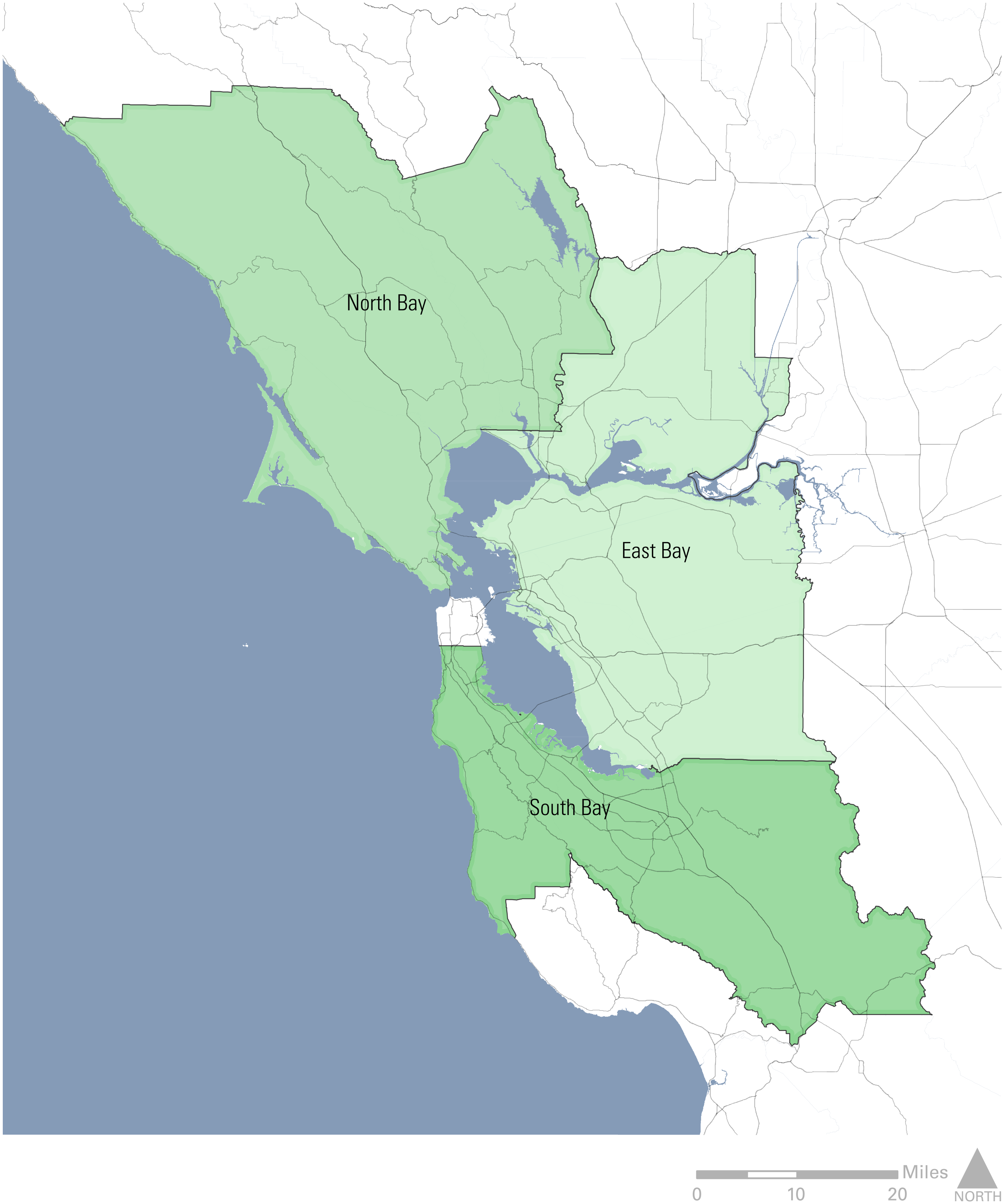


Figure 6

Regions Outside of San Francisco

At the same time, the superdistricts have several disadvantages. Heterogeneity of land use and transportation characteristics within a given superdistrict has long been an issue, particularly as variables that affect travel behavior (land use density, transportation projects) may change specific locations within a superdistrict. This is especially true of SD3, which contains a mix of compact, low-VMT development in neighborhoods like Mission Bay, quasi-suburban areas such as Twin Peaks, mixed-income transit corridors through the Mission and Outer Mission, and new master-planned development in Hunters Point and Candlestick Point. As such, the mode split and trip distribution data for a superdistrict may not closely resemble the travel activity in any given neighborhood within that superdistrict. Furthermore, the large size of the superdistricts can make trip assignment more challenging. This is especially true of transit trip assignment, and especially with regard to SD3. While the geographic direction of an SD1-SD3 trip may be fairly clear, the transit corridor on which that trip would occur will vary dramatically depending on the specific destination within SD3.

5.2 Traffic Analysis Zones

Many of the limitations of superdistricts have to do with their large size. Therefore, the use of TAZs was considered. As mentioned above, SF-CHAMP models a system of TAZs, 981 of them within San Francisco. Each TAZ's auto mode share was available as an output of SF-CHAMP, resulting in a fine-grained picture of the gradient of travel characteristics across San Francisco. San Francisco's TAZs, symbologized according to auto mode share, are shown in **Figure 7**.

5.2.1 Advantages and Disadvantages

As a geographic unit, TAZs are well-suited for use in a travel model. Their small size enables local transportation characteristics to be represented. However, TAZs are much too small for use as geographic units for SF Planning's transportation impact analysis workflow. The geographic units used in the SF Guidelines must be sufficiently large to enable the calculation of average mode split and trip distribution based on a set of primary data collection sites. Given the statistical noise inherent in primary data collection, several sites per geographic unit are needed. It would therefore take thousands of data collection sites to properly determine travel characteristics for each of San Francisco's 981 TAZs. Additionally, it would be too cumbersome to handle trip distribution and assignment among almost a thousand zones; at this level of effort, direct use of the model would likely be more appropriate. The use of existing model outputs may, however, serve a valuable purpose in travel analysis by allowing for a more generalized mode share to be established based on prior model runs. The primary limitation of this data is that it reflects only the land use and transportation network recorded in the model; a new land use to a neighborhood may not have the same level of detailed information.

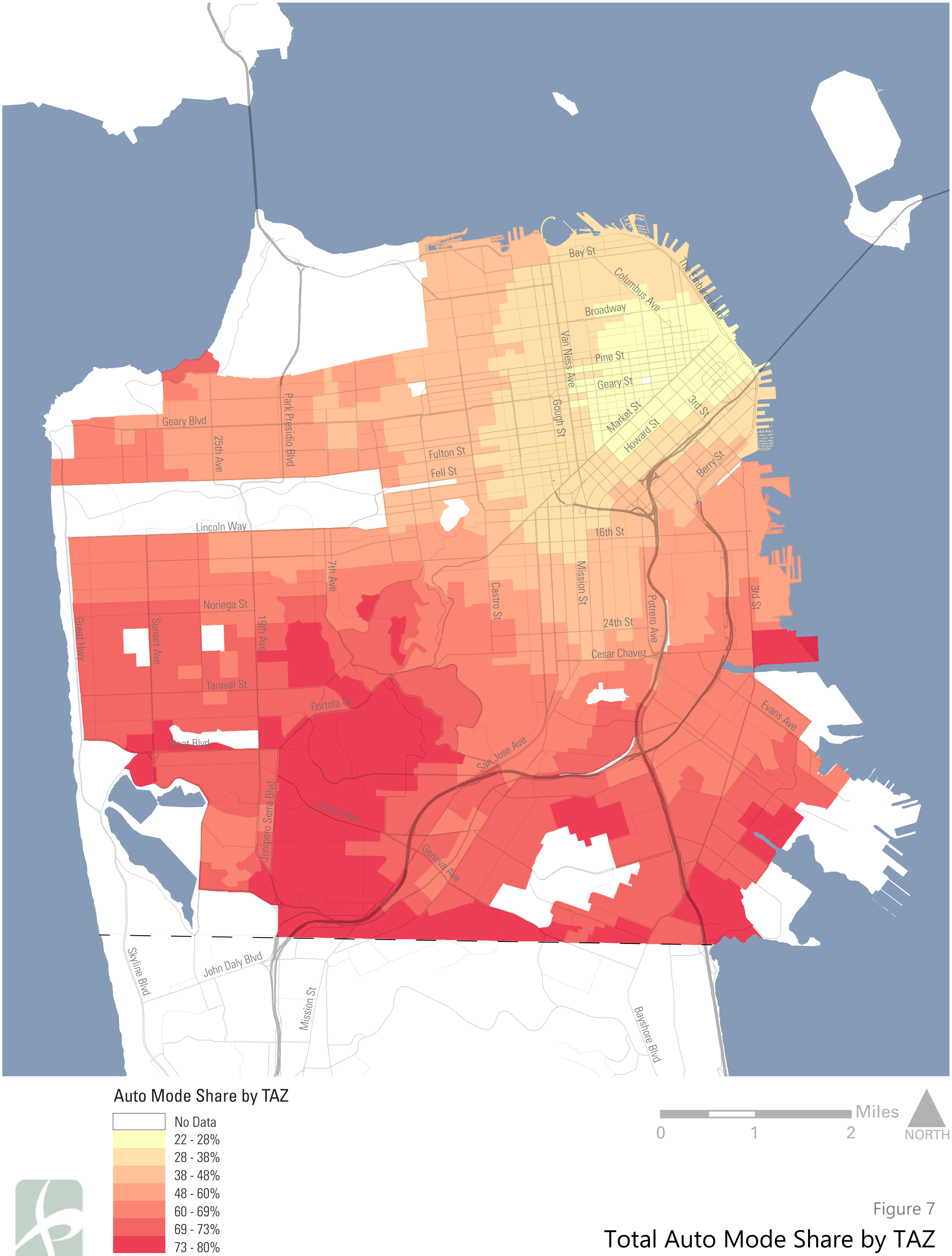


Figure 7

Total Auto Mode Share by TAZ

5.3 Place Types by TAZ Auto Mode Share

The auto mode share estimates from SF-CHAMP, available at the TAZ level as the average of the TAZ and surrounding TAZs, provide a basis for grouping the TAZs into a set of "place types." The groups are labeled as "Urban High Density" (low auto mode share), "Urban Medium Density" (moderate auto mode share), and "Urban Low Density" (high auto mode share).[20] Auto mode share serves as a proxy for several other neighborhood characteristics, which include the level of high quality transit service, residential and employment density, and the overall mix of uses within a neighborhood.

Of the 981 TAZs within San Francisco, 895 have auto mode share data from SF-CHAMP.[21] These 895 TAZs were sorted by auto mode share and divided into terciles (three evenly sized groups), with cutpoints between groups located at 40% and 65% auto mode share. Next, the three groups were manually adjusted to ensure that all TAZs in a given group were geographically contiguous (very few TAZs required such recategorization). The resulting place types by TAZ auto mode share are shown in **Figure 8**.

5.3.1 Advantages and Disadvantages

Place types defined by TAZs' auto mode share have several advantages. Because they are directly composed of TAZs according to each TAZ's auto mode share, such place types are very faithful to micro-level differences in transportation attributes. Categorizing the TAZs into only three zones means that trip distribution and assignment calculations can be performed with a reasonable level of effort, as is the case with the superdistricts used in the current SF Guidelines. A set of three zones is also very feasible to populate with observed data without requiring an excessive number of data collection sites. Also similar to the superdistricts, the Urban High place type is well-suited to a cordon-based assessment of transit impacts, as it approximates the location of the urban core in much the same manner as SD1, and would require minimal changes to assess transit travel along the maximum load points.[22]

Disadvantages of this set of place types include the fact that the breaks between the Urban High, Urban Medium, and Urban Low place types have no clear spatial or cultural basis. Without consulting the map of such place types, it would be difficult to judge in which zone a given project site is located. The three place types are shaped roughly like three concentric rings emanating from downtown San Francisco. While this

[20] This naming system was developed for the San Francisco Transportation Sustainability Program, for which these Place Types were originally developed according to a methodology very similar to this one.

[21] The remaining San Francisco TAZs are located either on the city's several islands; in the Presidio, which, as federally owned land, is generally excluded from City transportation analysis; or in large parks.

[22] Transit capacity analysis is currently calculated by assessing a project's effect in aggregate on SFMTA service "cordons" that combine multiple lines by their general directionality and approach to the urban core.

reflects the actual shape of the gradient of automobile use in the city, the concentric rings lack directionality: a trip originating in the Urban High zone and terminating in Urban Medium could be traveling directly south, or directly west, or anywhere in between. There remains a high amount of diversity among neighborhoods in each place type as well; although auto mode split within each of these zones may be more tightly clustered than within superdistricts, this could change over time as neighborhoods change. Finally, basing a set of place types on SF-CHAMP auto mode share estimates from a given year is an approach that is unlikely to age well. Future SF-CHAMP data are likely to change, and boundaries drawn based upon current-year SF-CHAMP data may come to seem arbitrary.

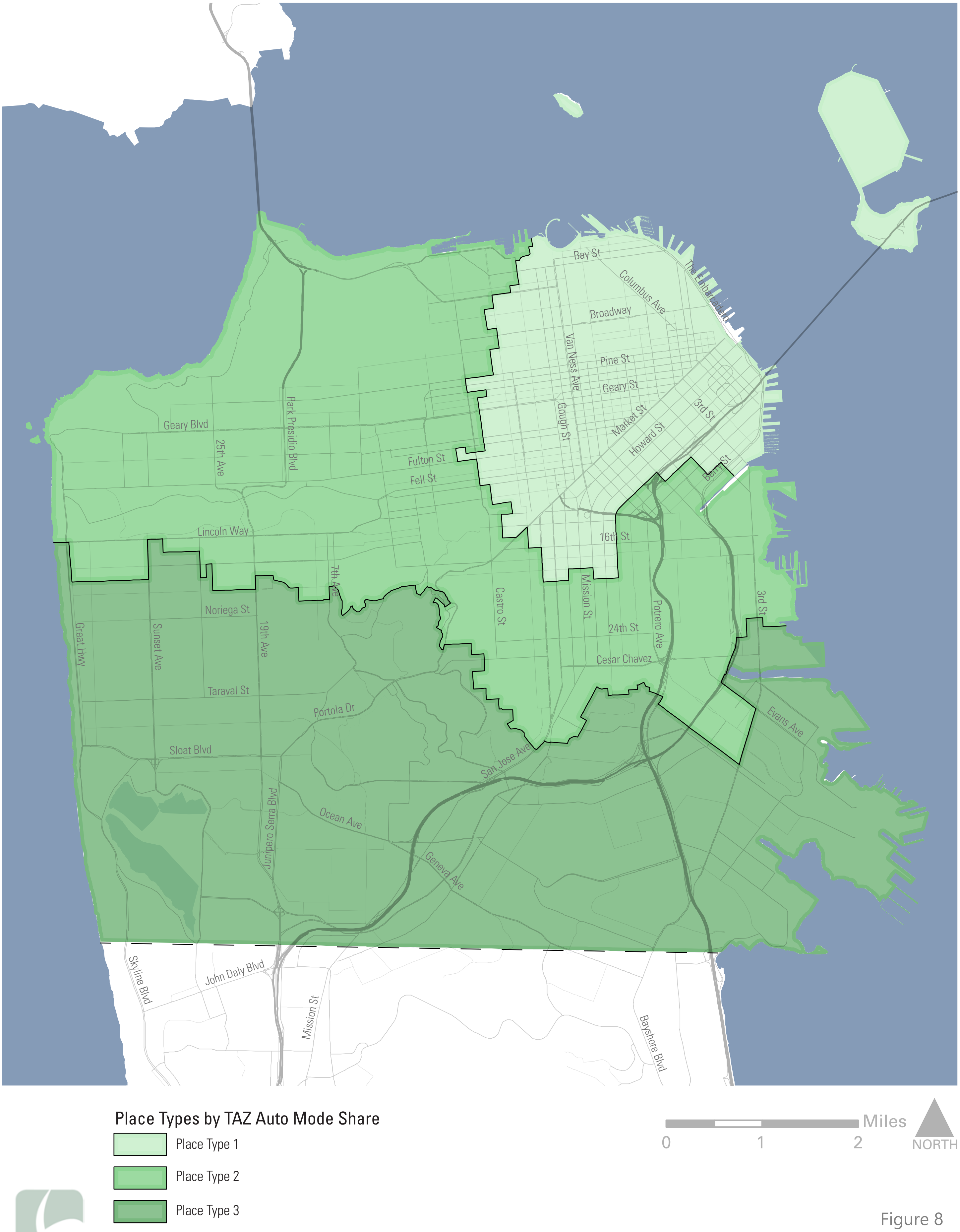


Figure 8

Place Types by TAZ Auto Mode Share

5.4 SF-CHAMP Neighborhoods

The SFCTA has developed a set of 13 neighborhoods (12 covering mainland San Francisco, plus an "Islands" neighborhood consisting of Treasure Island, Yerba Buena Island, Alcatraz, and the Farallons) that are collections of TAZs. These neighborhood boundaries, shown in **Figure 9**, were considered for use as transportation impact analysis geographies.

5.4.1 Advantages and Disadvantages

SF-CHAMP's neighborhood zones reasonably correspond to commonly understood districts of the city (although district names as recorded in SF-CHAMP may not fully reflect common nomenclature), and thus would be relatively easy to understand, particularly in cases where findings are presented to broader audiences such as community groups.

The use of these neighborhood zones in analysis introduces additional complications, as a set of 13 neighborhood zones is a relatively high number of zones for which to handle trip distribution and assignment. On the other hand, the neighborhoods are small enough that there would likely be only one or two plausible automotive or transit paths between a given pair of neighborhood zones, which would result in greater ease for analysts in assigning trips to either the roadway network or the transit network. The greater drawback with the SF-CHAMP neighborhoods is that populating 13 zones with empirically observed trip distribution and mode split data requires a larger set of data collection sites than that conducted here. As such, analysis of trip distribution by neighborhood used CHTS data points to inform the total trip distribution. While many neighborhood-to-neighborhood pairs had limited data, particularly when separated by mode, CHTS provides the most reliable source for identifying these patterns based on empirical data.

SF Planning's set of 36 neighborhoods was also briefly considered, but a set of 36 neighborhoods would have the same disadvantages as a set of 13 neighborhoods, but to a greater degree, while offering few new advantages.

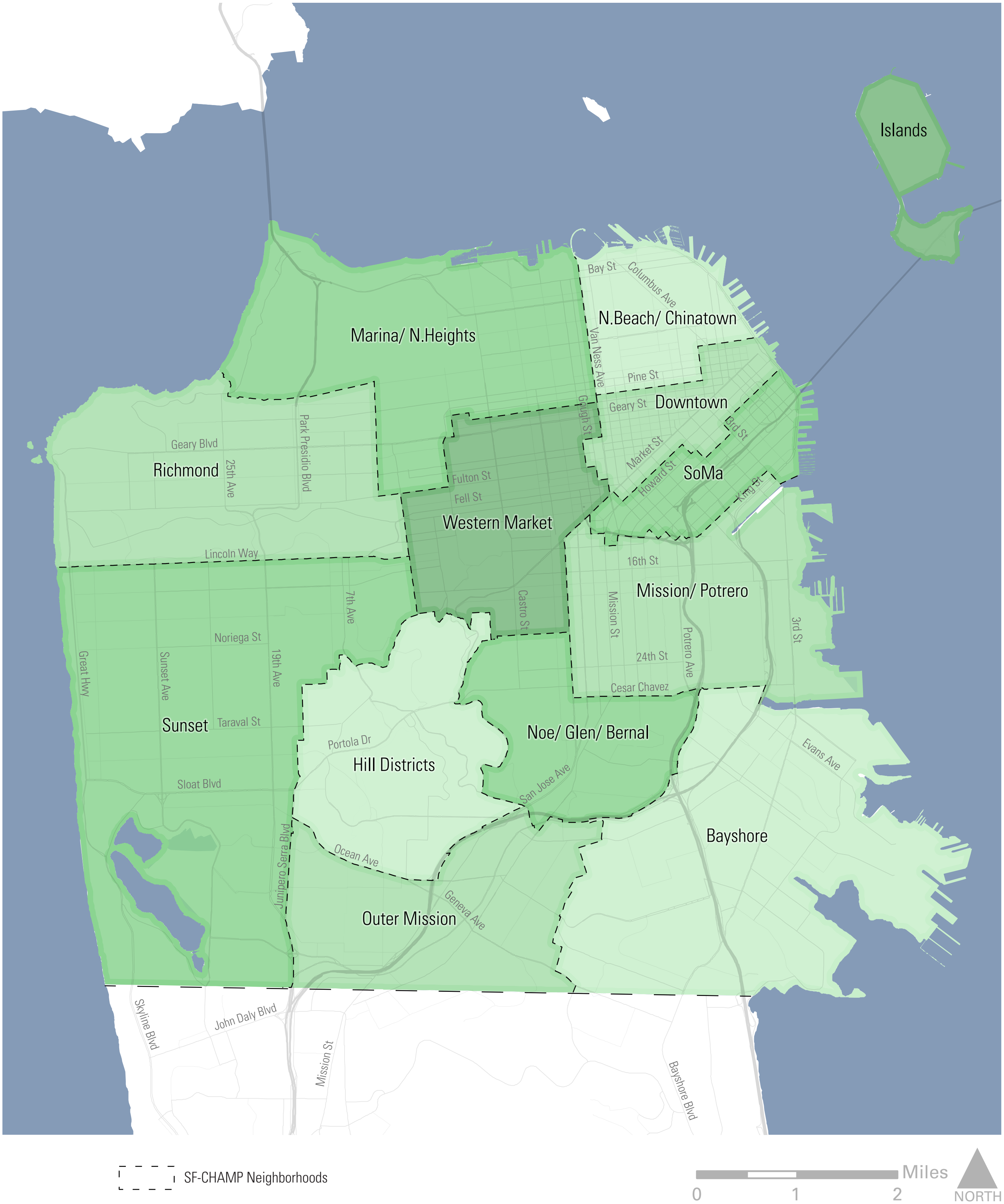


Figure 9

SF-CHAMP Neighborhoods

5.5 Place Types by SF-CHAMP Neighborhood

This geographical method sorts each of the 12 mainland San Francisco neighborhoods discussed in section 5.4 into one of three "place types" based on each neighborhood's auto mode share. In a method similar to that used in section 5.3, each TAZ's auto mode share was aggregated into an average auto mode share at the SF-CHAMP neighborhood level. The "cutpoints" for this sorting were reached based on a reasonable visual inspection of trends in neighborhood auto mode share; natural breaks occurred at approximately 40% and 60% auto mode share, while individual neighborhoods' auto mode shares ranged from 25.2% (Downtown) to 74.4% (Hill Districts). The three place types based on SF-CHAMP neighborhoods are shown in **Figure 10**, including an overlay of the neighborhood boundaries and their auto mode shares. These place types were labeled "Place Type 1" (low auto mode share), "Place Type 2" (medium auto mode share), and "Place Type 3" (high auto mode share).

SF-CHAMP 2012 auto mode share data for the "Islands" neighborhood, which contains Yerba Buena Island and Treasure Island, as well as Alcatraz and the Farallon Islands (to and from which all travel must occur by boat), may not reflect future land use decisions in that area. Relatively few development projects requiring transportation impact analysis are anticipated on Treasure Island and Yerba Buena Island, because the Treasure Island Master Plan EIR covers the environmental analysis of almost all projected development on those islands. Nevertheless, it is prudent to classify the Islands into one of the three Place Types.

It was determined that future auto mode share on Treasure Island is likely to most closely resemble that of Place Type 2, because while a substantial transit mode share (via ferry and bus) is expected, and relatively dense development on Treasure Island will support non-vehicular trips within the island, bicycling and walking trips between San Francisco and the island are not possible. Therefore an auto mode share in the 40 to 60 percent range is probable, which corresponds well to the range of auto mode shares of Place Type 2. For this reason, the Islands were included in Place Type 2, as shown in Figure 10.

5.5.1 Advantages and Disadvantages

A set of place types based on SF-CHAMP neighborhoods' average auto mode share offers many of the same advantages and disadvantages as the place types by TAZ auto mode share (see section 5.3 above) and some of the advantages of the SF-CHAMP neighborhoods themselves (see section 5.4 above). Again, a set of three place types makes it feasible, based upon the scope of the effort here, to collect sufficient real-world data to develop robust trip distribution and mode split tables for each place type (provided that the data collection sites include locations in each of the three place types). Furthermore, place types based on SF-CHAMP neighborhoods have more durable and less arbitrary boundaries than the rough outlines of TAZ-based place types.

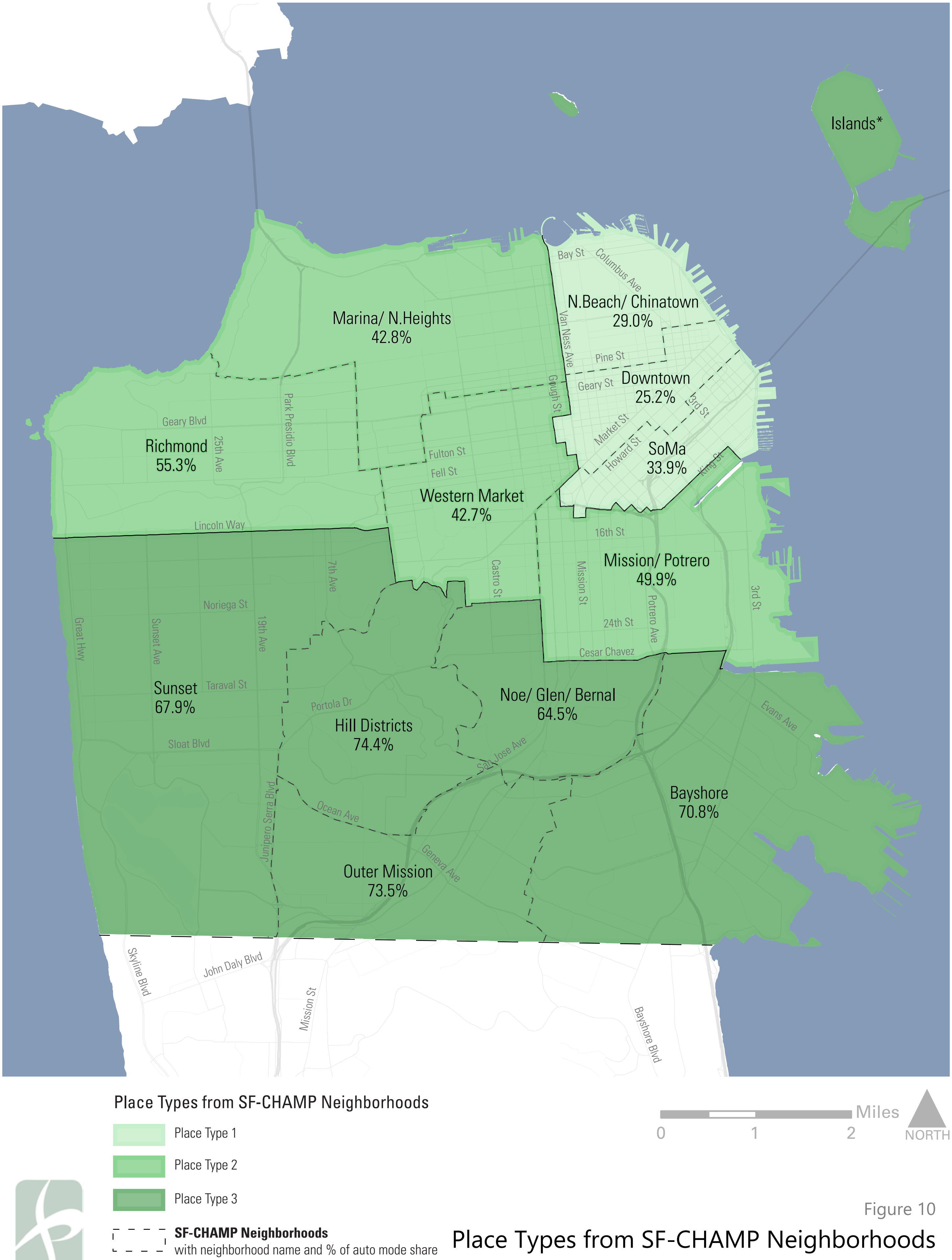


Figure 10

Place Types from SF-CHAMP Neighborhoods

Note: Development on Treasure Island is expected to substantionally change current auto mode share therefore AMS is not presented.

Like the other set of quasi-concentric place types, a set of place types by SF-CHAMP neighborhood does not have strong directionality in terms of trips between different place types. Also, the place types are quite geographically large, another feature that could confound vehicle and transit trip assignment. However, the fact that these place types are based on SF-CHAMP neighborhoods means that it would be feasible to compare with or use trip distribution derived by SF-CHAMP trip distribution tables or other neighborhood-based analysis in the future.

5.6 Recommended Geographic Analysis

Fehr & Peers recommends that SF Planning use the set of three place types based on SF-CHAMP neighborhoods for purposes of calculating trip generation and modal split. This set of geographic units is one for which empirical data can be feasibly collected to update this analysis in the future, and one for which our sample of survey sites is sufficient. The boundaries between adjacent zones have a basis in the city's cultural geography, which lend themselves to easy understanding. Like the set of SF-CHAMP neighborhoods themselves, the place types based on those neighborhoods offer the potential for integration with current and future SF-CHAMP model outputs. The primary limitation relates to trip distribution and assignment; the somewhat radial nature of the proposed geography may make it more challenging to assign trips to the roadway network based on place type-to-place type trip distributions.

This shortcoming may be partially addressed by integration with trip distribution outputs on the neighborhood level, as prepared by SFCTA staff, which could integrate cleanly with place-type level analysis. Providing a framework for distributing trips by each mode among these smaller neighborhood geographies would provide for an intuitive assignment of trips on a neighborhood-to-neighborhood basis.

Furthermore, as discussed in greater detail in section 6.2 below, the place types based on SF-CHAMP neighborhoods demarcate three regions within San Francisco in which travel characteristics (specifically, auto mode share) are substantially distinct, based on real-world data. **Appendix I** presents each data collection site's auto mode share, and separates the sites in three ways: by the existing superdistricts, by the place types based on TAZ auto mode share, and by the place types based on SF-CHAMP neighborhood auto mode share. This latter set of geographic units establishes clearer distinctions between the average auto mode share in each place type than methods using superdistrict or place types based on TAZ auto mode share.

For trips that include either an origin or destination outside of the City of San Francisco (such as trips between Oakland and San Francisco), we recommend continuing to use the aggregation of North Bay, East Bay, and South Bay for purposes of trip distribution and modal trip distribution. Because these geographies are both large and highly directional, an aggregation is useful for purposes of assigning trips to either the roadway network or to transit routes.

The remainder of this document uses the set of place types based on SF-CHAMP neighborhoods. That is, the analyses and results presented in Chapter 6 are based on these recommended geographic units.

Chapter 6. **Findings**

This chapter lays out the specific analytical processes by which key results were obtained from the raw video and survey data as well as the supplemental data sources, and presents the results of those analyses.

6.1 Person Trip Generation

Person trip generation was calculated for four land uses (office, retail, residential, and hotel, as discussed in section 1.1.1 above) and three time periods (daily, AM peak hour, and PM peak hour). The key primary data source was the video doorway and driveway counts, which were collected at 65 sites, each for a 24-hour period on a typical[23] Tuesday, Wednesday, or Thursday.[24] In addition to the video count data, the trip generation analysis relied on average vehicle occupancy assumptions, which were derived from CHTS data as discussed in section 4.1.1 above.

Each site's video doorway and driveway counts were input into a standardized processor in Excel. Driveway vehicle trips were converted to person trips using the assumed average vehicle occupancy. All doorway and driveway trips were added together and each site's AM and PM peak hours were identified. In accordance with standard trip generation analysis practices,[25] each site's AM peak hour was defined as the four consecutive 15-minute periods between 7:00 and 9:00 AM with the greatest number of person trips, and each site's PM peak hour was defined as the consecutive hour between 4:00 and 6:00 PM with the greatest number of person trips. In a master calculation spreadsheet, all sites' total daily, AM peak hour, and PM peak hour person trips were collected, along with the amount of land use (square feet of office or retail space, dwelling units, or hotel rooms) at each site.[26]

The temporal distribution of person trips at sites of each land use type is presented graphically in **Figures 11** through **14** below. The traditional "peaking" of trips around the AM and PM "peak" periods is evident for office and residential sites. Retail sites show fairly high activity throughout the day, with no visible AM

[23] Typical represents when San Francisco Unified Schools are in session and avoid local, state and federal holidays and events that draw from the San Francisco Bay Area region, such as parades.

[24] One of the 67 sites with video count data was unusable due to a truck blocking the doorway for large portions of the day; therefore, person trip generation rates are based on analysis of 66 data collection sites.

[25] See the *SF Guidelines (2002)*; *Trip Generation Manual, 4th Edition,* Institute of Transportation Engineers.

[26] Amount of land use was collected and aggregated from multiple sources, including direct information from property managers, review of environmental clearance documentation, and information from web sites. It is presented in Appendix D.

peak but a prominent PM peak period; hotel trip activity is more steady across the day, with more late evening trips.

Figure 11: Person Trips by Time of Day, All Sites – Office

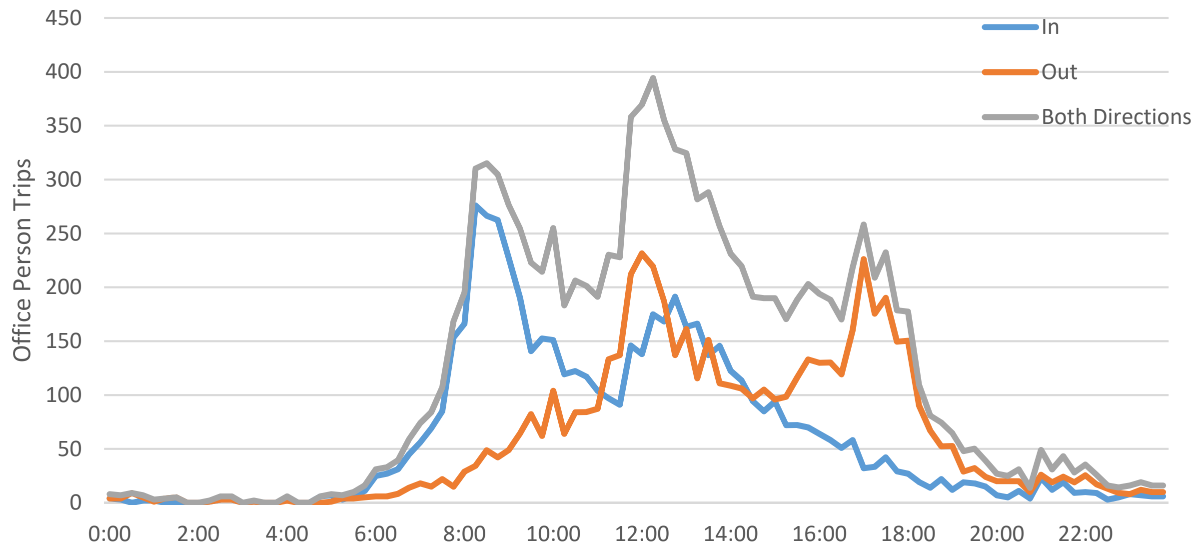


Figure 12: Person Trips by Time of Day, All Sites – Retail

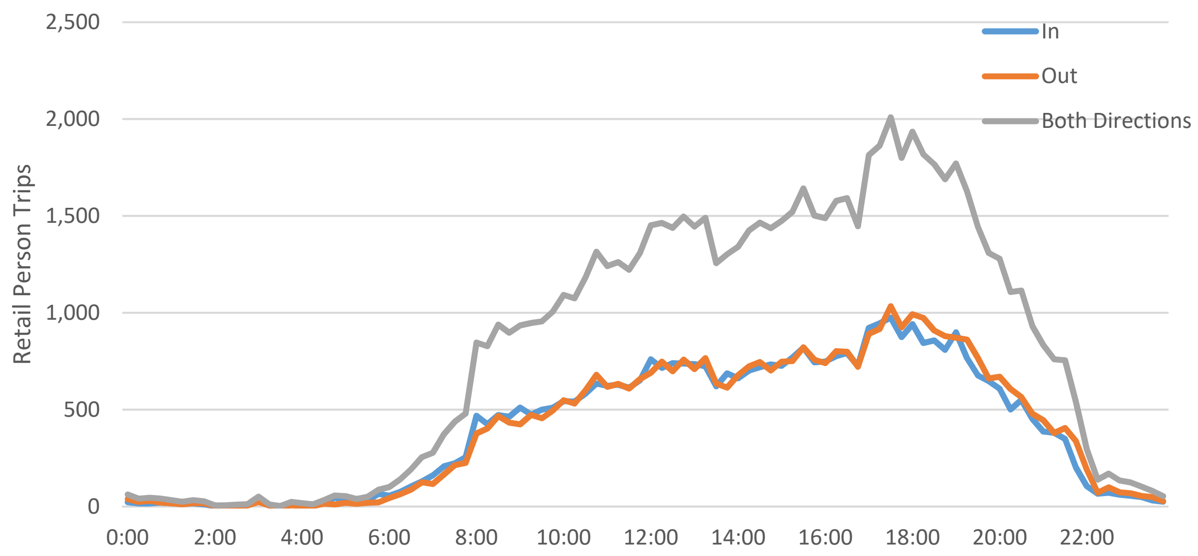


Figure 13: Person Trips by Time of Day, All Sites – Residential

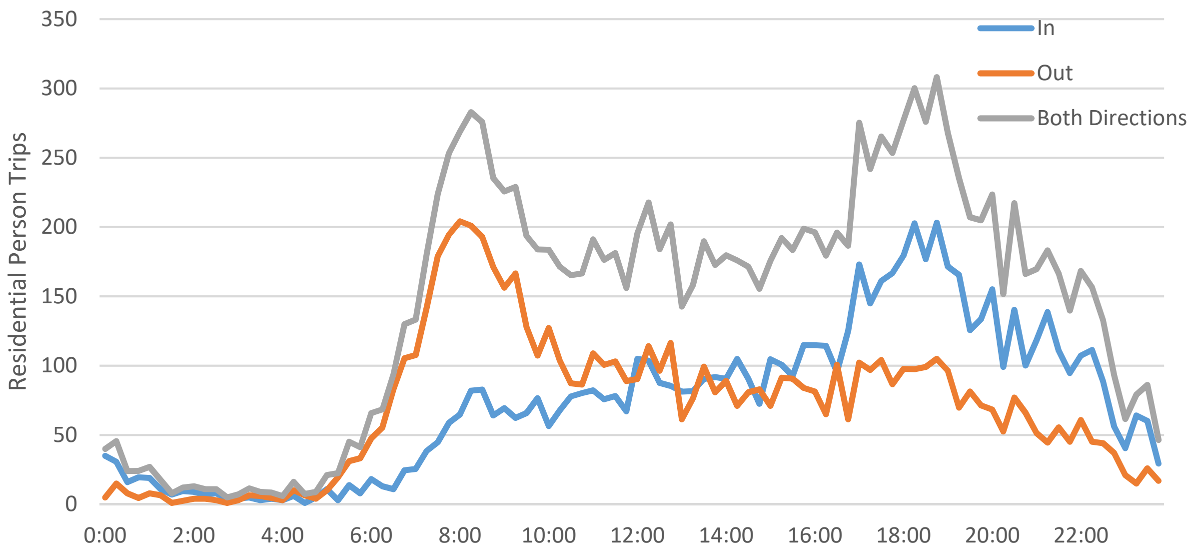
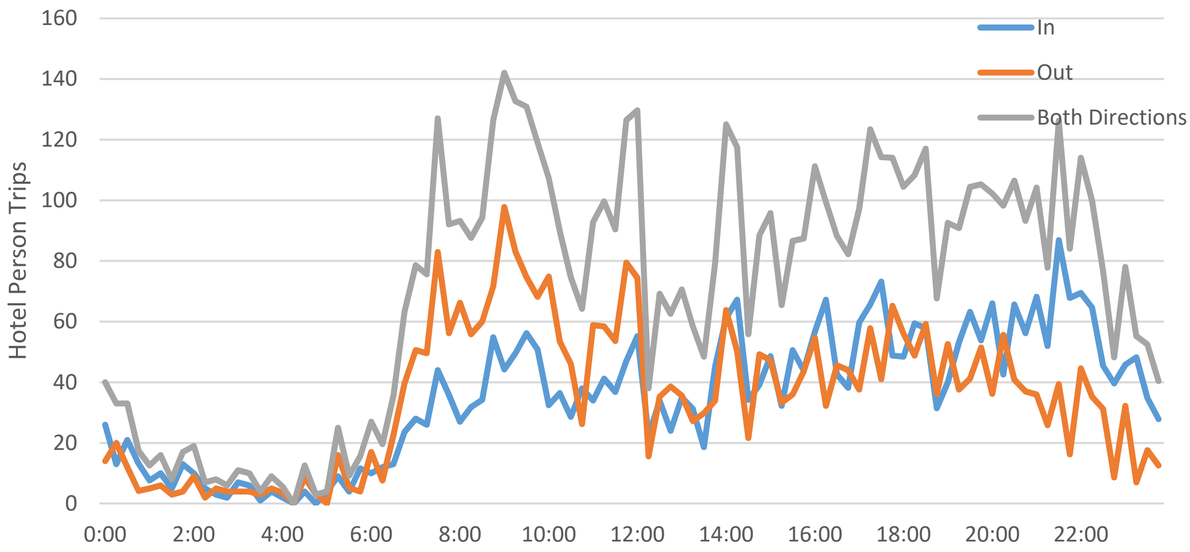


Figure 14: Person Trips by Time of Day, All Sites – Hotel



Each site's trip counts were divided by the amount of land use to identify that site's trip generation rates. To calculate an average trip generation rate for all sites of a given land use type, the person trips at all sites of that land use type were added together and divided by the sum of all land use amounts. For each land use, the 25th and 75th percentile trip generation rates were identified to indicate variability in trip rates. Averages were used rather than a fitted curve equation due to the modest sample size for each land use; additionally, this method insures that when rates are plotted they intersect the y-axis at zero (i.e., at zero land use, we would expect zero trips). This approach is similar to that used by the ITE *Trip Generation* manual.

The person trip generation rates by land use type calculated in this manner are presented in **Table 3** (office), **Table 4** (retail), **Table 8** (residential), and **Table 10** (hotel). These tables also present the rates currently presented for each land use in the existing SF Guidelines; for most uses, the existing SF Guidelines rates fall within the middle 50 percent of person trip generation at all sites, although the average observed trip generation is substantially different. For most land uses, the data collected indicate that peak period travel is spread across a larger period of time than when past surveys were conducted, and that there are correspondingly lower trip rates for the peak hour itself. **Figures 18** through **29** display each land use's individual sites, color-coded by place type, in comparison with the average trip generation rates for that land use.

Appendix J provides trip generation and mode split data at the individual site level, for every site for which data were collected.

6.1.1 Office

Office sites generated far fewer person trips per 1,000 square feet (ksf) than retail sites. Trip generation was roughly similar during the AM and PM peak hours, each of which accounted for about one tenth of total daily trips; this ratio is similar to the PM peak hour to daily person trip rates in the existing SF Guidelines. Office sites exhibited substantial variability in trip generation rates, with the 75th percentile rate approximately equaling three times the 25th percentile rate.

The observed office sites also generated substantially fewer person trips on a daily basis than presented in the existing SF Guidelines. Large office buildings in the financial district seemed to come closest to the trip generation rates currently in use, as shown in **Figure 15.** On average, however, sites sampled in this effort showed trip generation rates around half of the rates currently in use, and the existing rates presented in the SF Guidelines fall above the 75th percentile of surveyed sites. Only one site, at 417 Montgomery Street, exceeded the trip generation rates currently in use.

Table 3: Person-Trip Generation Rates – Office

Person-Trips per 1,000 Square Feet of Office Space				
Time Period	***25th Percentile***	***Average***	***75th Percentile***	***Current SF Guidelines Rate***
Daily	5.0	9.6	15.7	18.1
AM Peak	0.4	0.9	1.4	n/a
PM Peak	0.7	0.8	1.4	1.5

Source: Fehr & Peers, 2018.
Notes:
1. Rates reflect person trip counts conducted at 11 office sites throughout San Francisco.
2. A total of 11,538 person trips were observed.

Figure 15: Daily Person Trip Generation – Office

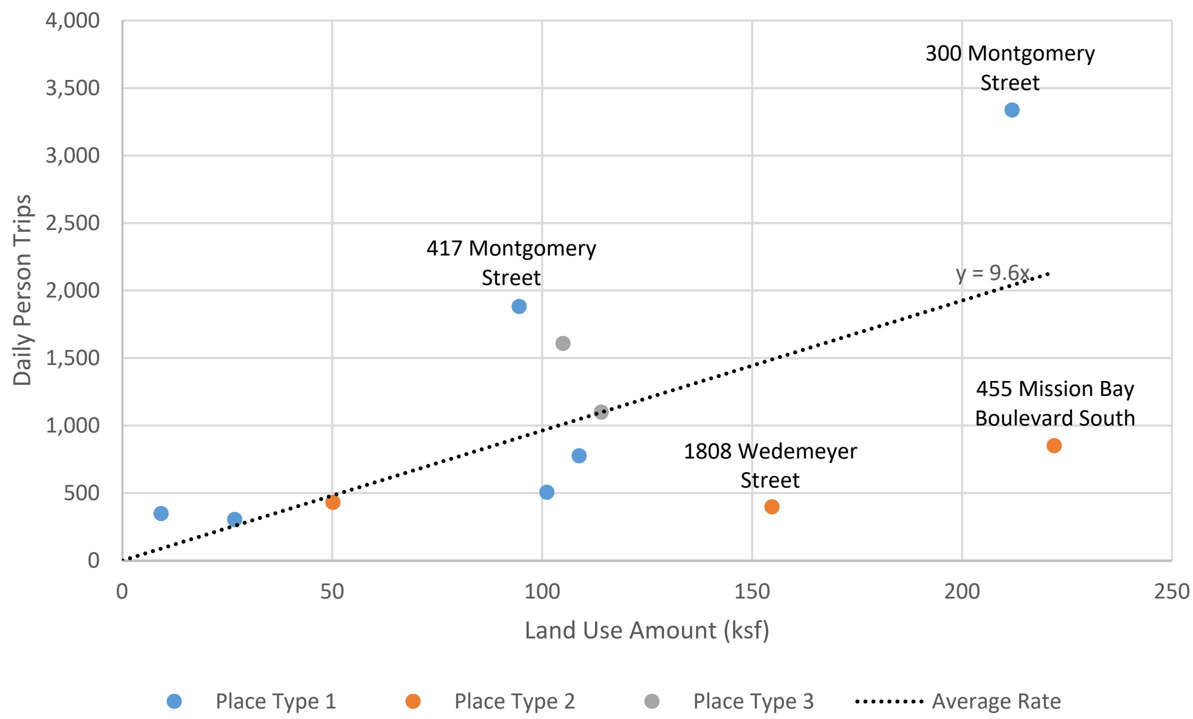


Figure 16: AM Peak Hour Person Trip Generation – Office

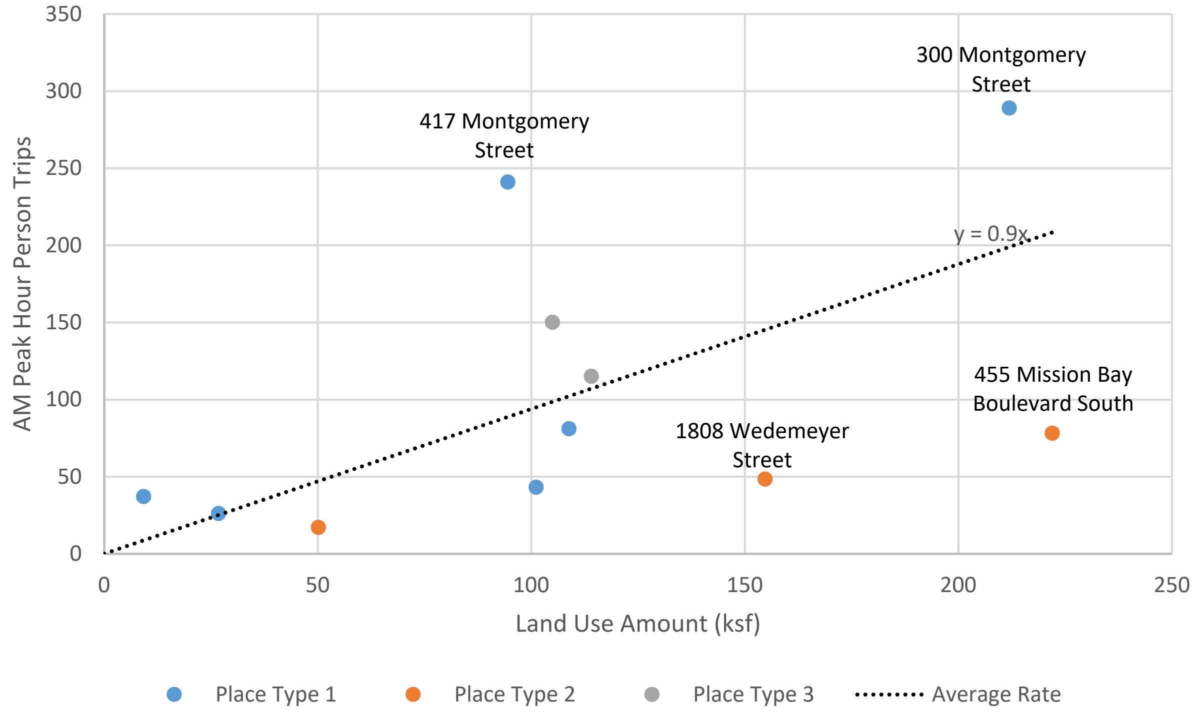
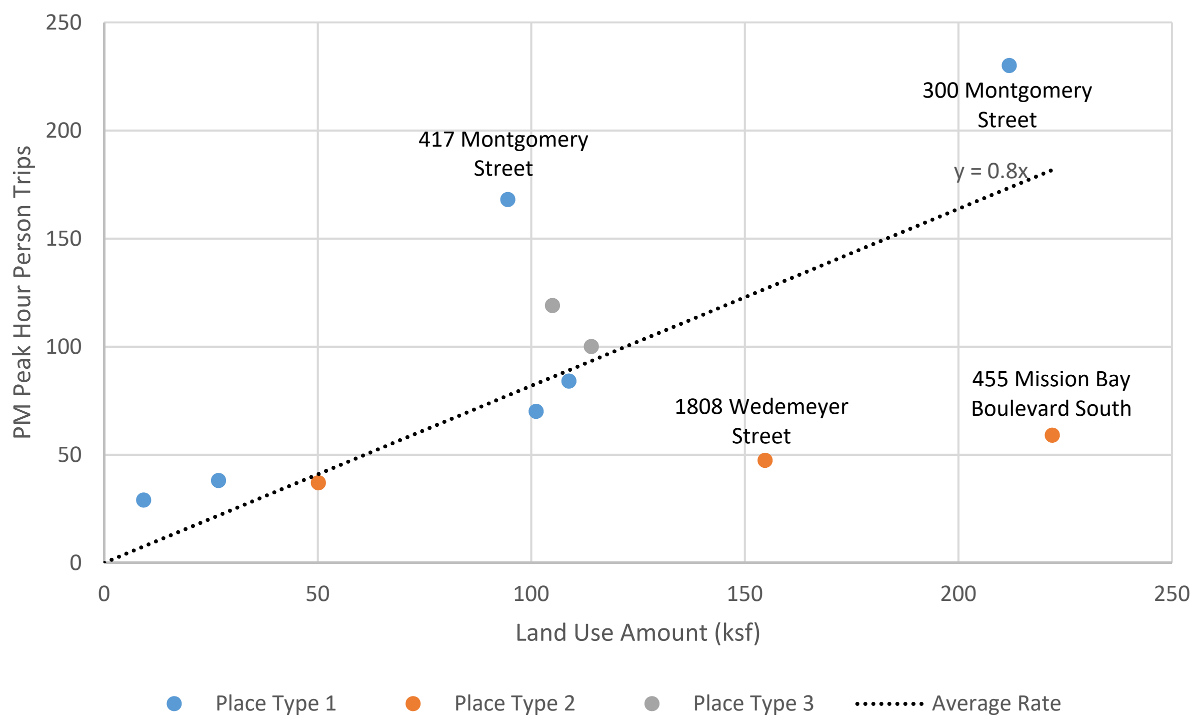


Figure 17: PM Peak Hour Person Trip Generation – Office



6.1.2 Retail

Retail uses generated a wide range of trips, between approximately 85 and 330 daily person trips per ksf of retail space, when looking at the 25th and 75th percentile. When comparing trip generation at different times of day, retail person trip generation was lower during the AM peak period compared to the PM peak period.

Compared to the current rates for general retail presented in the SF Guidelines (150 person trips per 1,000 square feet), the sites in the sample showed generally higher levels of trip making on both a daily and peak hour basis, although the current trip generation rates do fall within the middle 50 percent of rates among survey sites. This may be due to the types of retail sampled, which include several store types that tend to include high numbers of pass-by trips (such as corner stores and pharmacies), as well as several grocery stores.

Table 4: Person-Trip Generation Rates – Retail

Person-Trips per 1,000 Square Feet of Retail Space				
Time Period	***25th Percentile***	***Average***	***75th Percentile***	***Current SF Guidelines Rate***
Daily	85.7	252.3	331.4	150.0
AM Peak	--[3]	11.3	13.7	n/a
PM Peak	9.9	24.4	32.2	13.5

Source: Fehr & Peers, 2018.

Notes:
1. Rates reflect person trip counts conducted at 26 retail sites throughout San Francisco.
2. A total of 78,632 person trips were observed.
3. Many sites were not open during the AM peak hour and had zero values for AM trips, thus a 25th percentile number was not calculated

Figure 18: Daily Person Trip Generation – Retail

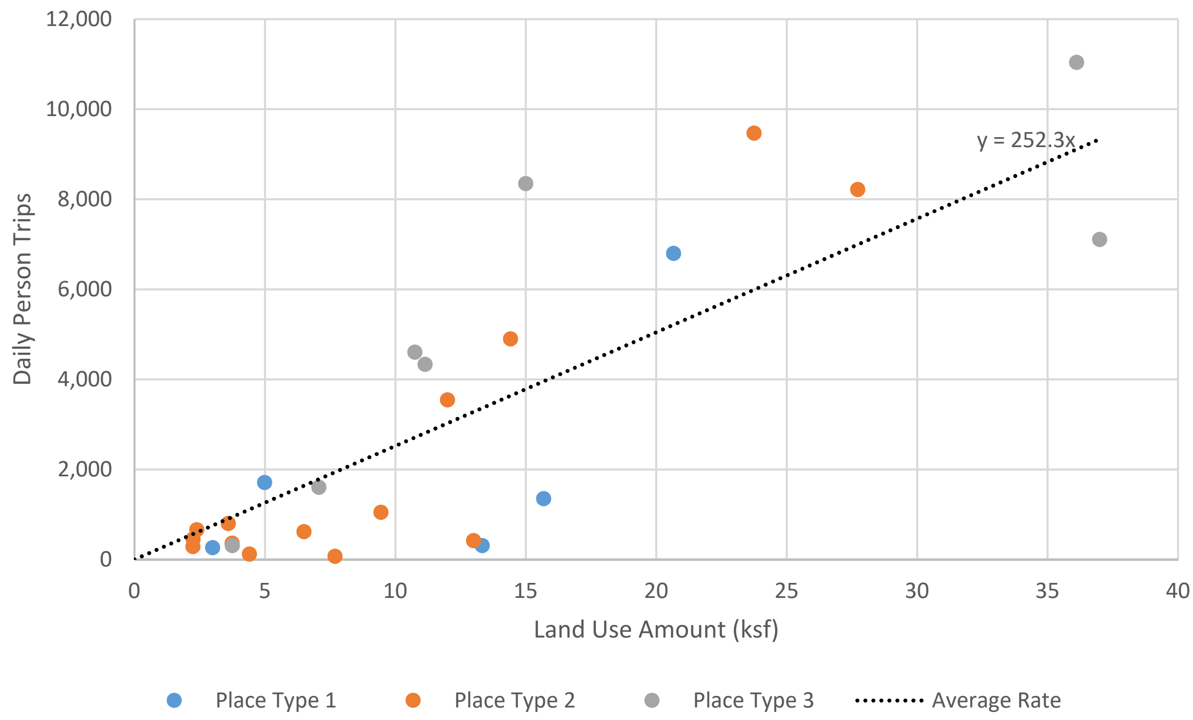


Figure 19: AM Peak Hour Person Trip Generation – Retail

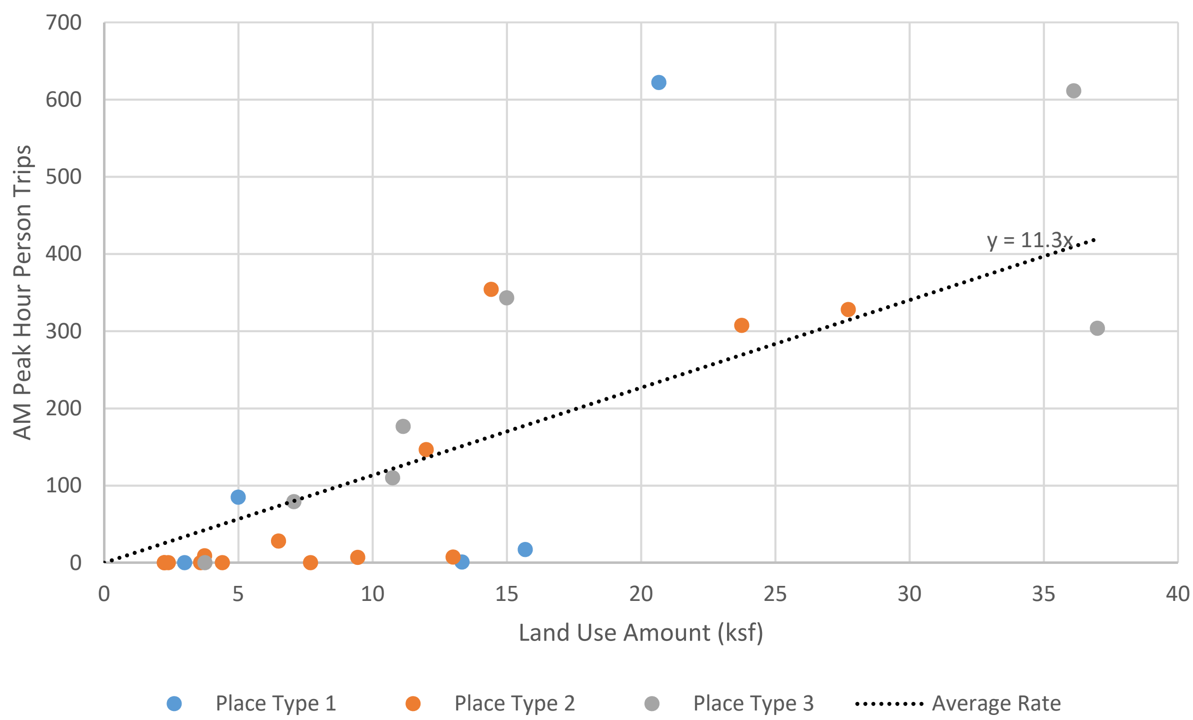
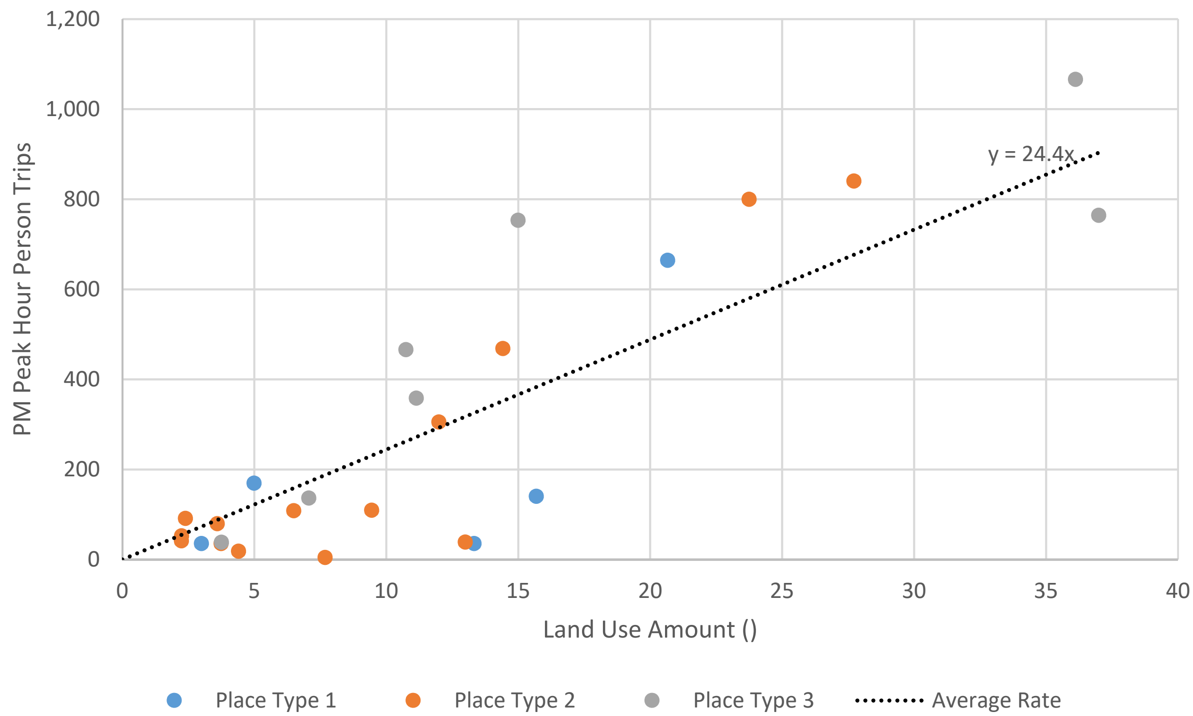


Figure 20: PM Peak Hour Person Trip Generation – Retail



Because the retail study sample included a wide variety of retail store types, a system that stratifies retail based on total floor area was tested. By visually examining the charts shown above, it does seem that trip generation patterns may be different for larger sites compared with smaller sites. First, larger stores are less likely to be closed during the AM peak hour, and have fewer AM peak hour zero values. Second, the very largest sites tended to generate trips at a somewhat higher rate than the sample as a whole.

In our data sample, the median site floor area was 10 ksf. We studied thirteen sites with more than 10 ksf of floor area, and 13 sites with fewer than 10 ksf of floor area. As shown in **Table 5**, based on the standard deviation and differences between rates for the two groups, there is some evidence that the study sites above the 10 ksf threshold have higher trip generation rate than those below. As such, we recommend the use of the average rates shown below for each retail grouping: 145.6 trips per ksf for retail sites under 10,000 square feet, and 282.2 trips per ksf for retail sites over 10,000 square feet.

Table 5: Comparison of Potential Retail Cutpoints

			Sites Below Cutpoint						Sites Above Cutpoint					
			Daily		AM		PM		Daily		AM		PM	
Cutpoint (ksf)	Sites Below	Sites Above	Average	StDev	Average	StDev	Average	StDev	Average	StDev	Average	StDev	Average	StDev
2.5	3	23	200.5	73.5	0.0	0.0	26.5	10.3	215.6	155.4	8.8	9.2	21.0	13.8
5	9	17	161.5	103.8	2.2	5.6	18.9	11.5	241.6	161.8	10.8	9.2	23.1	14.4
7	10	16	154.8	100.1	2.4	5.3	18.7	10.9	250.8	162.5	11.2	9.4	23.5	14.8
8	12	14	148.5	102.8	2.9	5.5	17.2	11.1	269.9	159.7	12.0	9.5	25.4	14.4
10	**13**	**13**	**145.6**	**98.9**	**2.7**	**5.3**	**16.8**	**10.8**	**282.2**	**159.2**	**12.9**	**9.3**	**26.5**	**14.4**
12	15	11	180.6	130.4	4.1	6.2	19.6	12.6	259.3	163.0	12.8	10.1	24.4	14.6
13	16	10	187.8	129.1	4.6	6.3	19.9	12.2	255.7	171.4	12.9	10.7	24.3	15.4
15	19	7	178.9	134.0	5.2	7.6	18.8	12.8	309.0	149.0	14.8	9.6	29.3	12.6
20	21	5	192.4	153.3	5.9	8.2	19.8	14.2	304.2	74.4	16.0	8.5	29.2	5.1

Source: Fehr & Peers, 2018

6.1.3 Residential

Fehr & Peers evaluated and compared several methodologies for calculating residential trip generation.

The simplest methodology is to calculate trip generation as a linear function of the number of dwelling units in a given residential building. This has the advantage that the required input (number of dwelling units) is easy to obtain and comprehend. However, this methodology does not account for the different trip-making characteristics of households in differently sized units. For example, we would expect that a three-bedroom unit would likely generate more trips than a studio.

Historically, SF Planning has calculated residential trip generation in a bivariate fashion: studio, junior one-bedroom, and one-bedroom units are assigned one trip generation rate, while two-bedroom, three-bedroom, and larger units are assigned a different, higher rate. For this approach (referred to below as "01-23"), it is necessary to know a development's unit mix. The unit mix is a standard piece of data provided to SF Planning as part of a development proposal, and therefore approaches that consider differently sized units separately are unproblematic from a data availability perspective.

Another methodology assigns different trip generation rates at a finer level than SF Planning's historic approach. For example, four rates could be determined, for studios and junior one-bedroom units; one-bedroom units; two-bedroom units; and three-or-more bedroom units. The major downside of such a granular methodology (referred to below as "0-1-2-3") is that the large number of input variables requires a large number of study sites (buildings whose unit mix is known and whose trip generation has been directly observed) to determine accurate trip generation rates for each subgroup of dwelling units.

Finally, it is possible to consider residential trip generation as a univariate function not of the number of dwelling units, but the number of *bedrooms*. Given a development's unit mix, it is simple to calculate the total number of bedrooms, which can then be multiplied by a trip generation rate. This methodology effectively accounts for different unit sizes while at the same time functioning well given a smaller set of study sites.

Fehr & Peers calculated trip generation rates according to the four approaches listed above. The study set included 13 residential sites with known unit mix and trip generation data. These sites ranged in size from 24 to 320 dwelling units. For the bedroom-based analysis, the total number of bedrooms was calculated using detailed unit mix information and was based on the following mapping:

- "0 bedroom units," i.e. studios and junior 1 bedrooms: 1 bedroom
- 1 bedroom units: 1 bedroom

- 2 bedroom units: 2 bedrooms
- 3+ bedroom units: 3.2 bedrooms (because some units will have more than 3 bedrooms)

The results of this analysis, including the coefficients for each unit type, the statistical goodness of fit of each approach, and a comparison to the current SF Planning TIA Guidelines, are presented in **Table 6**.

Table 6: PM Peak Hour Residential Trip Generation By Methodology

Person-Trips per Unit of Each Type					
Methodology	**Studio**	**1 BR**	**2 BR**	**3+ BR**	**Goodness of Fit**
SF Guidelines	1.298		1.730		-
Dwelling Units	0.494*				0.795
0-1-2-3	0.330	0.205	0.752*	0.980	0.757
01-23	0.257		0.744*		0.800
Bedrooms	0.331*		0.662*	0.993*	0.816

Notes:
1. "Studio" includes Junior 1 Bedroom.
2. "Goodness of Fit" refers to Adjusted R-Squared, a statistical measure that ranges from 0 to 1, where 0 signifies no relationship and 1 signifies a very strong relationship.
3. * indicates the coefficient is statistically significant.

Table 7: Daily Residential Trip Generation By Methodology

Person-Trips per Unit of Each Type					
Methodology	**Studio**	**1 BR**	**2 BR**	**3+ BR**	**Goodness of Fit**
SF Guidelines	7.5		10.0		-
Dwelling Units	6.2*				0.800
0-1-2-3	0.0	4.5	9.7*	9.4	0.790
01-23	2.3		10.4*		0.823
Bedrooms	4.2*		8.4*	12.6*	0.829

Notes:
1. "Studio" includes Junior 1 Bedroom.
2. "Goodness of Fit" refers to Adjusted R-Squared, a statistical measure that ranges from 0 to 1, where 0 signifies no relationship and 1 signifies a very strong relationship.
3. * indicates the coefficient is statistically significant.

The multivariate regressions (# of units of each size) were not exceptionally successful: adjusted R-squared values, which express the predictive power of the model, were not substantially higher than the univariate regression of person trips per dwelling unit. Furthermore, the coefficients of each explanatory variable were somewhat nonsensical; for example, one model estimated that each additional two-bedroom unit would generate four times as many person trips as each additional one-bedroom unit.

However, the approach of performing a simple linear regression of person trips by the total number of bedrooms was very successful. Holding the y-intercept at zero, this approach determined that each bedroom generated 4.2 daily person trips, 0.32 AM peak hour person trips, and 0.33 PM peak hour person trips. Adjusted R-squared values were higher for this approach than for any other approach, and the coefficients for daily, AM peak hour, and PM peak hour person trip generation are all sensical and highly statistically significant.

It is possible that given a larger sample set of residential sites, especially sites with a broad range of unit sizes, the coefficients in the 01-23 and 0-1-2-3 analyses could become more plausible and more statistically significant. However, given the available sample set, Fehr & Peers recommends the use of either a dwelling units-based or a bedrooms-based approach to residential trip generation.

Residential Trip Generation Results by Dwelling Unit

Residential sites were found to generate approximately six person trips per dwelling unit in a given 24-hour period. The variation in residential trip generation rates was narrower than for other land uses: the AM and PM peak hours' 75th percentile rates were about twice the 25th percentile rates, and daily trip generation displayed an even tighter grouping, as shown in **Figure 21** below.

When compared to the rates currently in use for one bedroom and studio apartments in the SF Guidelines, daily rates of trip making are similar but somewhat lower (with the daily trip generation presented in the SF Guidelines still falling within the middle 50 percent of surveyed sites), and the number of trips occurring in the PM peak period is much lower. This may reflect a tendency for trips to shift outside of the PM peak period, or it may reflect different demographics in the types of buildings surveyed under this effort (which tended to be newer construction, market rate buildings).).

The residential person-trip generation rates derived from newly collected video data are similar to rates calculated using 2012 CHTS data (see section 4.1.4 above). Daily trip generation is slightly higher than in CHTS (5.9 vs 5.6 daily person trips per dwelling unit), while the AM peak hour rate is slightly below and the PM peak hour rate is very close to the corresponding rates from CHTS data.

Table 8: Person-Trip Generation Rates – Residential

Person-Trips per Residential Dwelling Unit					
Time Period	***25th Percentile***	***Average***	***75th Percentile***	***Current SF Guidelines Rate (1BR / studio)***	***2012 CHTS Rate***
Daily	4.6	5.7	7.8	7.5	5.6
AM Peak	0.4	0.5	0.7	n/a	0.6
PM Peak	0.4	0.4	0.6	1.3	0.5

Source: Fehr & Peers, 2018.

Notes:
1. Rates reflect person trip counts conducted at 19 residential sites throughout San Francisco.
2. A total of 13,886 person trips were observed.

Figure 21: Daily Person Trip Generation per du– Residential

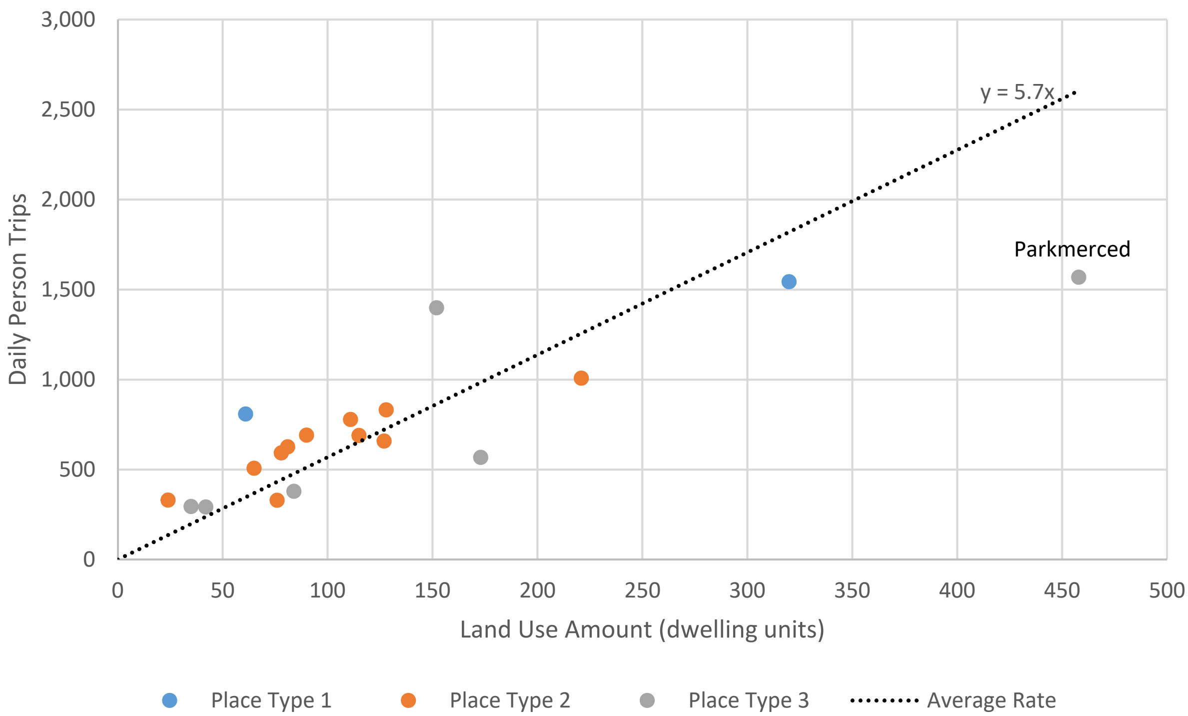


Figure 22: AM Peak Hour Person Trip Generation per du – Residential

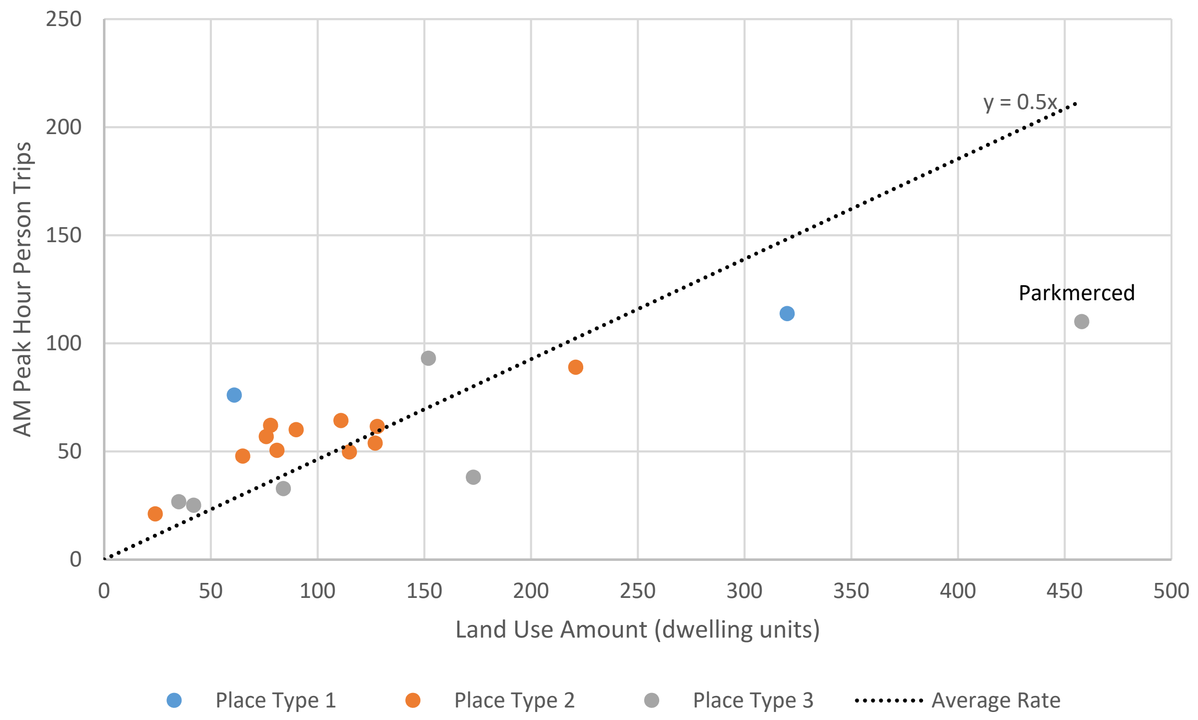
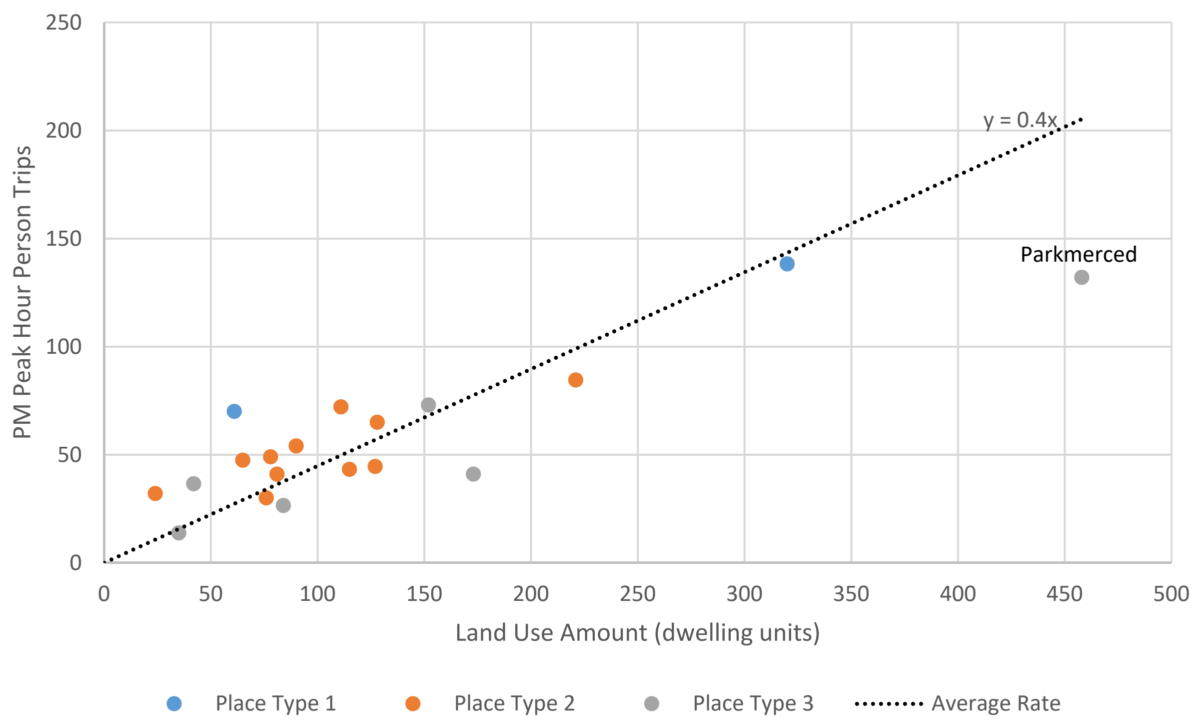


Figure 23: PM Peak Hour Person Trip Generation per du – Residential



Residential Trip Generation Results by Bedroom Count

Residential sites were found to generate approximately four person trips per bedroom in a given 24-hour period, as discussed above. The resulting average, 25th, and 75th percentile rates are presented in **Table 9** and fitted curves are shown in **Figure 24**, **Figure 25**, and **Figure 26**.

When compared to the rates currently in use for one bedroom and studio apartments in the SF Guidelines, daily rates of trip making are lower, with the one bedroom and studio rates exceeding the 75th percentile per bedroom rates at our surveyed sites. This pattern also holds true for the AM and PM peak periods.

The residential person-trip generation rates derived from newly collected video data are slightly lower than rates calculated using 2012 CHTS data (see section 4.1.4). This is to be expected, as CHTS data are on a per household basis, and many households live in units with more than one bedroom.

Table 9: Person-Trip Generation Rates per Bedroom – Residential

Person-Trips per Residential Bedroom					
Time Period	***25th Percentile***	***Average***	***75th Percentile***	***Current SF Guidelines Rate (1BR / studio)***	***2012 CHTS Rate (per household)***
Daily	4.0	4.9	6.1	7.5	5.6
AM Peak	0.3	0.4	0.5	n/a	0.6
PM Peak	0.3	0.4	0.5	1.3	0.5

Source: Fehr & Peers, 2018.

Notes:
1. Rates reflect person trip counts conducted at 19 residential sites throughout San Francisco.
2. A total of 13,886 person trips were observed.

Figure 24: Daily Person Trip Generation per Bedroom – Residential[27]

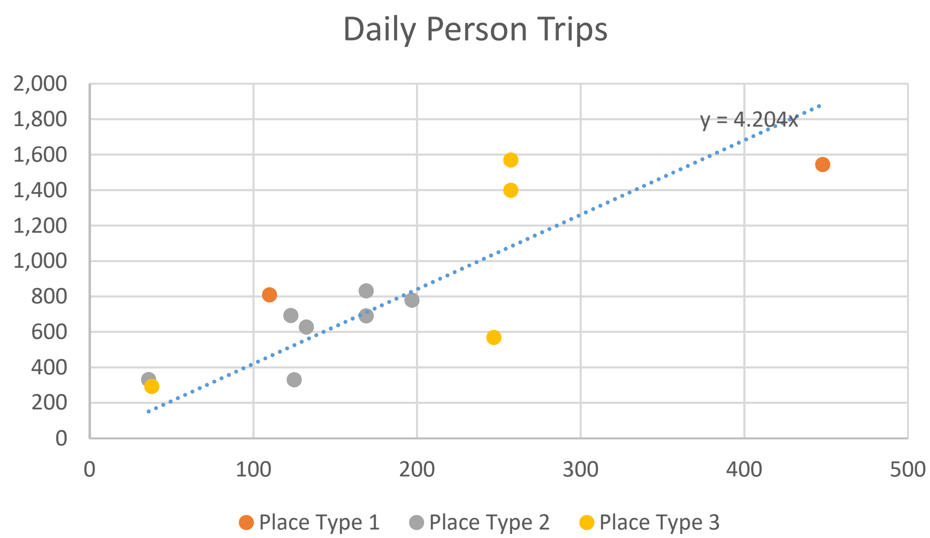
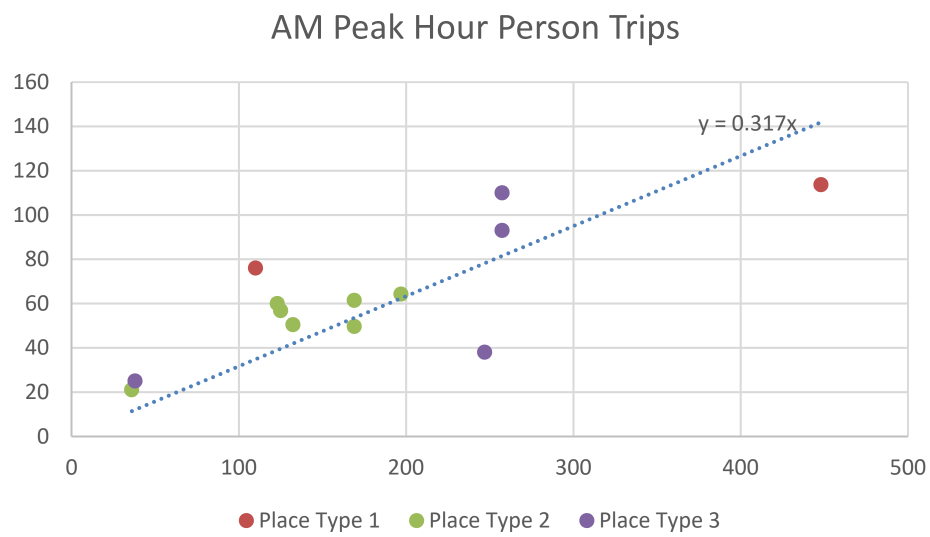
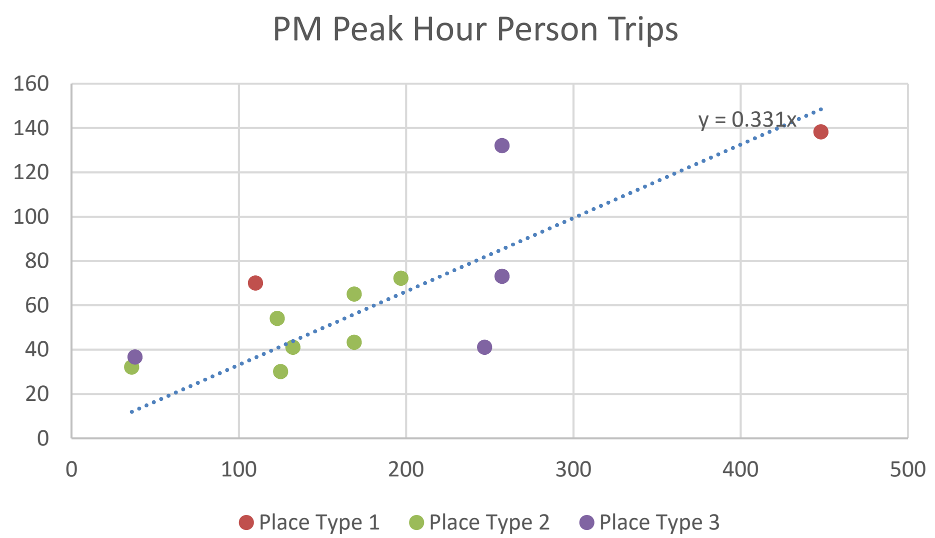


Figure 25: AM Peak Hour Person Trip Generation by Bedroom – Residential[27]



[27] For residential trips per bedroom, the fitted curve coefficient was used rather than the average rate.

Figure 26: PM Peak Hour Person Trip Generation by Bedroom – Residential[27]



6.1.4 Hotel

Hotel sites generated an average of approximately nine person trips per day per room. Compared with the other land uses examined in this report, hotels' trip generation was less temporally peaked, with the AM and PM peak hours accounting for about seven percent of daily trip generation each. The variability of hotel sites' trip generation rates was also relatively narrow, approximately similar to that of residential sites.

The hotel sites surveyed had similar rates of person trip generation compared to the rates currently in use in the SF Guidelines, with slightly higher levels of daily trip making and slightly fewer trips occurring during the PM peak period. For both daily trips and trips in the PM peak hour, the rates currently in use fall within the 25th to 75th percentile range of surveyed sites.

Table 10: Person-Trip Generation Rates – Hotel

Person-Trips per Hotel Room				
Time Period	***25th Percentile***	***Average***	***75th Percentile***	***Current SF Guidelines Rate***
Daily	6.1	8.4	10.8	7.0
AM Peak	0.4	0.6	0.8	n/a
PM Peak	0.4	0.6	0.7	0.7

Source: Fehr & Peers, 2018.

Notes:
1. Rates reflect person trip counts conducted at 9 hotel sites throughout San Francisco.
2. A total of 6,773 person trips were observed.

Figure 27: Daily Person Trip Generation – Hotel

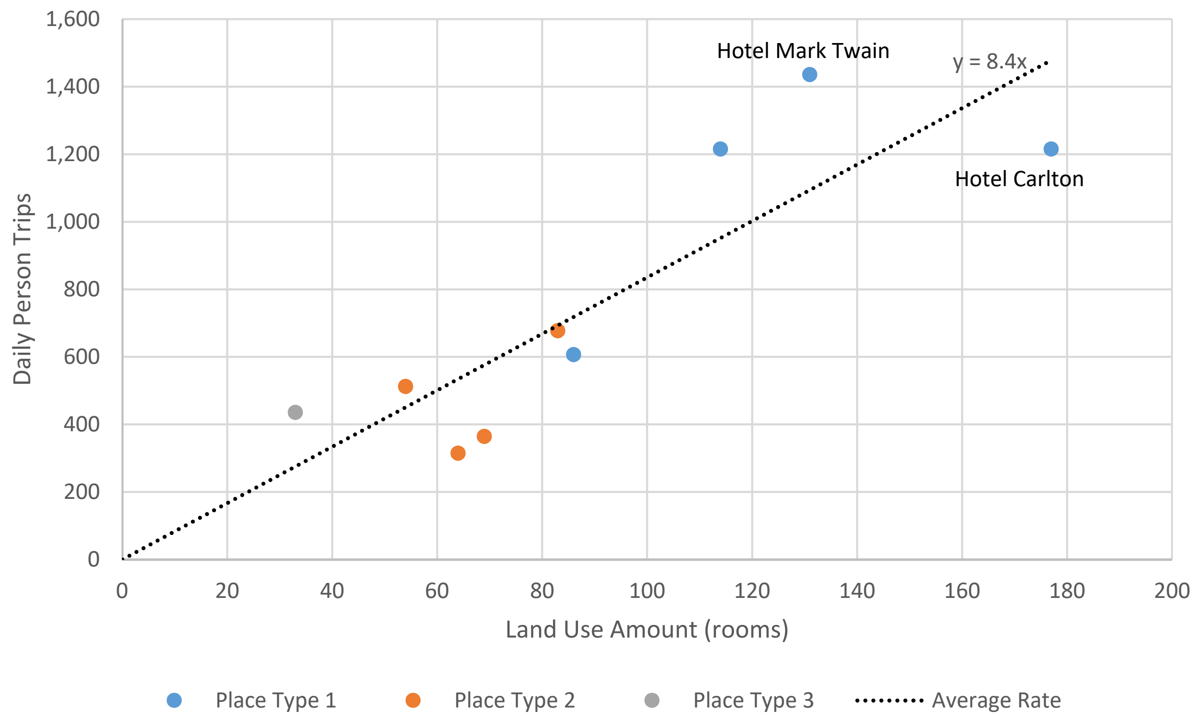


Figure 28: AM Peak Hour Person Trip Generation – Hotel

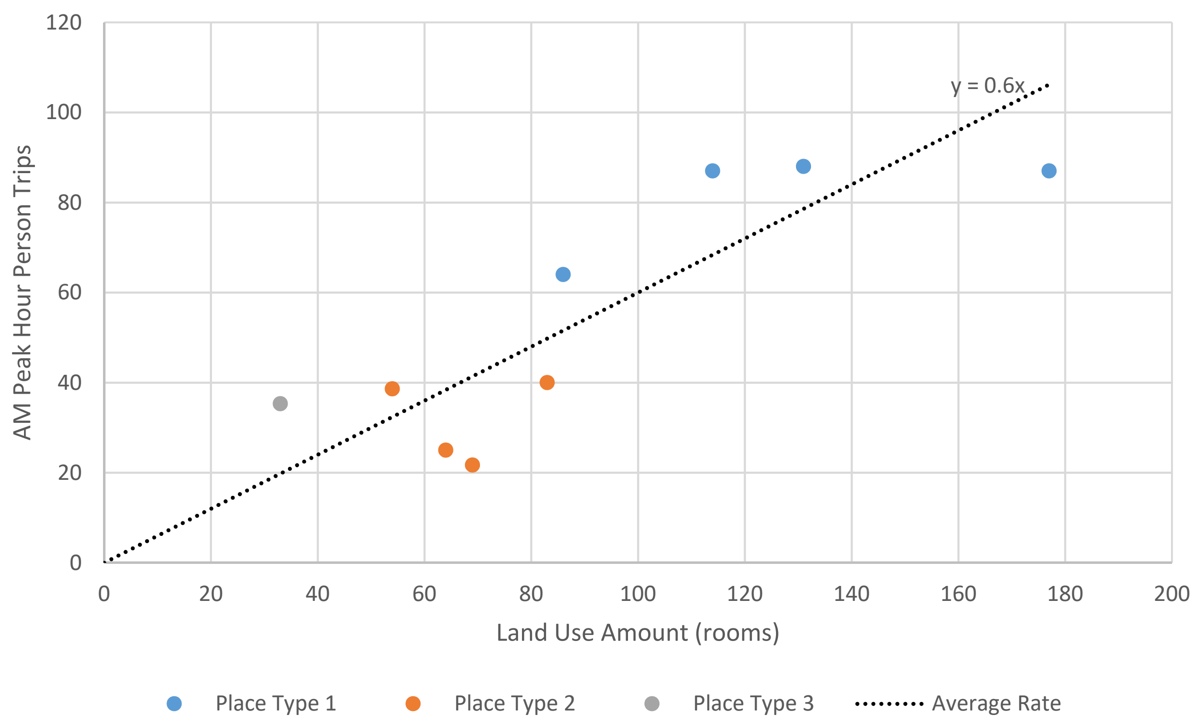
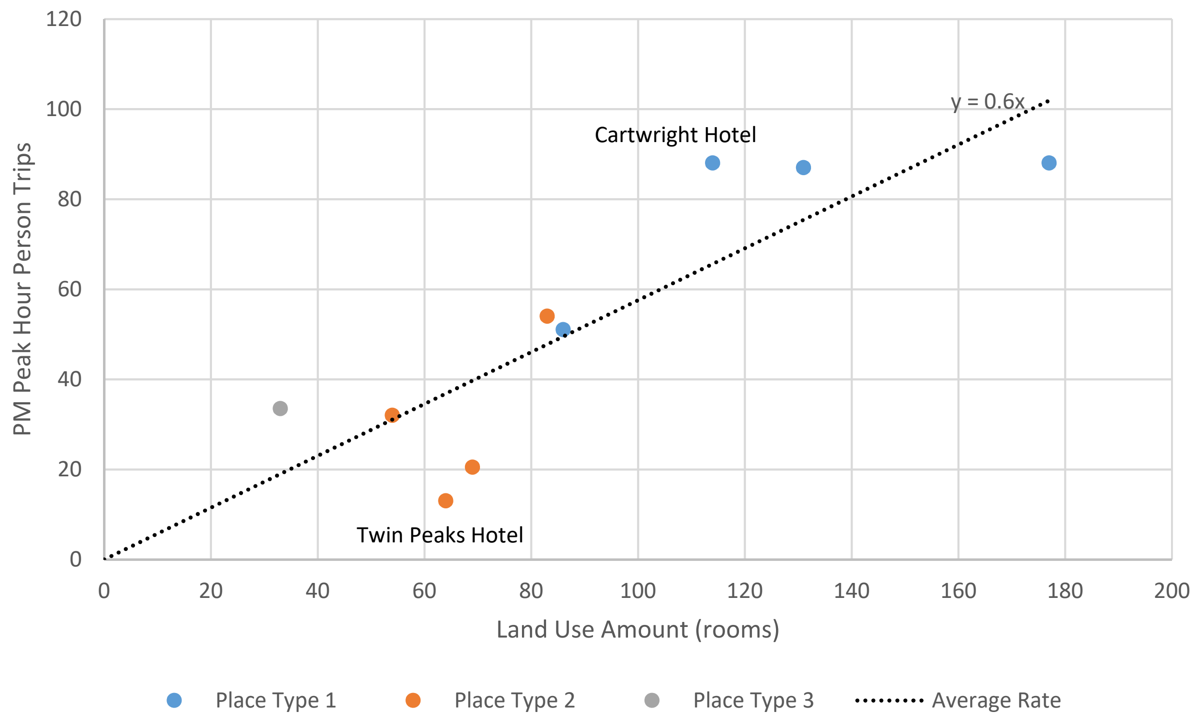


Figure 29: PM Peak Hour Person Trip Generation – Hotel



6.2 Extended PM Peak Mode Split

Fehr & Peers calculated the mode split (the share of individuals using each of the modes presented in the travel survey) for the extended PM peak period (3:00 to 7:00 PM) at each of the data collection sites where surveys were conducted. These mode splits were then further aggregated at the individual trip level, based on both land use and location within San Francisco.

Mode splits were calculated based on intercept survey data, which were collected at 65 sites during the extended PM peak period; therefore, the mode splits presented in this analysis reflect travel patterns during that time period. CHTS data were used to supplement mode split data for residential uses only. In addition, garage and driveway vehicle counts were used to provide additional information on vehicle modes for sites where we could not conduct intercept surveys due to direct access between the building and garage.

A total of 9,913 survey responses were collected, of which 6,014 indicated a travel mode and were therefore suitable for inclusion in this analysis. At sites where no interior parking garage was present (16 sites), or where permission was obtained to survey at both interior and exterior doorways (five sites), the intercept survey data were the sole source of mode split information. Where interior parking was present and surveying at interior doorways was not feasible, additional calculations were performed; these calculations drew on the video person trip count data and parameters from CHTS. Ultimately, a total of 65 sites were included in the mode split analysis.

The mode split analysis inherits all assumptions used in the trip generation analysis discussed in section 6.1 above. Additionally, assumptions were made regarding the breakdown of vehicle trip types (Drive Alone/HOV Driver/HOV Pax). These assumptions came from analysis of CHTS data, as discussed in section 4.1.1 above.

Mode splits were first calculated at the individual site level. The methodology was as follows:[28]

1. Calculate the site's survey mode splits. Each survey mode split was equal to the number of survey responses indicating a given mode divided by the total number of site survey responses indicating any mode.
2. Apply these survey mode splits to the count of doorway person trips (collected via video counts).
3. Apply the vehicle trip type breakdown (drive alone vs. HOV) derived from CHTS data to the count of driveway vehicle trips (This step is not applicable to sites where no interior parking garage was present or where permission was obtained to survey at both interior and exterior doorways)
4. Sum up total person trip counts for each mode.
5. Calculate the site's final mode split as the number of person trips for a given mode divided by the total number of person trips for all modes.

Sites were then aggregated by place type and land use, with average mode splits being calculated as a simple average of each site's mode splits.

The results of the mode split analysis are presented in **Table 11**. A summary table, which aggregates individual modes into Auto (Drive Alone, HOV Driver, and HOV Pax), Taxi/TNC, Public Transit (Bus, Light Rail, and Heavy Rail), Private Transit (Private Shuttle), Walk, and Bike, is shown in **Table 12**.

[28] The methodology presented here is the more complex one employed at sites with interior parking present for which interior survey data were unavailable.

Table 11: Mode Split by Place Type and Land Use

Land Use	Place Type	Number of Sites	Number of Survey Responses	Drive Alone %	HOV Driver %	HOV Pass-enger %	Walk %	Taxi / TNC %	Bike %	Bus[1] %	Light Rail[2] %	Heavy Rail[3] %	Private Shuttle[4] %
Office	Place Type 1	8	942	12.2%	3.7%	2.5%	42.3%	6.1%	3.7%	7.1%	3.2%	18.5%	0.6%
	Place Type 2	7	893	27.6%	5.3%	4.5%	17.1%	11.1%	2.8%	8.1%	2.0%	8.5%	12.9%
	Place Type 3	3	413	56.1%	3.2%	10.1%	5.7%	2.0%	0.6%	0.3%	1.2%	2.1%	18.6%
Retail	Place Type 1	4	347	9.3%	0.2%	1.8%	54.9%	4.6%	3.7%	6.1%	7.9%	11.4%	0.0%
	Place Type 2	10	1,096	17.5%	5.1%	3.3%	57.6%	1.4%	2.8%	6.6%	2.2%	3.0%	0.5%
	Place Type 3	7	949	31.6%	13.8%	8.6%	27.8%	1.0%	1.1%	10.5%	3.7%	1.6%	0.3%
Residential	Place Type 1	4	366	15.6%	3.6%	5.6%	37.7%	6.0%	2.9%	14.9%	5.9%	7.2%	0.5%
	Place Type 2	9	392	27.3%	4.3%	7.3%	34.3%	3.5%	3.9%	8.2%	10.2%	0.6%	0.3%
	Place Type 3	2	177	18.6%	7.6%	5.3%	28.3%	4.2%	5.1%	15.7%	11.3%	2.7%	1.2%
Hotel	Place Type 1	4	196	5.3%	7.8%	4.4%	55.1%	19.6%	0.0%	1.6%	1.5%	2.8%	1.8%
	Place Type 2	5	187	11.3%	7.0%	8.6%	38.4%	15.7%	0.0%	7.2%	5.0%	2.5%	4.2%
	Place Type 3	2	56	21.7%	11.8%	12.0%	45.6%	7.5%	0.0%	0.0%	1.5%	0.0%	0.0%

Source: Fehr & Peers, 2018.

Notes:
1. Bus includes Muni bus service, AC Transit, SamTrans, and Golden Gate Transit.
2. Light Rail includes Muni Metro.
3. Heavy Rail includes BART and Caltrain.
4. Private Shuttle includes employer-operated shuttles (including long-haul "tech shuttles"), private bus operators such as Chariot, and short-haul shuttles operated by nonprofit or business groups (such as the University of California San Francisco, Executive Park, or the Mission Bay Transportation Management Association).

Table 12: Mode Split by Place Type and Land Use (Summary)

Land Use	Place Type	Number of Sites	Number of Survey Responses	Auto[1] %	Taxi / TNC %	Public Transit[2] %	Private Transit[3] %	Walk %	Bike %
Office	Place Type 1	8	942	18%	6%	29%	1%	42%	4%
	Place Type 2	7	893	37%	11%	19%	13%	17%	3%
	Place Type 3	3	413	69%	2%	4%	19%	6%	1%
Retail	Place Type 1	4	347	11%	5%	25%	0%	55%	4%
	Place Type 2	10	1096	26%	1%	12%	0%	58%	3%
	Place Type 3	7	949	54%	1%	16%	0%	28%	1%
Residential	Place Type 1	4	366	25%	6%	28%	0%	38%	3%
	Place Type 2	9	392	39%	4%	19%	0%	34%	4%
	Place Type 3	2	177	32%	4%	30%	1%	28%	5%
Hotel	Place Type 1	4	196	17%	20%	6%	2%	55%	0%
	Place Type 2	5	187	27%	16%	15%	4%	38%	0%
	Place Type 3	2	56	45%	7%	1%	0%	46%	0%

Source: Fehr & Peers, 2018.

Notes:
1. Auto includes Drive Alone, HOV Driver, and HOV Pax.
2. Public Transit includes Bus, Light Rail, and Heavy Rail.
3. Private Transit includes Private Shuttle.

6.2.1 Office

As shown in **Figure 30**, the extended PM peak period mode splits of office sites within Place Type 1 were dominated by transit and walking trips. Approximately a quarter of Place Type 1 office trips were made by auto or taxi/TNC. Office sites' auto mode share increased steadily from Place Type 1 to 2 and 3. Place Type 3's mode split reflects high auto activity and private transit ridership, and minimal public transit or active transportation (walk or bike) trips.

The relatively high proportion of office trips made by private transit reflects factors that are particular to individual sites. Several office sites in Place Types 2 and 3 were served by private transit: an office building in Mission Bay was adjacent to a Mission Bay Transportation Management Association bus stop, and multiple sites in Executive Park were near designated private employer shuttle stops. In the absence of proximity to such facilities, an office site in Place Type 2 or 3 might not exhibit very high private transit mode share. Whether those trips would otherwise be made by public transit, driving, or some other mode likely depends on other factors such as distance to high quality transit and parking pricing and availability. This may lead to an undercounting of car trips at similar, future office developments, particularly in areas without strong transit service, unless the office development also includes private shuttles.

Each individual office site's auto mode share is shown by Place Type in **Figure 31**. It is important to note that Figure 31, and the subsequent figures like it for the other land use categories, considers both Auto and Taxi/TNC to be part of "auto mode share," as they have similar implications for VMT, GHG emissions, and roadway congestion. This figure shows that with the exception of 1000 Brannan Street, which is located at the very edge of Place Type 1 and adjacent to freeway on- and off-ramps, Place Type 1 office sites were closely grouped around a low auto mode share. By contrast, there was substantial variation in auto mode share at office sites in Place Type 2. Place Type 3's office sites, while fewer in number of sites, auto mode share were relatively closely grouped.

Figure 30: Mode Splits by Place Type – Office

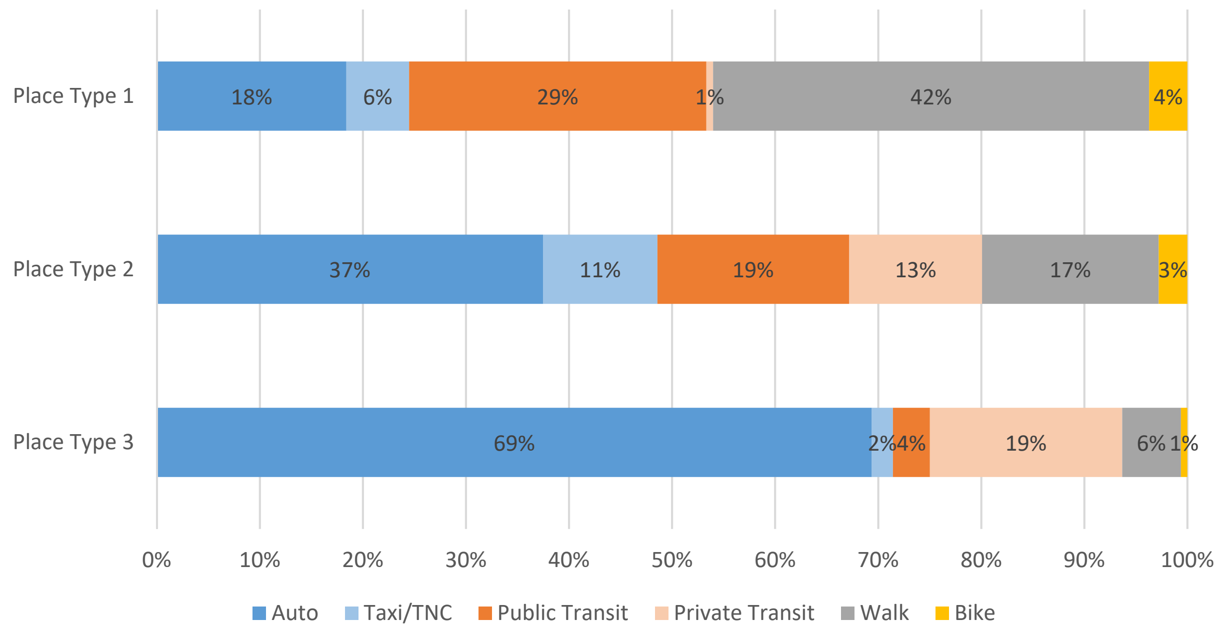


Figure 31: Auto Mode Share Scatter – Office

6.2.2 Retail

Throughout San Francisco, the extended PM peak period mode splits at retail sites reflect a high level of walking. As shown in **Figure 32**, a full 80 percent of trips at retail sites within Place Type 1 take place by walking or public transit. More than half of the retail mode splits in Place Type 2 are walking trips, while auto trips increase to make up for a reduced transit mode share. Within Place Type 3, auto trips are dominant, but nearly half of extended PM peak period trips to and from retail sites take place by public transit or walking. This high share of walking and transit trips likely reflects the prevalence of local-serving retail, which generates many trips due to pass-by activity (or people stopping on their way to another location).

Figure 33 shows each retail site's auto mode share. Of particular note is the fairly wide range of variability in Place Type 2, where sites' auto mode shares ranged from zero percent to more than 50 percent. Within Place Type 3, there was a clearer grouping of high auto mode share, with a couple of outliers.

Figure 32: Mode Splits by Place Type – Retail

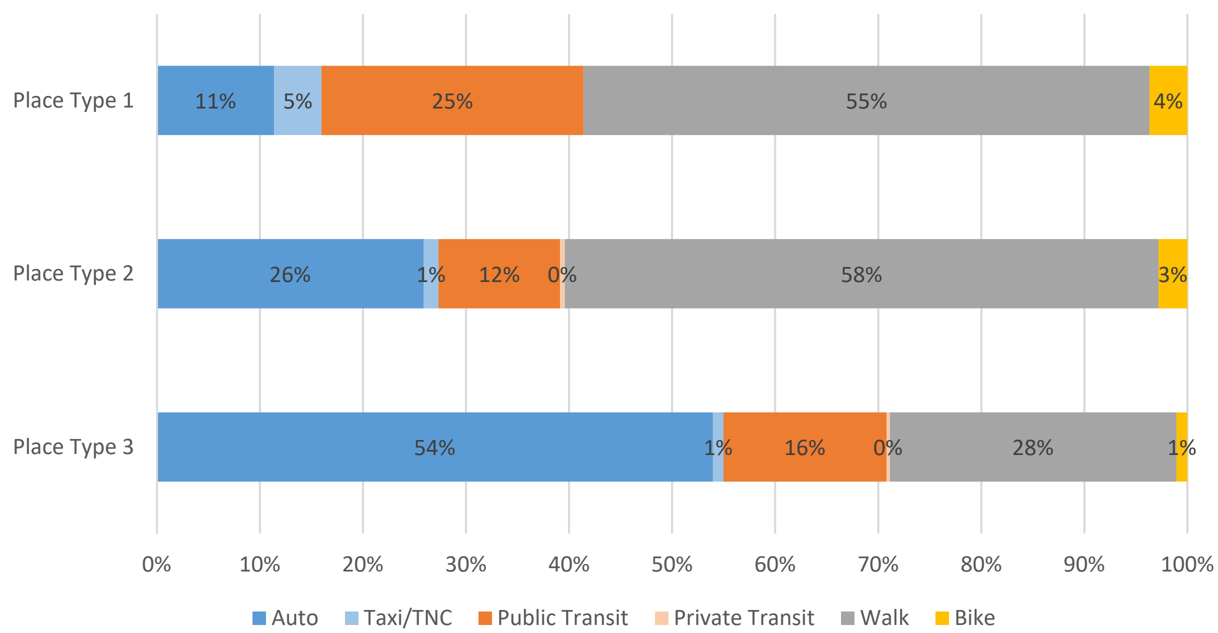
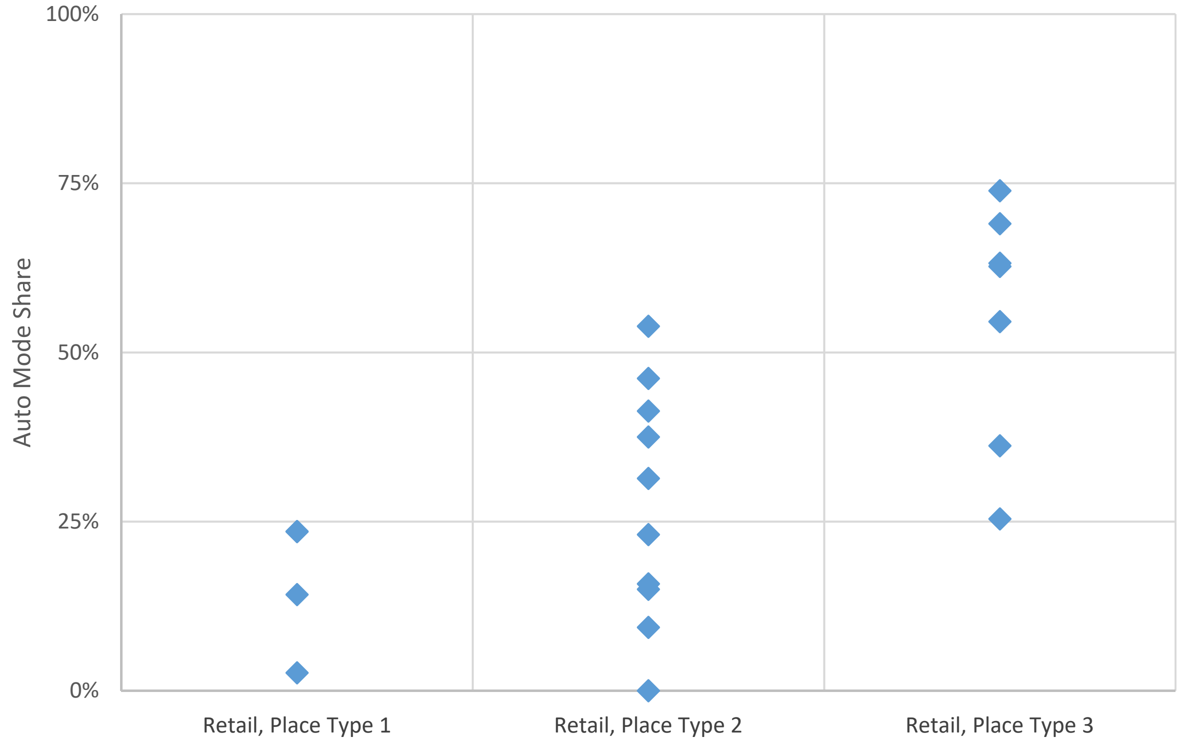


Figure 33: Auto Mode Share Scatter – Retail



6.2.3 Residential

The extended PM peak hour mode splits for residential sites in each of the three Place Types are presented graphically in **Figure 34**. Residential sites throughout San Francisco were served by a roughly equal mix of auto, public transit, and walking trips. Walk trips were most prevalent in Place Type 1. **Figure 35** shows each residential site's auto mode share (including Taxi/TNC trips). 45 Lansing Street, a high-rise building immediately adjacent to Bay Bridge on- and off-ramps, was an outlier within Place Type 1, whose other residential sites are concentrated around 20 percent auto mode share. As was the case with office and retail sites, the residential sites in Place Type 2 display a wide range of auto mode shares. This is likely due to the diversity of land use types and urban contexts within that place type

Because of the predominantly single-family makeup of the housing stock in Place Type 3, intercept surveying was conducted solely at two residential towers in Parkmerced. Because of the high rates of student occupancy at Parkmerced, and because students tend to make fewer auto trips than other residents, it is likely that mode splits at Parkmerced may differ from mode splits at other residential buildings in Place Type 3.

Figure 34: Mode Splits by Place Type – Residential

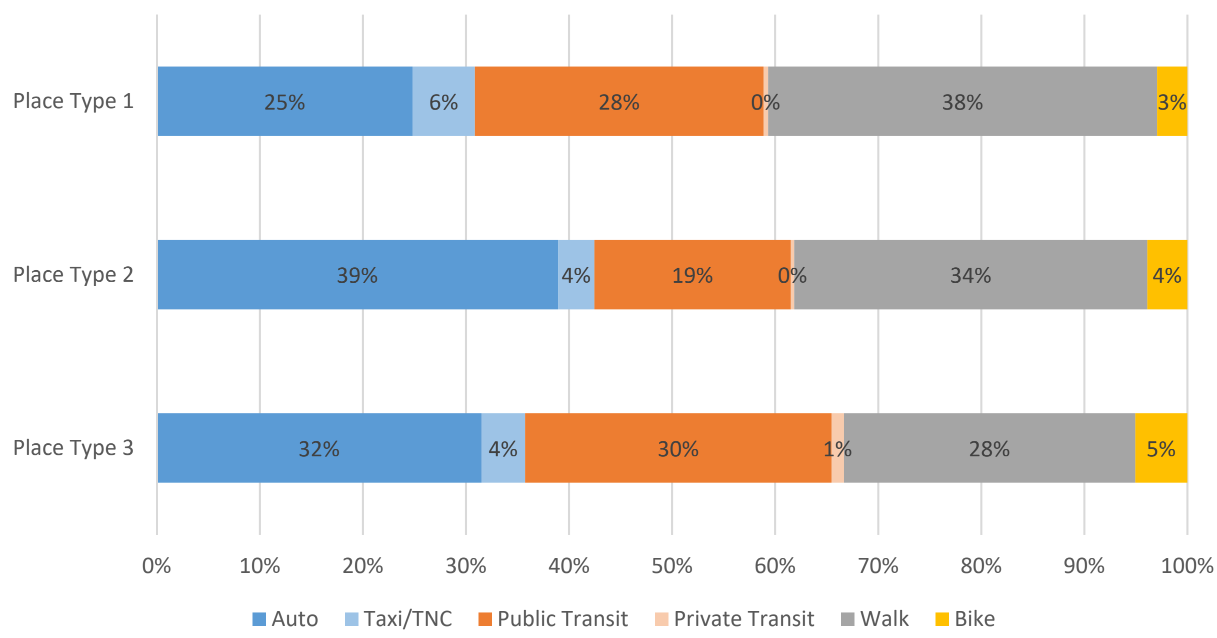
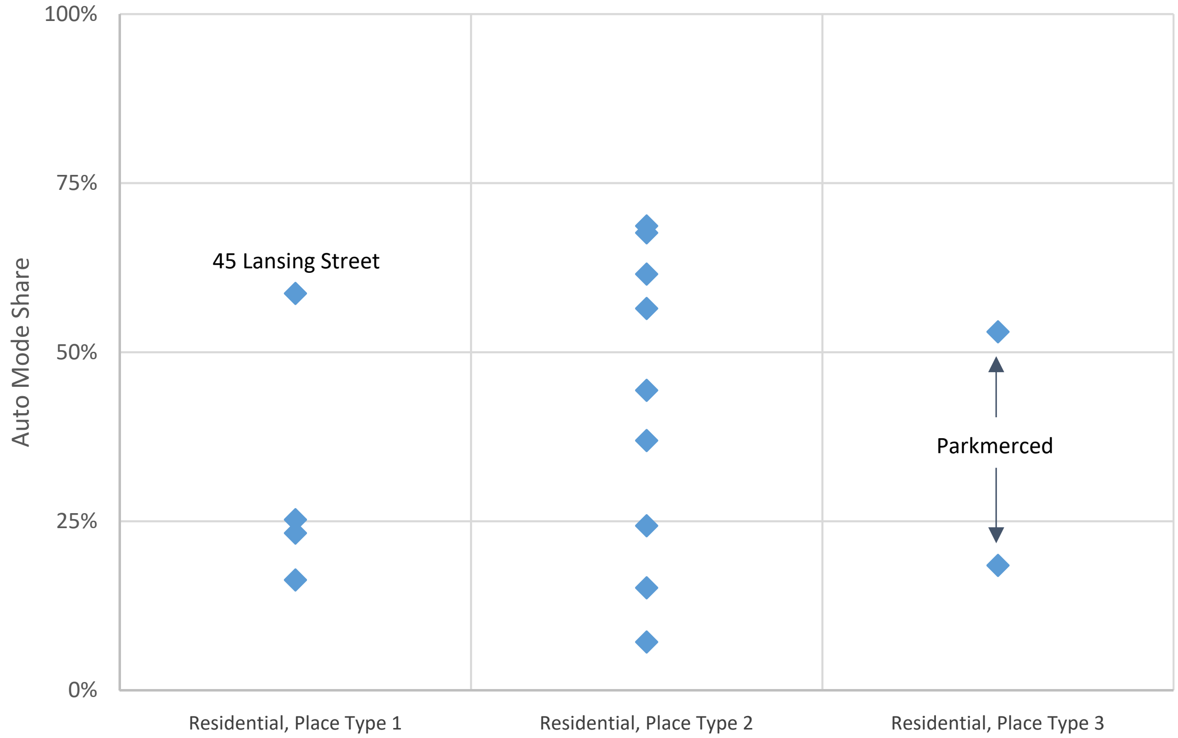


Figure 35: Auto Mode Share Scatter – Residential



6.2.4 Hotel

The average extended PM peak period mode splits for hotel sites by Place Type are shown in **Figure 36**. Walk trips were common at hotel sites across the city. Taxi and TNC trips were also a common travel mode at hotel sites, as would be expected given that hotel visitors are less likely to have access to a private car or bicycle, or to be familiar with local public transit.

Each hotel site's auto mode share (including Taxi/TNC) is shown in **Figure 37**. The hotel sites in Place Type 1 were divided between sites dominated by walking trips and sites with a large number of auto and TNC trips. Within Place Type 2, the Coventry Motor Inn is a substantial outlier in terms of auto mode share, although its name, marketing, and location along the portion of Lombard Street that is designated as part of US Highway 101 make its high auto mode share relatively unsurprising.

Figure 36: Mode Splits by Place Type – Hotel

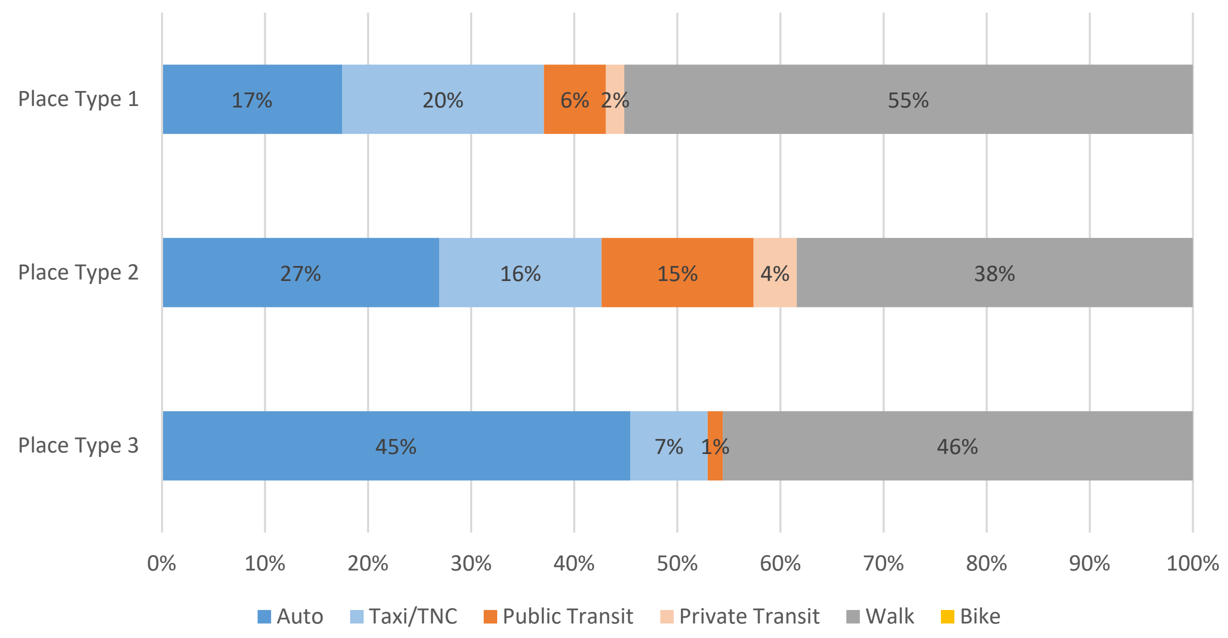
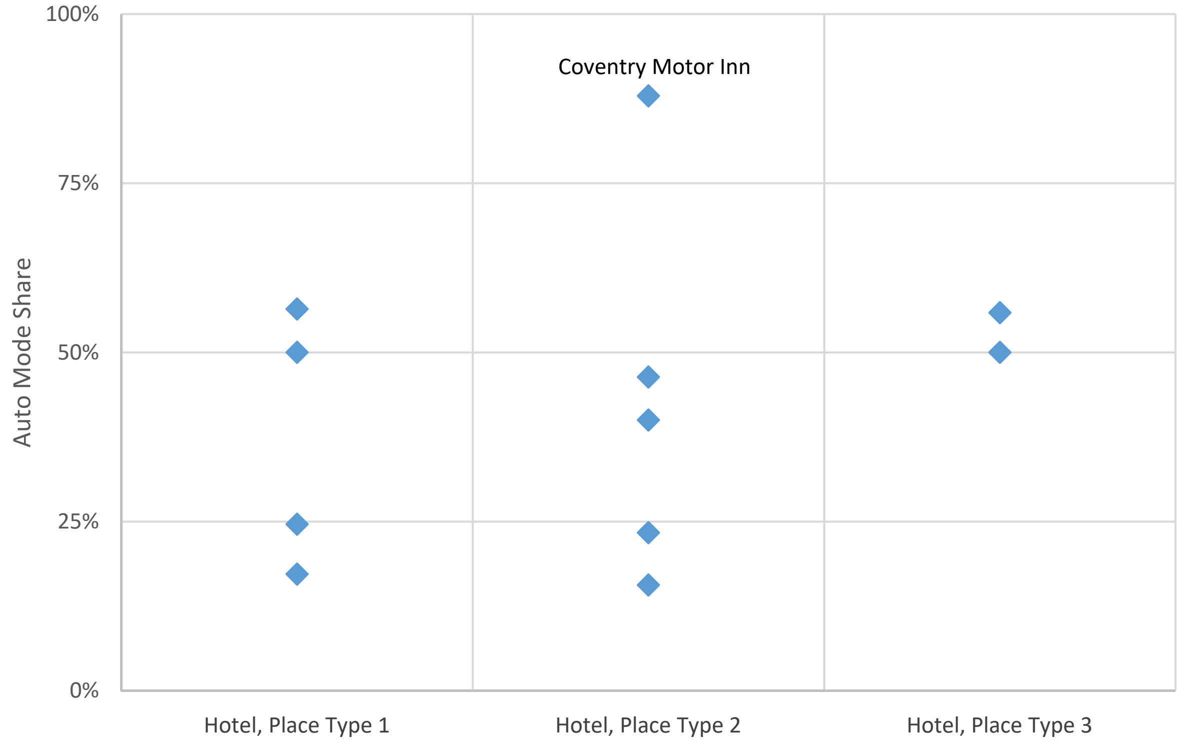


Figure 37: Auto Mode Share Scatter – Hotel



6.3 Trip Distribution

This section discusses three methodologies used to calculate trip distribution: one based solely on newly collected intercept survey data, one based on analysis of CHTS data, and one that incorporates both data sources.

6.3.1 Survey Data

The key data source for survey trip distribution calculations was the set of 9,913 intercept survey responses collected at 65 sites throughout San Francisco. As discussed above, these data were collected between 3:00 and 7:00 PM on typical Tuesdays, Wednesdays, and Thursdays. 4,712 survey records were ultimately found to contain useful responses to the question of where the respondent's immediately preceding or following origin or destination was located.

Survey responses were geocoded in ArcGIS using the United States Census Bureau's address locator files. Additional geocoding was performed manually. Responses that indicated a short distance (e.g. "I'm just coming from around the corner" or "a few blocks away") were assumed to refer to the same Place Type as the site where the record was collected.

Trip distribution was calculated at the Place Type level, using each site's Place Type as the trip's origin and each survey response's Place Type as the trip's destination for inbound trips, and the reverse for outbound trips. This analysis was performed via Excel PivotTable. The results of the survey-based trip distribution analysis, by land use and place type, are presented in **Tables 13** through **16** below.

Table 13: Trip Distribution - Office, by Place Type

Percent of Trips by Origin/Destination						
Destination / ***Origin***	***Place Type 1***	***Place Type 2***	***Place Type 3***	***North Bay***	***East Bay***	***South Bay***
Place Type 1	46%	18%	6%	1%	16%	12%
Place Type 2	25%	39%	5%	3%	16%	12%
Place Type 3	11%	11%	25%	3%	21%	29%

Source: Fehr & Peers, 2018.

Notes:
1. Rates reflect intercept surveys conducted at 18 office sites throughout San Francisco.
2. A total of 1,822 office survey responses indicated a geographic origin/destination.
3. Values may not sum to 100% due to rounding.

Table 14: Trip Distribution - Retail, by Place Type

Percent of Trips by Origin/Destination						
Destination / ***Origin***	***Place Type 1***	***Place Type 2***	***Place Type 3***	***North Bay***	***East Bay***	***South Bay***
Place Type 1	74%	15%	4%	1%	5%	1%
Place Type 2	8%	70%	16%	<1%	2%	4%
Place Type 3	6%	7%	78%	<1%	3%	6%

Source: Fehr & Peers, 2018.

Notes:
1. Rates reflect intercept surveys conducted at 21 retail sites throughout San Francisco.
2. A total of 1,866 retail survey responses indicated a geographic origin/destination.
3. Values may not sum to 100% due to rounding.

Table 15: Trip Distribution - Residential, by Place Type

Percent of Trips by Origin/Destination						
Destination / ***Origin***	***Place Type 1***	***Place Type 2***	***Place Type 3***	***North Bay***	***East Bay***	***South Bay***
Place Type 1	58%	23%	5%	1%	4%	8%
Place Type 2	27%	52%	8%	<1%	3%	9%
Place Type 3	21%	7%	65%	1%	<1%	6%

Source: Fehr & Peers, 2018.

Notes:
1. Rates reflect intercept surveys conducted at 15 residential sites throughout San Francisco.
2. A total of 689 residential survey responses indicated a geographic origin/destination.
3. Values may not sum to 100% due to rounding.

Table 16: Trip Distribution - Hotel, by Place Type

Percent of Trips by Origin/Destination						
Destination / ***Origin***	***Place Type 1***	***Place Type 2***	***Place Type 3***	***North Bay***	***East Bay***	***South Bay***
Place Type 1	73%	7%	1%	3%	1%	14%
Place Type 2	32%	46%	1%	4%	3%	14%
Place Type 3	7%	20%	53%	<1%	<1%	20%

Source: Fehr & Peers, 2018.

Notes:
1. Rates reflect intercept surveys conducted at 11 hotel sites throughout San Francisco.
2. A total of 335 hotel survey responses indicated a geographic origin/destination.
3. Values may not sum to 100% due to rounding.

6.3.2 CHTS Data at Place Type Level

Because of the relatively low number of survey sites in certain land use/Place Type combinations, the trip distribution patterns of CHTS data were examined.

CHTS Approach

Each trip's "land use type" was identified according to the methodology for associating each CHTS trip record with a "land use type" discussed in section 4.1.1 above. Trips' origin and destination Place Types were identified using a lookup table that associated the census tract geographies provided by CHTS.[29] A PivotTable analysis similar to the one used for newly collected intercept survey data was subsequently conducted in Excel. The results of this analysis for each of the three "land use types" are presented in **Tables 17** through **19** below.

Table 17: Trip Distribution "Office-type", by Place Type

Percent of Trips by Origin/Destination						
Destination / ***Origin***	***Place Type 1***	***Place Type 2***	***Place Type 3***	***North Bay***	***East Bay***	***South Bay***
Place Type 1	26%	21%	9%	4%	27%	12%
Place Type 2	29%	26%	19%	4%	11%	11%
Place Type 3	20%	29%	18%	3%	11%	19%

Source: California Household Travel Survey, 2012; Fehr & Peers, 2018.
Note: Values may not sum to 100% due to rounding

Table 18: Trip Distribution "Retail-type", by Place Type

Percent of Trips by Origin/Destination						
Destination / ***Origin***	***Place Type 1***	***Place Type 2***	***Place Type 3***	***North Bay***	***East Bay***	***South Bay***
Place Type 1	50%	28%	5%	2%	10%	5%
Place Type 2	21%	57%	13%	2%	5%	3%
Place Type 3	6%	22%	55%	1%	4%	12%

Source: California Household Travel Survey, 2012; Fehr & Peers, 2018.
Note: Values may not sum to 100% due to rounding

[29] Each Census tract was assigned to the Place Type or region that contained its centroid.

Table 19: Trip Distribution "Residential-type", by Place Type

Percent of Trips by Origin/Destination						
Destination / ***Origin***	***Place Type 1***	***Place Type 2***	***Place Type 3***	***North Bay***	***East Bay***	***South Bay***
Place Type 1	26%	21%	12%	3%	24%	13%
Place Type 2	14%	47%	24%	3%	6%	7%
Place Type 3	10%	32%	39%	2%	5%	11%

Source: California Household Travel Survey, 2012; Fehr & Peers, 2018.
Note: Values may not sum to 100% due to rounding

6.3.3 Blended Data at Place Type Level

As discussed in section 4.1.1 above, the trip distribution tables derived from newly collected intercept survey data were combined with those derived from CHTS data to construct a maximally complete picture of trip distribution patterns.[30] When sample weights were applied, total trips in the CHTS data set were similar in number to the survey sample, and so data were combined in a simplistic 1-to-1 fashion. **Tables 20** through **22** below display the results of this blended trip distribution analysis.

Table 20: Trip Distribution Office, by Place Type (Blended)

Percent of Trips by Origin/Destination						
Destination / ***Origin***	***Place Type 1***	***Place Type 2***	***Place Type 3***	***North Bay***	***East Bay***	***South Bay***
Place Type 1	36%	20%	8%	3%	22%	12%
Place Type 2	27%	33%	11%	4%	14%	12%
Place Type 3	15%	20%	22%	3%	16%	24%

Source: California Household Travel Survey, 2012; Fehr & Peers, 2018.
Note: Values may not sum to 100% due to rounding

[30] Because the California Household Travel Survey does not sample visitors from outside California, a category of traveler that constitutes a majority of visitors to San Francisco's hotels, CHTS data were not incorporated into the trip distribution calculations for Hotel sites.

Table 21: Trip Distribution Retail, by Place Type (Blended)

	Percent of Trips by Origin/Destination					
Destination / ***Origin***	***Place Type 1***	***Place Type 2***	***Place Type 3***	***North Bay***	***East Bay***	***South Bay***
Place Type 1	58%	24%	5%	1%	8%	4%
Place Type 2	14%	64%	14%	1%	4%	4%
Place Type 3	6%	13%	69%	<1%	3%	8%

Source: California Household Travel Survey, 2012; Fehr & Peers, 2018.
Note: Values may not sum to 100% due to rounding

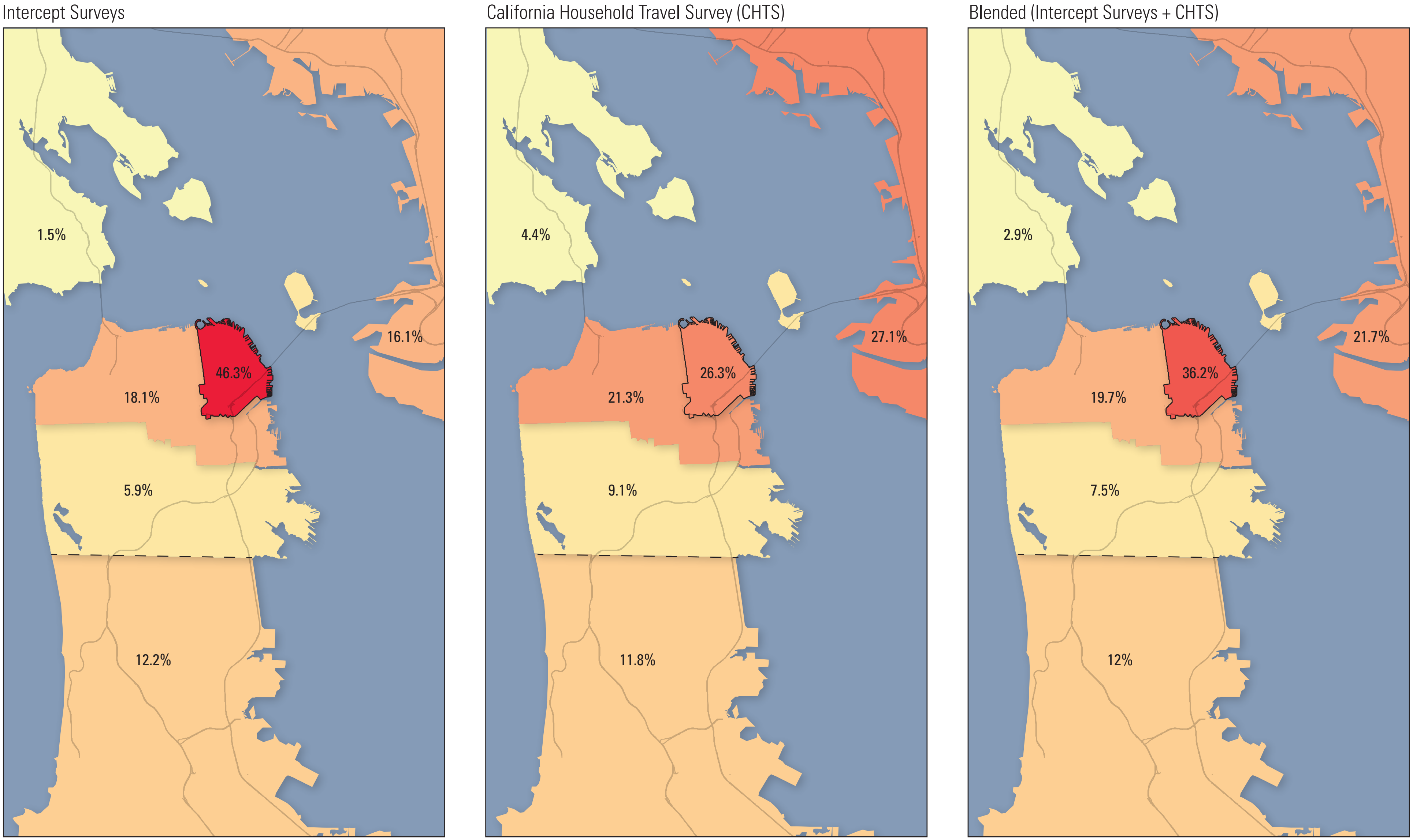
Table 22: Trip Distribution Residential, by Place Type (Blended)

	Percent of Trips by Origin/Destination					
Destination / ***Origin***	***Place Type 1***	***Place Type 2***	***Place Type 3***	***North Bay***	***East Bay***	***South Bay***
Place Type 1	34%	22%	10%	3%	19%	12%
Place Type 2	16%	48%	21%	2%	6%	7%
Place Type 3	12%	29%	42%	2%	4%	11%

Source: California Household Travel Survey, 2012; Fehr & Peers, 2018.
Note: Values may not sum to 100% due to rounding

Figures 38 through **40** below visually compare the trip distribution for trips at office sites and office-type CHTS trips. Each figure shows the distribution of trips from or to a given place type, according to the survey data only, the CHTS data only, and the blended data. These figures demonstrate that the newly collected survey data captured more short-range trips (i.e. trips that start and end in the same Place Type) than the CHTS data did.

Possible explanations for this dynamic include the fact that CHTS trip data are based primarily on travel diaries in which participants recorded all their trip activity at the end of the day, and short-range trips (such as a quick walking trip from the workplace to the store) may have been underreported on those travel diaries, relative to more "major" trips such as the journey to work. Alternatively, it is possible that people on foot (who are likelier to make a shorter trip) were more likely to respond to the intercept surveys.



Share of Trips to/from Place Type 1

–Low

–High

Place Type 1

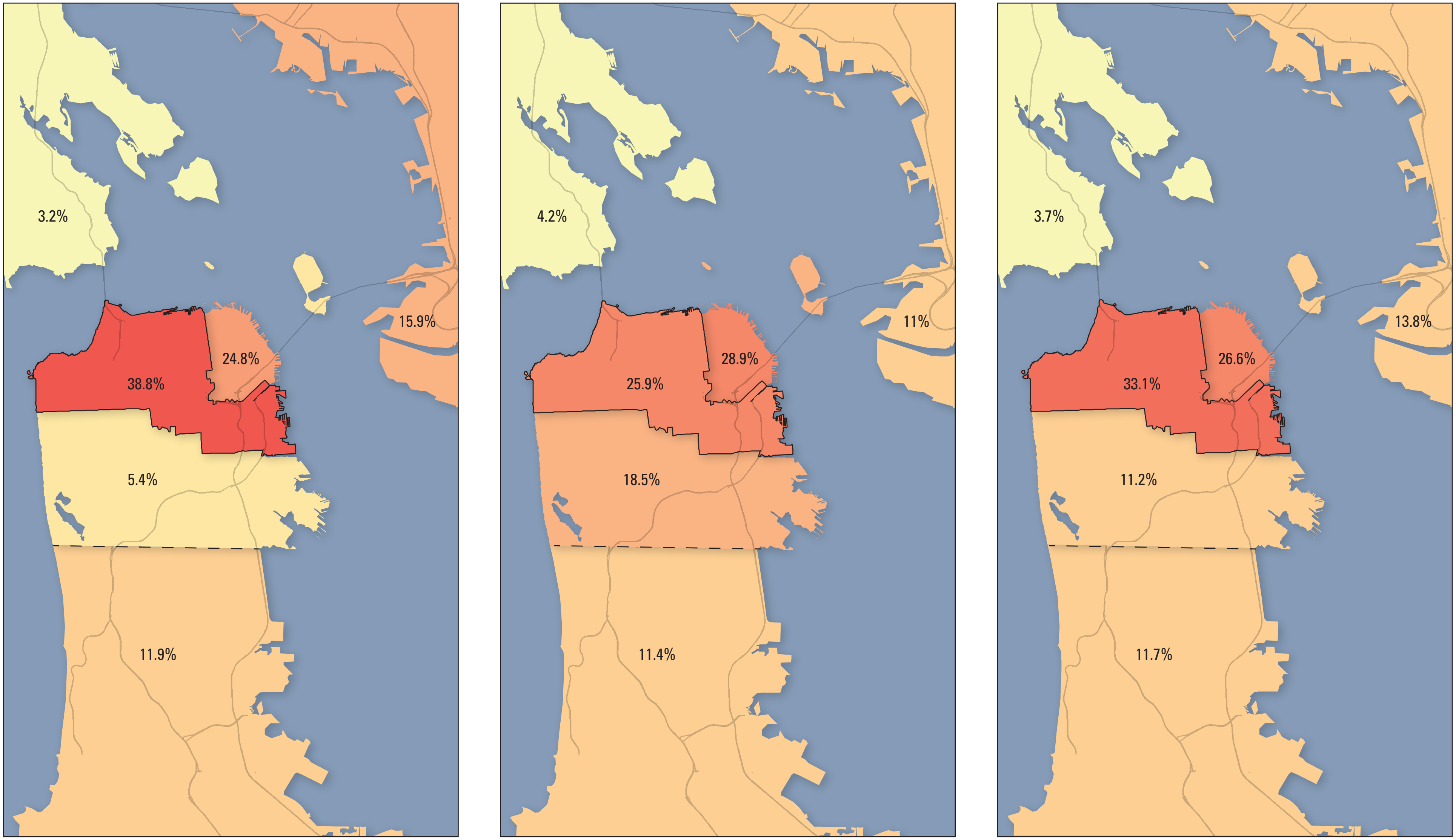
Miles

0 2.5 5

Figure 38

Trip Distribution - Office - Place Type 1

Intercept Surveys | California Household Travel Survey (CHTS) | Blended (Intercept Surveys + CHTS)



Share of Trips to/from Place Type 2

–Low

–High

Place Type 2

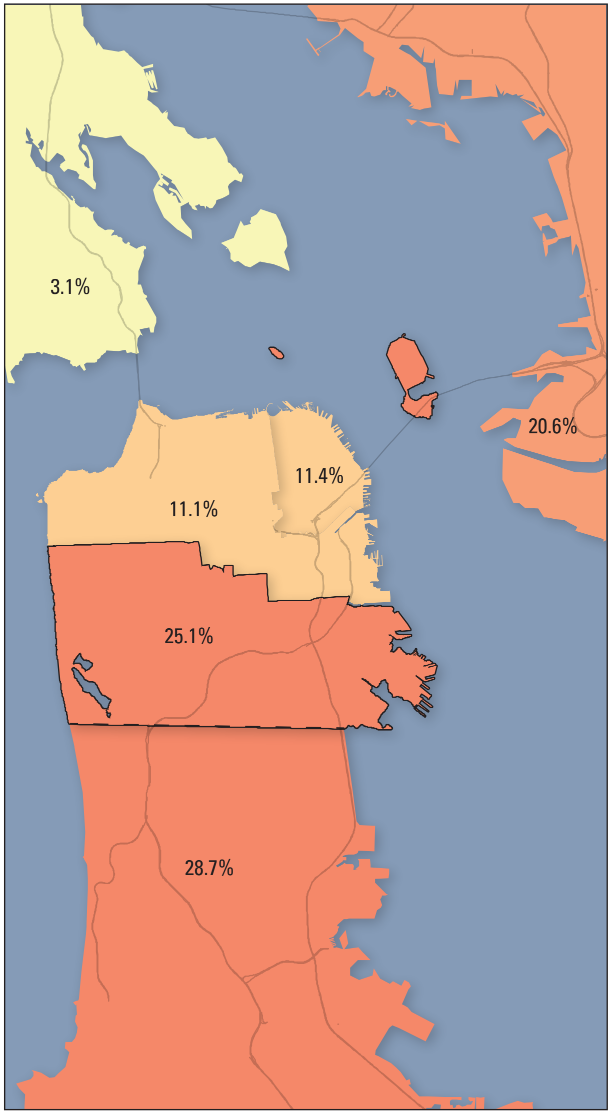
Miles

0 2.5 5

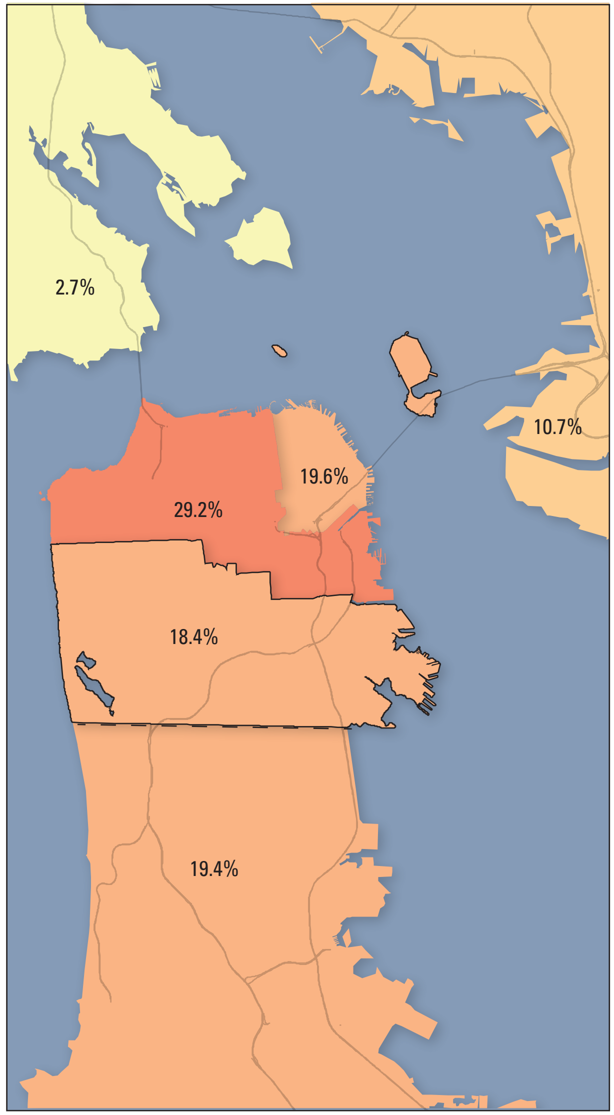
Figure 39

Trip Distribution - Office - Place Type 2

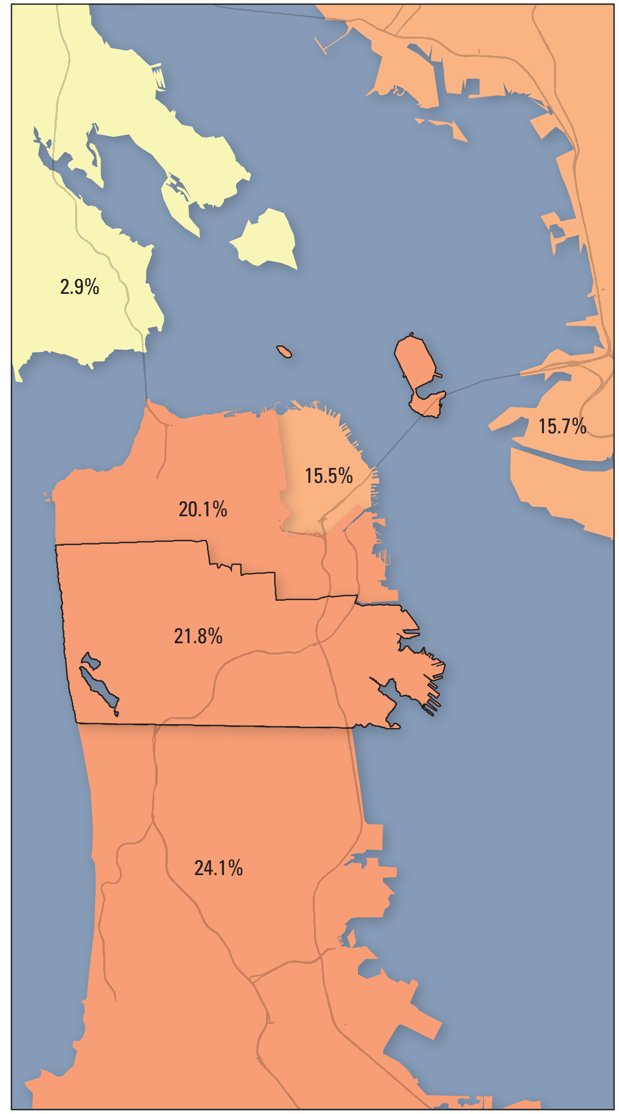
Intercept Surveys



California Household Travel Survey (CHTS)



Blended (Intercept Surveys + CHTS)



Share of Trips to/from Place Type 3

–Low

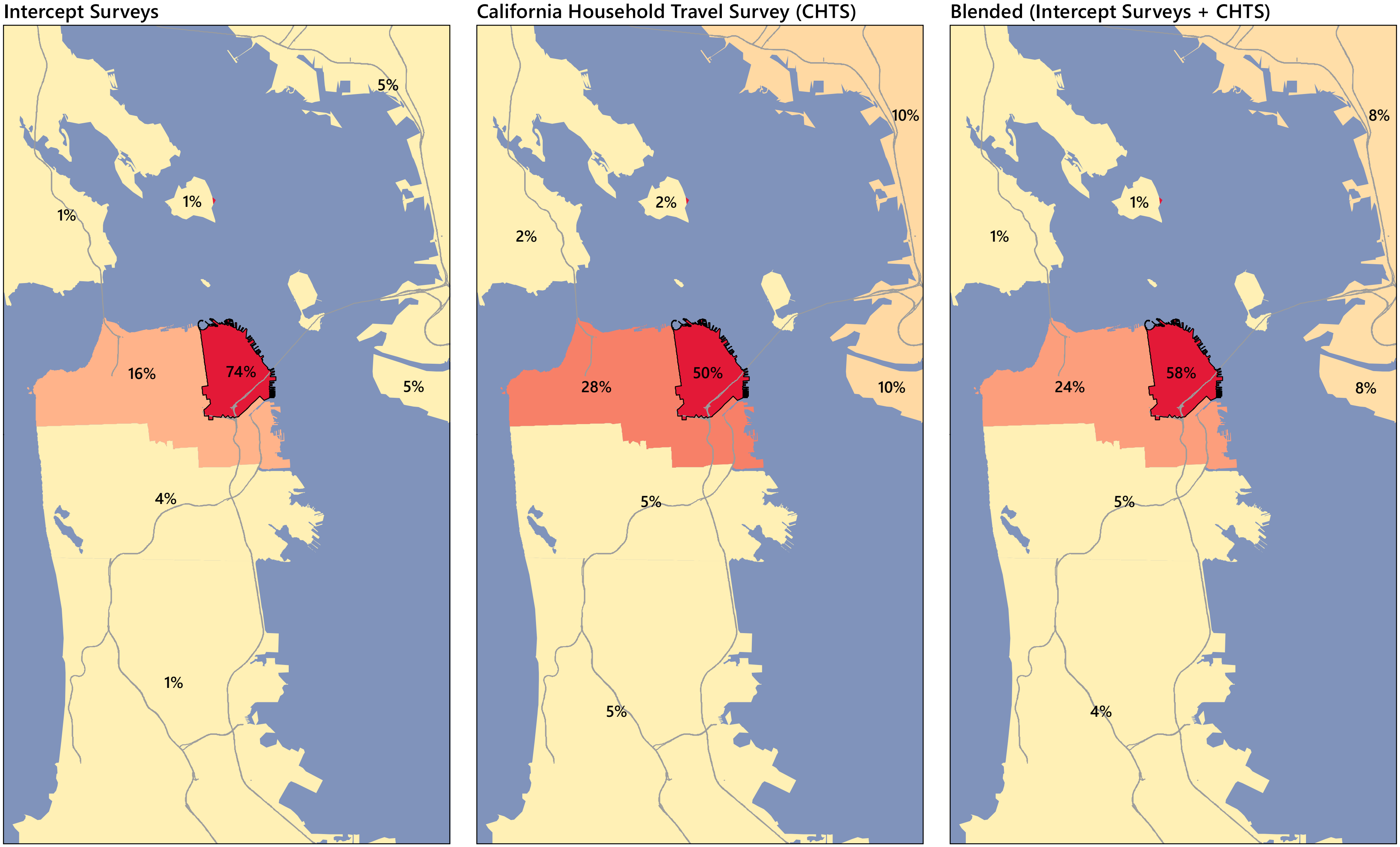
–High

Place Type 3

Miles
0 2.5 5

Figure 40

Trip Distribution - Office - Place Type 3



Share of Trips to/from Place Type 1

Low

High

Place Type 1

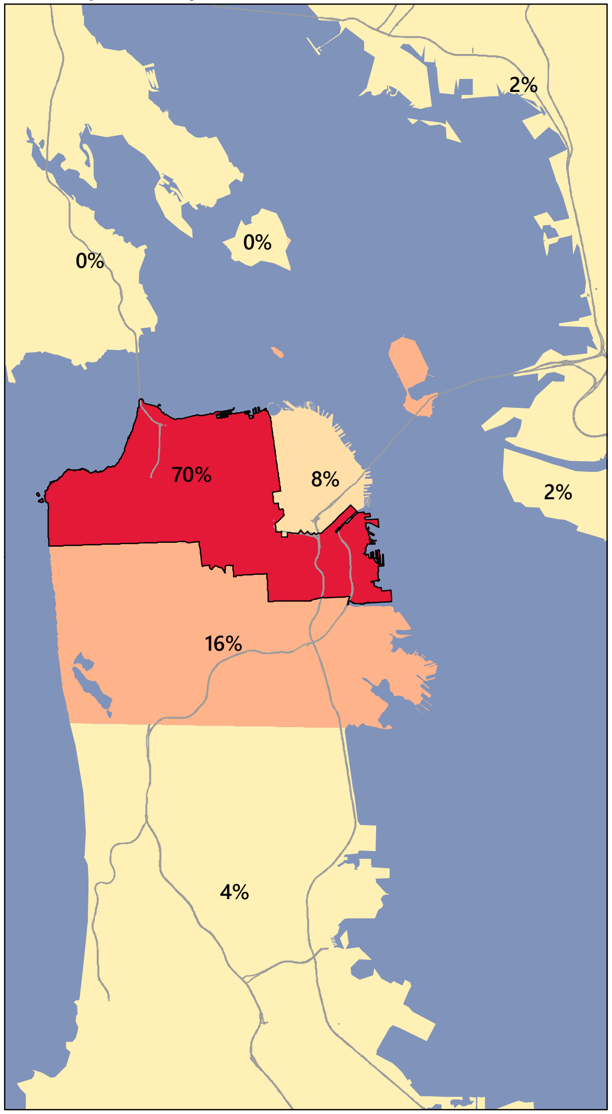
Miles

0 1.25 2.5 5

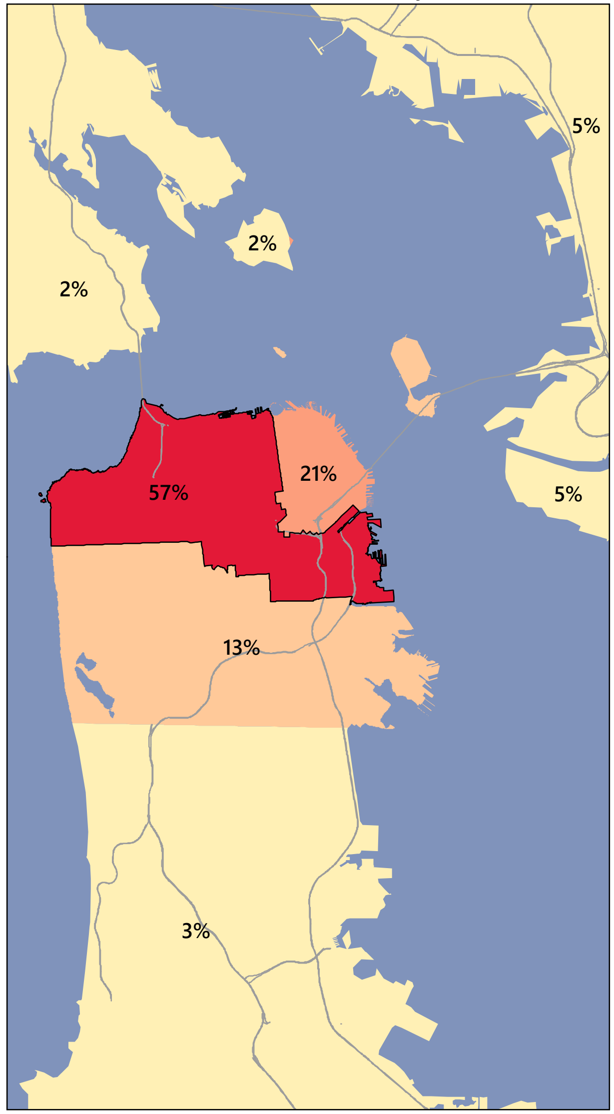
Figure 41

Trip Distribution - Retail - Place Type 1

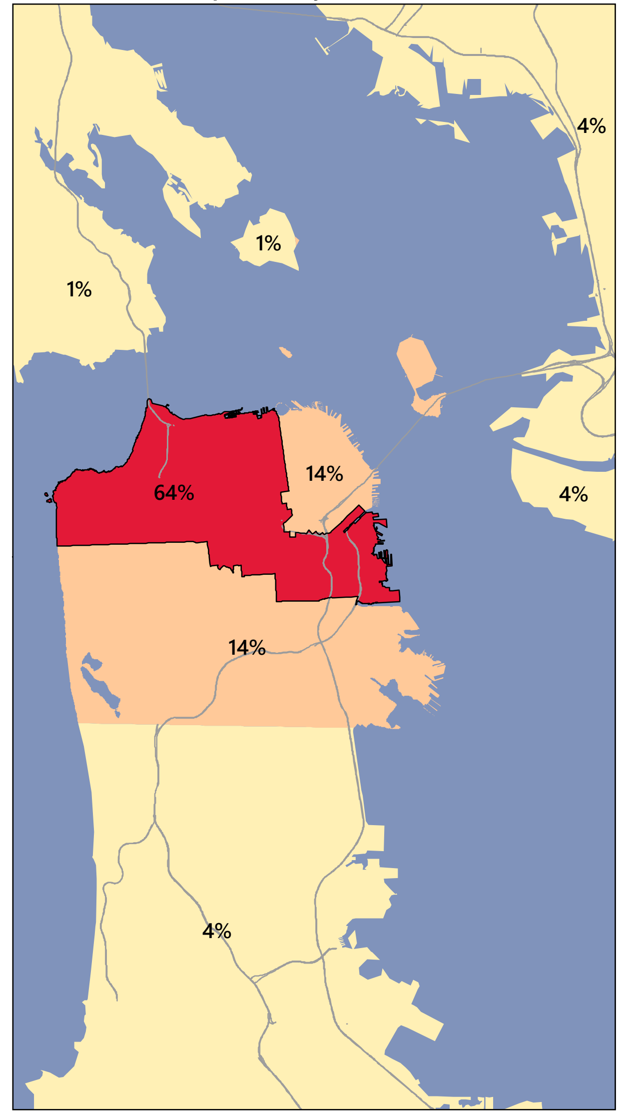
Intercept Surveys



California Household Travel Survey (CHTS)



Blended (Intercept Surveys + CHTS)



Share of Trips to/from Place Type 2

Low

High

Place Type 2

Miles
0 1.25 2.5 5

Figure 42

Trip Distribution - Retail - Place Type 2

N:\Projects\Non_SanJose_Projects\SF Projects\SF15-0864_SF Travel Demand Update\Graphics\GIS\MXD\Fig 45 - Trip Distribution - Retail Place - Type 2.mxd

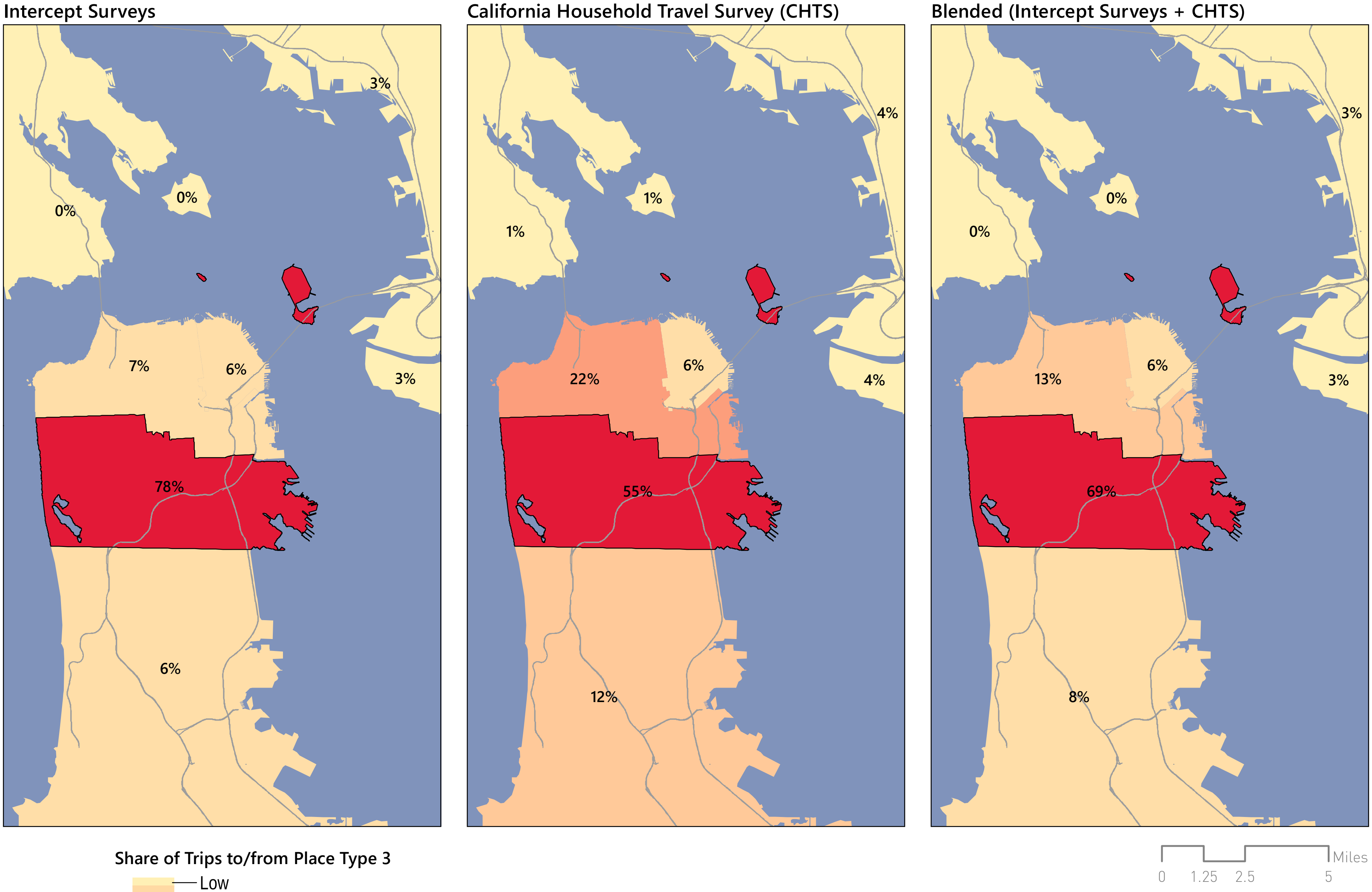


Figure 43

Trip Distribution - Retail - Place Type 3

N:\Projects\Non_SanJose_Projects\SF Projects\SF15-0864_SF Travel Demand Update\Graphics\GIS\MXD\Fig 46 - Trip Distribution - Retail Place - Type 3.mxd

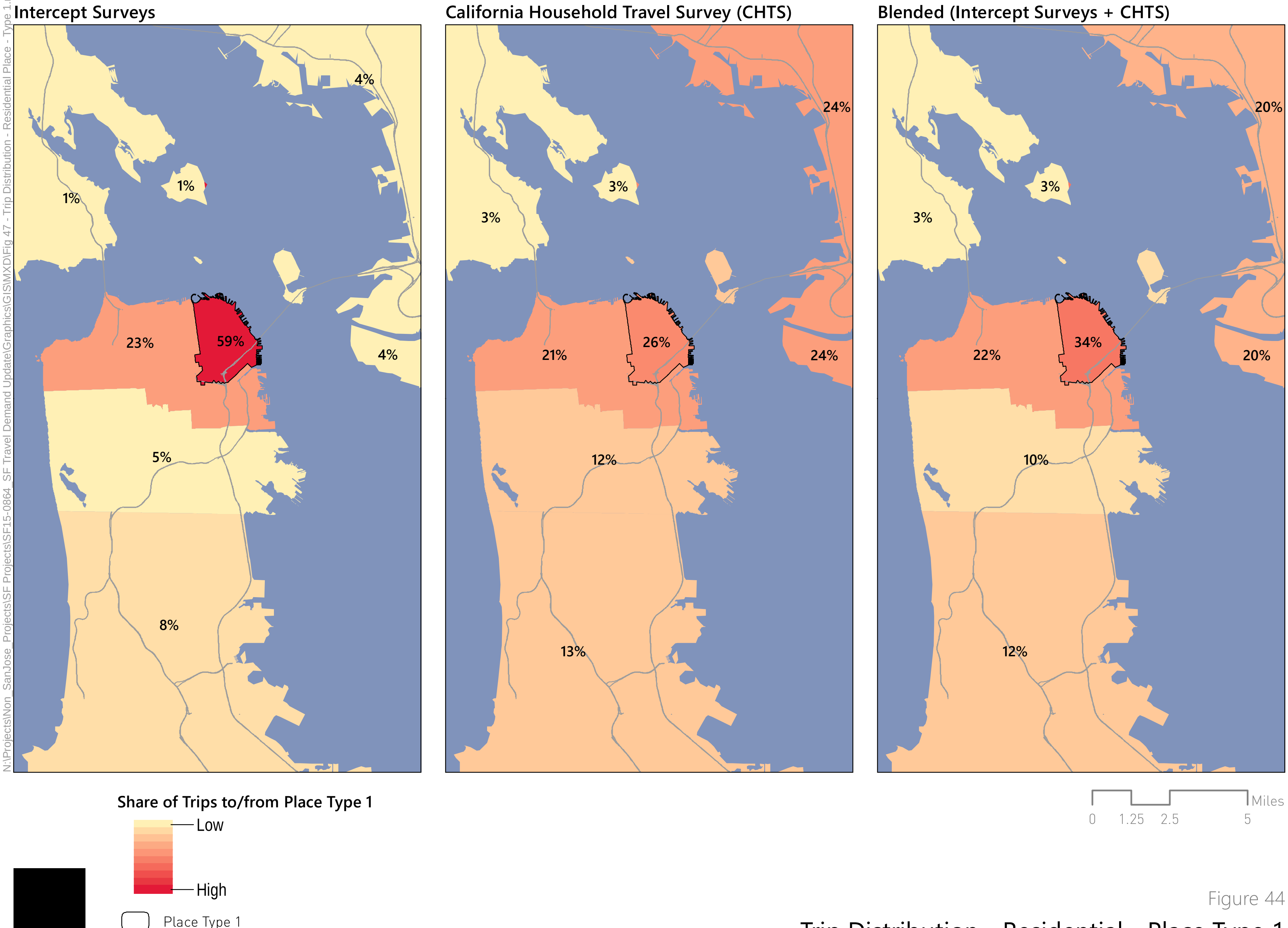
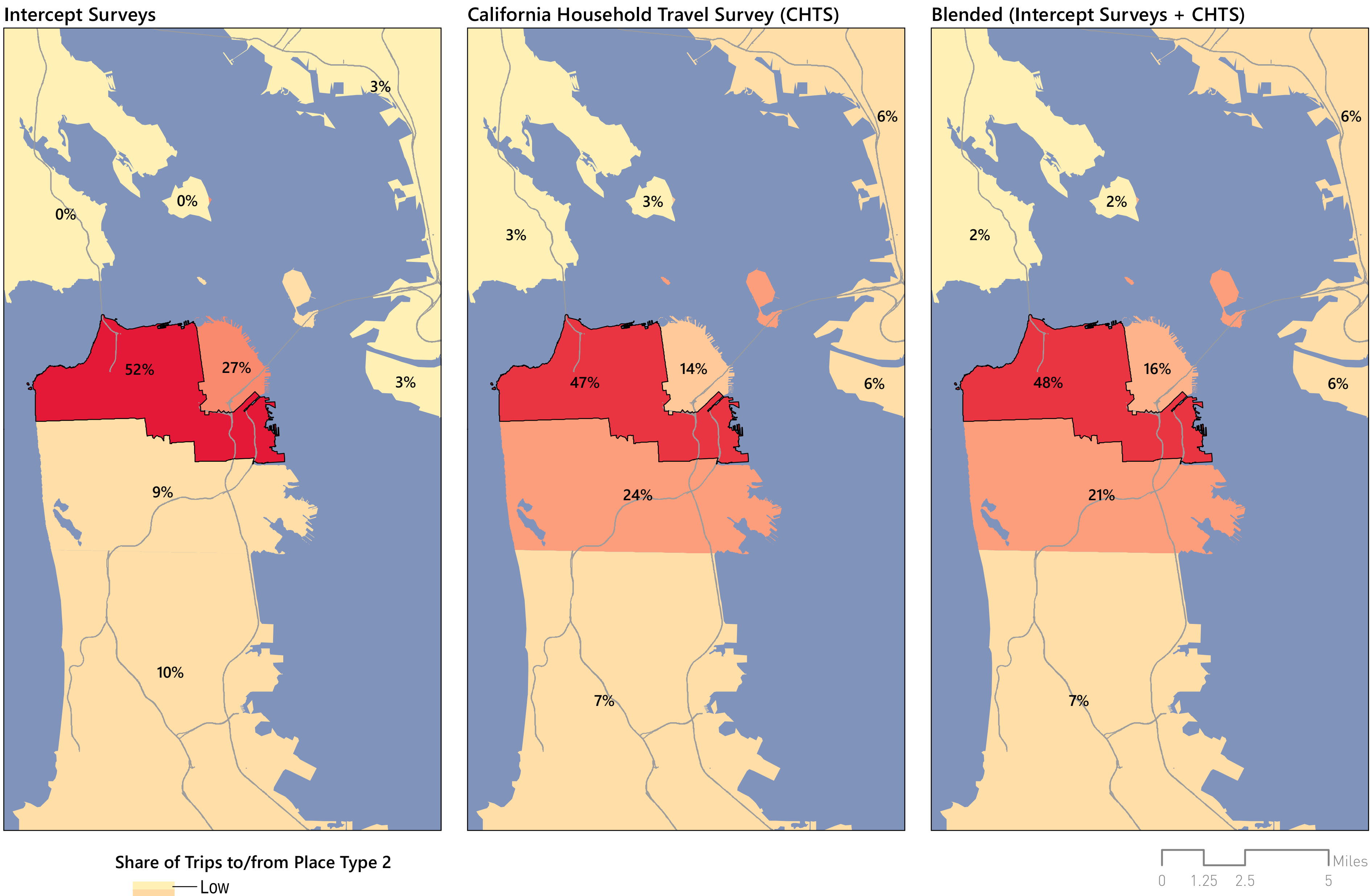


Figure 44

Trip Distribution - Residential - Place Type 1



Share of Trips to/from Place Type 2

Low

High

Place Type 2

Figure 45

Trip Distribution - Residential - Place Type 2

N:\Projects\Non_SanJose_Projects\SF Projects\SF15-0864_SF Travel Demand Update\Graphics\GIS\MXD\Fig 48 - Trip Distribution - Residential Place - Type 2.mxd

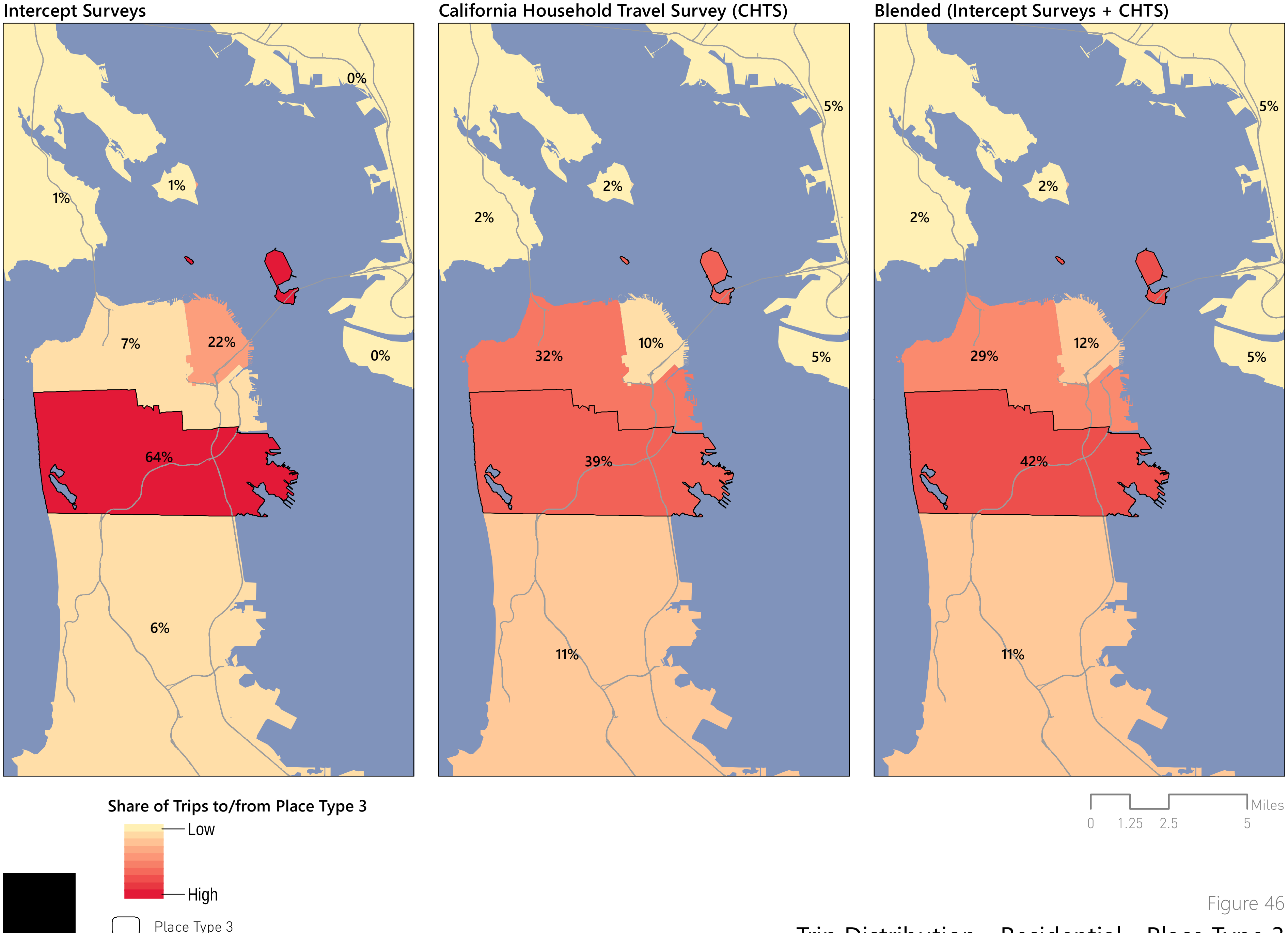


Figure 46

Trip Distribution - Residential - Place Type 3

N:\Projects\Non_SanJose_Projects\SF Projects\SF15-0864_SF Travel Demand Update\Graphics\GIS\MXD\Fig 49 - Trip Distribution - Residential Place - Type 3.mxd

6.3.4 CHTS Data at Neighborhood Level

In addition to summarizing survey findings at the Place Type level, additional analysis was conducted by SFCTA staff to examine how CHTS data could be used to express trip distribution by mode at the neighborhood level. This additional analysis was intended to help capture the inter-related nature of mode choice, trip origin/destination, and trip purpose, as work trips tend to have differing distributions from non-work trips.

In this method, CHTS records of 5,106 trips with at least one end in San Francisco were classified by trip purpose (work trips vs. all other trips) and mode (drive alone, shared ride (2 people), shared ride (3 or more people), taxi/TNC, or transit). Residential trips were identified as trips that included 'home' as either the origin or destination; office trips were identified as trips that included 'work' as either the origin or destination; and retail trips were identified as trips that were neither home nor work based. Trips were weighted according to the household weighting scheme prepared by CHTS to approximate total trips in each O-D pair on a daily basis. Detailed tables are included as **Appendix K.**

Following calculation of the number of trips represented by the CHTS sample, an Excel spreadsheet was used to provide summary distributions for inbound and outbound trips by mode. These distributions are summarized for each land use and district for vehicle trips, person trips in vehicles, and transit trips. The share of trips associated with work vs. non-work purposes are calculated based on the total CHTS database for each neighborhood according to the land use, as categorized above.

While this methodology allows for some approximation of district-to-district flows for each district, some locations or land use and location combinations have somewhat sparse data recorded. As such, SFCTA also prepared this analysis summarizing origins and destinations by mode for each place-type in total. In cases where the CHTS data set may be sparse, or where there are few instances of a given land use in a neighborhood, using the place type summary can still provide a method for examining trip distributions by mode and by purpose.

Detailed documentation of this approach is included as **Appendix H.**

Chapter 7. Loading Demand

Loading demand analysis represents how the trips generated by a project will affect the use of available loading facilities. As such, it can inform design of both the project and the street, curbs, and sidewalks surrounding the project. Providing adequate loading facilities of the proper type and in the right place can help manage vehicle queuing and limit unsafe loading practices. Generally, if there is adequate loading space provided, vehicles performing both passenger loading as well as deliveries will be able to perform this activity outside of travel lanes.

Loading generally represents demand for a temporary use of space, but that use may negatively affect the surrounding transportation system. If there is not adequate space available for loading, vehicles may double-park and load from a travel lane, which can create hazardous conditions for other people using the transportation system. As such, when loading demand regularly exceeds the amount of loading space provided at a site, there may be secondary impacts to the transportation system due to double-parking, queuing, creation of new hazards for various ways that people travel, or other issues (e.g., local congestion).

Loading spaces may be off-street, such as in a loading dock or driveway, or they may be on-street, in the form of designated curb space ("white curb" passenger loading, "yellow curb" commercial loading, or occasionally "green curb" short-term parking). Off-street loading activity tends to involve deliveries or larger service vehicles, while on-street loading activity may be either deliveries or passenger loading (such as when an individual is dropped off or picked up); however, in practice, many types of vehicles may utilize both off-street loading space as well as on-street loading space. Demand for these spaces is expressed as the number of expected loading instances during a given time period, along with an average expected length of stay. These variables allow for a calculation of how much space is necessary to accommodate loading activity either in an off-street facility or at the curb.

The City currently analyzes loading activity via a methodology that assumes passenger loading occurs at the curb, while all other loading occurs in designated loading spaces either at the curb (in the form of yellow curb commercial loading spaces) or in a loading dock, garage, or other off-street facility. Freight and delivery loading is calculated using loading demand rates established via a 1980 study of goods movement activity in San Francisco. This methodology focuses on use of off-street loading spaces such as loading docks and bays, and passenger loading demand, when requested, is calculated via a methodology based on assumptions used for hotel loading or other cases where loading demand is primarily related to passenger loading.

However, the City has reason to believe that there could be substantial changes in loading activity since the 2002 update to the *San Francisco Transportation Impact Analysis Guidelines*. The rise of for-hire vehicles, such as transportation network companies (TNCs), as well as the increase in deliveries associated with both internet commerce and on-demand app-based services, could generate an overall increase in curb loading activity since the 1980s. Additionally, activities that may have previously occurred in loading docks or driveways (such as unloading deliveries or moving activity) are perceived to have moved to the curb in many instances due to convenience or through policies (e.g., curb cut restrictions) that seek to limit the number of vehicles crossing sidewalks where people are walking. Therefore, Fehr & Peers collected two sets of data to ascertain whether existing curb loading supply is sufficient for typical levels of demand, as well as to assess the total level of passenger loading demand associated with shifts in travel patterns over time.

As discussed in this report, the collected data indicate that loading varies a great deal between different land uses and locations; however, there has been an increase in curb-based loading activity over time. Accommodating this additional demand for curb activity may require additional curb space dedicated to loading activity, or more efficient use of existing loading space, depending on the surrounding land use context. As such, Fehr & Peers recommends slight modifications to the loading demand methodology for new projects that incorporate a model wherein both freight and passenger loading share loading space, and that reflects up-to-date data on the number of loading instances expected for a given land use and the duration of those loading instances. Through estimating potential curb demands of new development, the City can better inform its policy decisions on allocating valuable curb space between parking, loading, and other uses.

7.1 Key Terms and Concepts

Components of loading activities are listed below:

- Vehicle types
- Activity types
- Loading facility types/locations

This section defines these key terms for use throughout the remainder of this chapter.

7.1.1 Vehicle Types

The Federal Highway Administration (FHWA) publishes a vehicle classification list, included as **Appendix L**. These vehicle type descriptions refer to the FHWA vehicle classification in addition to providing a description of each vehicle type’s common uses.

Heavy Trucks

Heavy trucks are large trucks (semi trucks or tractor trailers) with wheelbases of 40 feet or more, whose total length may approach 55 feet. Heavy trucks correspond to FHWA vehicle classes 8 through 13, although the largest of these classifications do not generally operate in urban environments. These trucks are approximately 8.5 feet wide. These trucks occupy approximately 60 feet, or three passenger car equivalents (PCEs), assuming each are 20 feet in length, when parked. Heavy trucks are commonly used for large commercial deliveries to businesses such as grocery stores, and for transport of large volumes of goods such as furniture or office records. A typical heavy truck is shown in **Figure 47**.

Figure 47: A typical heavy truck. Source: Google Street View, 2018.

Light Trucks

Light trucks include large panel trucks (e.g. bike share rebalancing vehicles), delivery vans such as UPS, FedEx, or Amazon vehicles, and mid-sized single-unit box trucks, such as U-Haul trucks. Light trucks correspond to FHWA vehicle classifications 5 through 7. Light trucks are commonly used for package delivery, transport of goods, and public and private services, such as garbage pick-up or linen service. The larger end of the light truck vehicle type may occupy approximately 40 linear feet, or two PCEs, when parked. Two typical light trucks are shown in **Figure 48**.

Figure 48: Two typical light trucks. Sources: Google Street View, 2018; Fehr & Peers, 2018.

Taxis

Taxis are passenger cars (FHWA classification 2) dedicated to the hired transport of passengers. Taxis are ubiquitous in large American cities including San Francisco. A typical taxi is shown in **Figure 49**.

Figure 49: A small panel van (Other-type vehicle) at left; a typical taxi at right. Source: Google Street View, 2018.

Other Vehicles

Other vehicles involved in loading include motorcycles, passenger cars, and vans (FHWA classifications 1 through 3).[31] These vehicles may be operating as TNCs, dropping off passengers, delivering light goods, or performing food deliveries. TNCs are included within the "other" category because it is generally infeasible to distinguish whether a passenger car is in operation as a TNC except via costly in-person observations or video analysis. Some vehicles may be in fully private operation yet still be involved in passenger loading, as when a passenger car picks up or drops off a family member at a school or another destination. Additionally, the "other" category includes small panel vans ("cargo vans"), as shown in Figure 49; these vehicles perform a wide variety of loading-type tasks.

7.1.2 Activity Types

Loading activities may involve freight loading, package delivery (a subset of freight loading), or passenger loading. This report refers to the act of accessing a loading zone, stopping the vehicle, and loading or unloading passengers or goods as "loading instances."

Freight Loading

Freight loading involves the delivery or collection of goods, as opposed to passengers. Heavy trucks and light trucks are commonly engaged in freight loading; a typical freight loading instance is depicted in **Figure 50**. Many businesses involve regular freight loading, such as grocery stores and other large retail businesses in order to maintain stocks of goods for use or customer purchase.

[31] Bicycles are involved in a small proportion of deliveries, especially food or fresh flower deliveries, but they are not considered in further detail in this analysis because (1) they represent a small percentage of total deliveries and (2) they can exit the roadway and load/unload off-street, thus generally do not add to on-street curb demand for loading space.

Figure 50: A typical (off-street) freight loading instance. Source: Google Street View, 2018.

Package Delivery and Delivery Service

Package delivery and delivery services are a subset of freight loading. Package delivery is likelier to involve light trucks such as large panel trucks or other-type vehicles such as panel vans, while traditional, larger-scale freight loading primarily involves heavy trucks. Package delivery activities are often dispersed across a large number of destination buildings, as in the case of USPS deliveries to residential uses, UPS and FedEx deliveries to offices, or courier services between offices. A vehicle engaged in package delivery therefore often makes multiple relatively short stops along its route. A typical package delivery instance is shown in **Figure 51**.

Delivery services are similar to package delivery in that they may involve multiple interim stops. These services include door-to-door pick-up or delivery of items such as food (including catering and restaurant orders), dry cleaning, flowers, and groceries or bulk shopping orders. These services may be performed on a more ‘ad-hoc’ basis; rather than having a regular route or set of customers, delivery service is dispatched each time a customer places an order. These services may include trips to offices, residential units, or hotels, and are often conducted in a standard passenger vehicle or small van, although they may also be conducted by light truck, bicycle, or on foot.

Figure 51: A typical package delivery loading instance. Source: Google Street View, 2018.

Passenger Loading

Passenger loading involves the drop-off and/or pick-up of passengers. A typical passenger loading instance is shown in **Figure 52**. For the purpose of loading analysis, passenger loading is considered to include person trips made by taxi or TNC, and some non-SOV person trips (i.e., those where an individual is dropped off by the driver at their destination). Public and private transit trips involving curbside boarding of the transit vehicle also have a loading component; however, these trips' loading activities take place at a dedicated transit stop or station. Rather than analyzing a development project's effects on transit passenger loading in the consideration of loading space provision, it is typically analyzed as a part of determining a project's effects on transit operations. The present analysis considers person trips whose loading component occurs via private or commercial vehicles at or immediately adjacent to the subject project's land use.

Passenger loading activities include both drop-offs and pick-ups. These two activities have different average durations, as discussed in section 7.3.4 below. In the case of taxi or TNC passenger loading, a single loading instance may sometimes involve a drop-off followed immediately by a pick-up (more so in the case of taxis because they can be visually hailed by passengers from the street). However, most passenger loading instances involve either a drop-off or a pick-up, but not both.

Figure 52: A typical passenger loading instance, in an on-street passenger loading facility (white curb). Source: Fehr & Peers, 2017.

7.1.3 Loading Facility Types

Loading facilities are divided into two categories: off-street and on-street facilities, which further consist of several different types of loading situations. While not an exhaustive list, **Table 23** shows several examples of loading instances categorized by where they typically occur, as well as by activity type.

Table 23: Examples of Loading Activities by Location and Type

	Off-Street	On-Street
Goods Movement	• Grocery store truck loading/unloading • Move-in/ move-out (larger buildings) • Garbage, compost, and recycle pick-up service (e.g., large buildings)	• Move-In/ Move-Out • FedEx, UPS, USPS parcel service • Computer or app-based deliveries • Garbage, compost, and recycle pick-up service (e.g., rolled out to curb) • Commercial loading at yellow curb • Brief stops at green curb for dry-cleaning pick-up; food pick-up; etc.
People Movement	• Hotel guest drop-off and pick-up at a porte-cochère • Use of parking lot for drop-off and pick-up	• Taxi and for-hire vehicle passenger loading • Passenger loading at white curb • School and child care facility pick-up/drop-off • Institutional use (Residential Care Facilities, Community Centers, Museums) pick-up/drop-off • Casual Carpool loading • Event pick-up/drop-off

Source: Fehr & Peers, 2018.

Off-Street

Off-street freight loading facilities accommodate light and heavy trucks engaged in freight loading. These facilities may include loading docks whose heights match the elevated floors of heavy trucks and single-unit light box trucks, or less-specialized off-street bays into which trucks may maneuver in order to load and unload goods within a building. Grocery stores and other large retail, office, and residential buildings typically include at least one off-street freight loading facility to accommodate the loading of merchandise, furniture, maintenance vehicles, move-ins and move-outs, and other similar activities. A typical off-street freight loading facility is shown in **Figure 53**.

Figure 53: A typical off-street freight loading facility. Source: Google Street View, 2018.

Off-street passenger loading facilities are generally associated with hotels and some larger residential developments. Often taking the form of a porte-cochère and sometimes a parking lot, an off-street passenger loading facility enables passenger cars to exit the right of way in order to perform passenger loading and unloading. Such facilities usually protect passengers from exposure to weather, and may permit more leisurely pick-ups and drop-offs, as well as a dedicated space for individuals to maneuver any luggage or large packages they may be carrying. Off-street passenger loading facilities can create conflicts between vehicles and pedestrians if large volumes of loading vehicles are crossing a sidewalk with a substantial number of people walking. A typical off-street passenger loading facility is shown in **Figure 54**.

Figure 54: A typical off-street passenger loading facility. Source: Google Street View, 2018.

On-Street

On-street loading takes place at the curb face adjacent to or near the target building. The facilities for on-street loading are generally segments of curb designated for loading use. In San Francisco, white curbs are used to indicate passenger loading zones (which have a five minute time limit), yellow curbs indicate freight loading zones (which have varying duration and time of day time limits), and green curbs indicate short-term parking. Typical on-street loading facilities are shown in **Figure 55**.

Figure 55: Two typical on-street loading facilities. Left: yellow curb (freight loading); right: white curb (passenger loading). Source: Google Street View, 2018.

Many sites, particularly hotels and schools, have associated white curb zones in front of the site itself. Elsewhere, notably in the Financial District, entire block faces may be designated for freight loading outside of peak travel periods. Many such block faces transition to become travel lanes during peak periods. This is an example of “flex” curb management. Other time-based flex options are possible, such as shifting between freight and passenger loading designations according to time of day, but these configurations are uncommon at present.

When the on-street loading facilities provided for a given land use are insufficient, drivers may conduct loading activities in unoccupied parking spaces or at building driveways; or they may conduct double-parking or loading at a red curb (see **Figure 56**) or in the travel lane. The potential hazards associated with these types of loading activities underscore the importance of providing sufficient on- and off-street loading facilities, and/or actively managing locations of loading instances.

A secondary example of loading that occurs on-street is loading at a traditional taxi stand, where taxis queue while waiting for passengers, who are able to enter the vehicle at the front of the queue. Because these facilities are not affiliated with individual land uses, they are typically not considered as part of a project's on-street loading demand unless the project itself is proposing the facility (e.g., hotel).

Figure 56: Loading activities occurring in bicycle facilities. Source: Google Street View, 2018.

7.1.4 Summary

The present analysis focuses on the following combinations of vehicle type, activity type, and facility type:

- Off-street freight loading by light and heavy trucks: this activity constitutes the traditional "freight loading" approach and is the type of activity currently considered by the existing TIA Guidelines.
- On-street package delivery and delivery service by light trucks and other vehicles: this subset of freight loading is likelier to occur on the street, where its demand for curb space has implications for a project's transportation impacts.
- On-street passenger loading by taxis and other vehicles: passenger loading instances have become far more common in recent years driven by the popularity of TNCs.

7.2 Loading Analysis Methodology

This study of how land use and loading demand are related approaches loading in two ways: by surveying the usage of existing loading spaces and by surveying individuals to ascertain what percentage of person trips are associated with loading activities.

To assess demand for existing loading zones, Fehr & Peers identified the primary loading spaces affiliated with a subset of sites across a variety of land uses. Typically, these loading spaces were sections of "white curb" passenger loading space or "yellow curb" commercial loading space adjacent to the study site, although off-street loading was studied at a smaller subset of sites. Using time-lapse cameras, we obtained utilization rates for each studied loading zone in five minute increments. By examining the use of the physical loading space, we were able to assess whether the primary loading zone was adequate to accommodate the site's loading activity.

We then used results from intercept travel surveys to calculate the share of trips at each survey site that involved either passenger or commercial loading; trip types that were determined to involve loading activity included delivery, TNC/Taxi, and some percentage of HOV passenger. By examining the share of total trips associated with loading activity, we are able to estimate an expected level of curb loading for each land use and place type cross-section. This estimation was compared to camera observations; however, because of limitations to the observation methodology (such as recording passenger loading instances of limited duration), some information was obtained primarily from intercept surveys.

7.2.1 Loading Observations

Loading observations were made at a subset of the data collection sites used for intercept surveys and trip counts, and largely followed similar distributions of geographic location, land use, and urban context. Sites selected for loading observations were required to have a loading zone adjacent to the site (either white curb, yellow curb, or a dedicated driveway / loading zone) that was clearly visible from the public right of way, and capable of being captured on time-lapse camera. The key constraint to sites selected for loading observations was that for most loading zone types, there is no restriction on whether individuals using the zone are affiliated with the use being studied. Several sites were isolated enough that there is little reason to believe that non-affiliated loading behavior was occurring (for example, large office buildings occupying an entire block face); however, for sites in dense neighborhoods, data could reflect total loading demand for an area larger than the use itself.

In addition, three loading zones in the Financial District were subject to peak period travel lane conversion. In these conditions, the loading zone is converted into a travel lane during either the AM peak period or the PM peak period, which affects statistical analysis of overall occupancy in the sense that these affected loading zones are excluded from analysis of occupancy and availability during the periods in which they are not operating as loading zones.

In total, 41 sites were selected for loading time lapse data collection; their locations are shown in **Figure 4** above. Of these, 14 sites included at least one off-street loading space; 15 included at least one white curb passenger loading space; and 17 included at least one yellow curb commercial loading space. Details are included in **Appendix M.**

Loading observations were made via time lapse camera, with images captured every five minutes. The use of time lapse photography allowed for inclusion of a larger number of sites and the ability to collect 24-hour data. Five minute intervals were selected in order to provide a robust number of data points over the 24-hour period while still being economical with the data collection resources available (i.e. higher frequency would be more expensive). If a site had an adjacent loading zone (i.e., white passenger loading curb or yellow commercial loading curb), the camera was positioned to capture whether each space was occupied. For some sites, loading data collection included occupancy of a loading dock or driveway visible from the public right-of-way.

Loading observations consist of data indicating the number of vehicles in the identified loading zone in five-minute increments over a 24-hour period. These data represent "snapshots" of individual loading zones over the course of a typical mid-week weekday (see **Appendix D** for a full list of sites with dates data were collected). These observations were then used to assess occupancy or vacancy of each loading space (and double-parking and multiple vehicles sharing a loading zone, to the extent feasible[32]) during each five-minute period.

Because of the nature of time lapse photography data, there is some level of uncertainty concerning loading data such as length of stay, and the total number of vehicles using a space. In other words, images captured at five-minute intervals may fail to document loading instances (especially passenger loading given the duration is often less than five minutes) that occurred entirely between consecutive images; such instances would be omitted from both length-of-stay calculations and the count of total loading instances. As such, this measure assesses whether the provided length of loading zone is adequate to accommodate demand across the course of a day, rather than the exact number of loading instances accommodated by that same loading zone. Information on loading zone use by instance, including stop duration, was further assembled using video data discussed in section 7.2.3 below.

[32] Generally, the data collection firm was able to provide counts of multiple vehicles utilizing a single loading space, as in instances of double-parking, resulting in a higher than 100% occupancy rate for a given time. However, there may be some instances where double parking occurred but was not registered as such in post-processing.

7.2.2 Intercept Surveys

Intercept surveys were conducted as discussed in section 2. Generally, individuals entering and exiting a study site were asked what mode they used to travel to the site. Three response categories to the mode question were identified as contributing to loading activity at the curb: trips flagged as "delivery" where the mode was "drive alone," trips made via the Taxi/TNC mode, and trips whose mode was identified as "HOV passenger," which includes some individuals being dropped off or picked up by private vehicles.

Because survey data do not differentiate between passengers in private vehicles who were dropped off and those who were in a vehicle that parked, it was necessary to impute a number of loading instances from the total HOV passenger mode share. This study assumes for loading purposes that half of these HOV passenger respondents were dropped off (rather than parking and traveling with a group that includes the vehicle driver); this represents a conservative estimate of how many HOV trips involve loading rather than parking.[33]

7.2.3 Additional Observations

As a supplement to the above observations and survey efforts, Fehr & Peers analyzed data from a parallel effort conducted for SFMTA's TNCs and Street Safety Study. For this study, video data was collected along 20 blocks of San Francisco during daylight hours, providing information concerning street observations.[34] Five street segments/videos were identified with previously existing white curb passenger loading zones, and IDAX Data Solutions processed the data to provide an average dwell time for passenger loading instances at each zone during the PM peak period from 4PM – 6PM. The time of each loading instance was measured from when the vehicle arrived at the loading zone to when it departed the loading zone. Data include instances where vehicles did not fully enter the loading zone (i.e., stopped partially or fully in the travel lane next to the loading zone).

The five data collection sites used for this method were located at:

- Columbus Avenue, between Broadway and Pacific Avenue, in the North Beach neighborhood
- Brannan Street, between Seventh Street and Eighth Street, in the South of Market neighborhood
- Castro Street, between 18th Street and Market Street, in the Castro neighborhood
- Sutter Street, between Grant Street and Stockton Street, in the Union Square neighborhood

[33] Because survey respondents were not asked to specify if they were dropped off or simply part of a group arriving in a single vehicle, we have chosen to select a 50% factor for HOV trips for purposes of loading analysis. This factor is conservative in that it likely slightly overestimates total passenger loading activity, as for most uses carpooling activity is likely among individuals traveling to the end location together.

[34] *TNCs and Street Safety,* San Francisco Municipal Transportation Agency. Forthcoming.

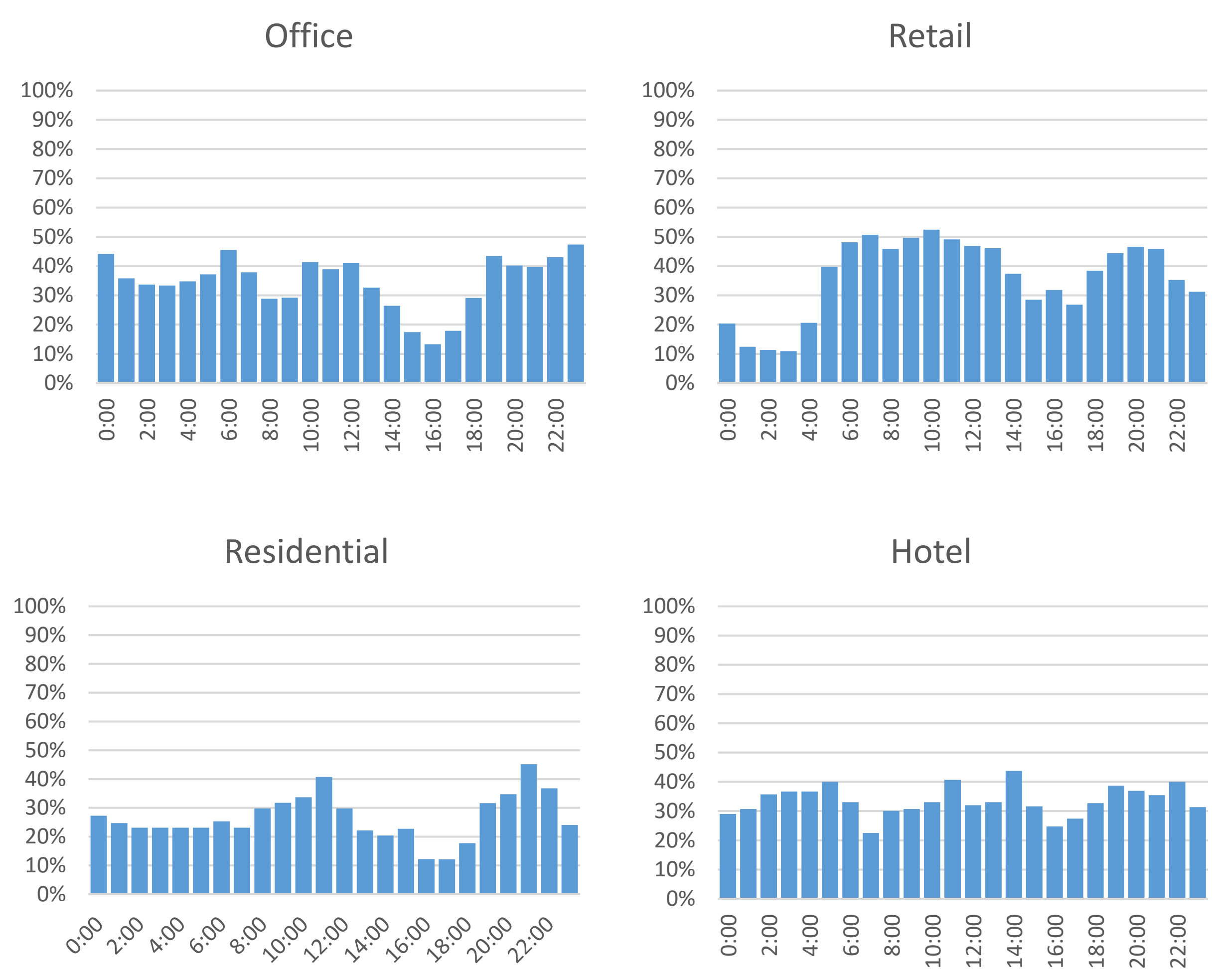
- California Street, between Montgomery Street and Kearny Street, in the Financial District

7.3 Loading Findings

7.3.1 Loading Zone Occupancy

At each of the 41 loading observation sites, 5-minute time lapse footage was taken during a 24-hour period. For each five-minute period, data was processed to indicate whether the loading zone was occupied or vacant, which was used to reach an average occupancy rate by time of day, by land use across the city. This data is presented in Figure 57.

Figure 57: Average Loading Space Occupancy by Time of Day, All Loading Spaces



As shown in the figures, each land use has its own time-of-day profile. For office, retail, and residential sites, a dip in occupancy was observed during the extended PM peak period. This may be partially due to loading spaces in the busiest portion of the city excluded from both the supply and occupancy data when they are in use as travel lanes, assuming that these sites in the busiest portion of the City where loading would have continued to have higher occupancy if loading were permitted. Delivery vehicles and freight vehicles may also attempt to avoid the busiest travel hours in order to reduce time lost in congestion.

Additionally, as shown in Figure 57, across the city, around 20 to 50 percent of loading spaces are occupied at any given time. This occupancy level includes activities such as overnight parking in loading zones that convert to parking overnight (which is why there is generally 10 – 40 percent occupancy in the late night to early morning hours), as well as general loading activities.

Figure 58: shows the average occupancy over time of day for curb loading spaces only (this includes both white curb passenger loading as well as yellow curb commercial loading). Several time-of-day patterns are more pronounced among curbside loading. Compared to the average loading space occupancy across all loading space types (both on and off-street) as shown in Figure 57, Occupancy for curb loading spaces (as shown in Figure 58) is noticeably higher for residential and retail uses throughout the day, which indicates that curb loading is more frequently used than off-street loading at these land use types. In terms of patterns across time of day, residential uses have noted increased activity during the late morning and late evening hours. Retail sees similar increases in activity during the morning to early afternoon hours and the evening hours of the day. Hotel loading remains fairly steady throughout the day, and office loading also remains similar to the combined loading occupancy presented above.

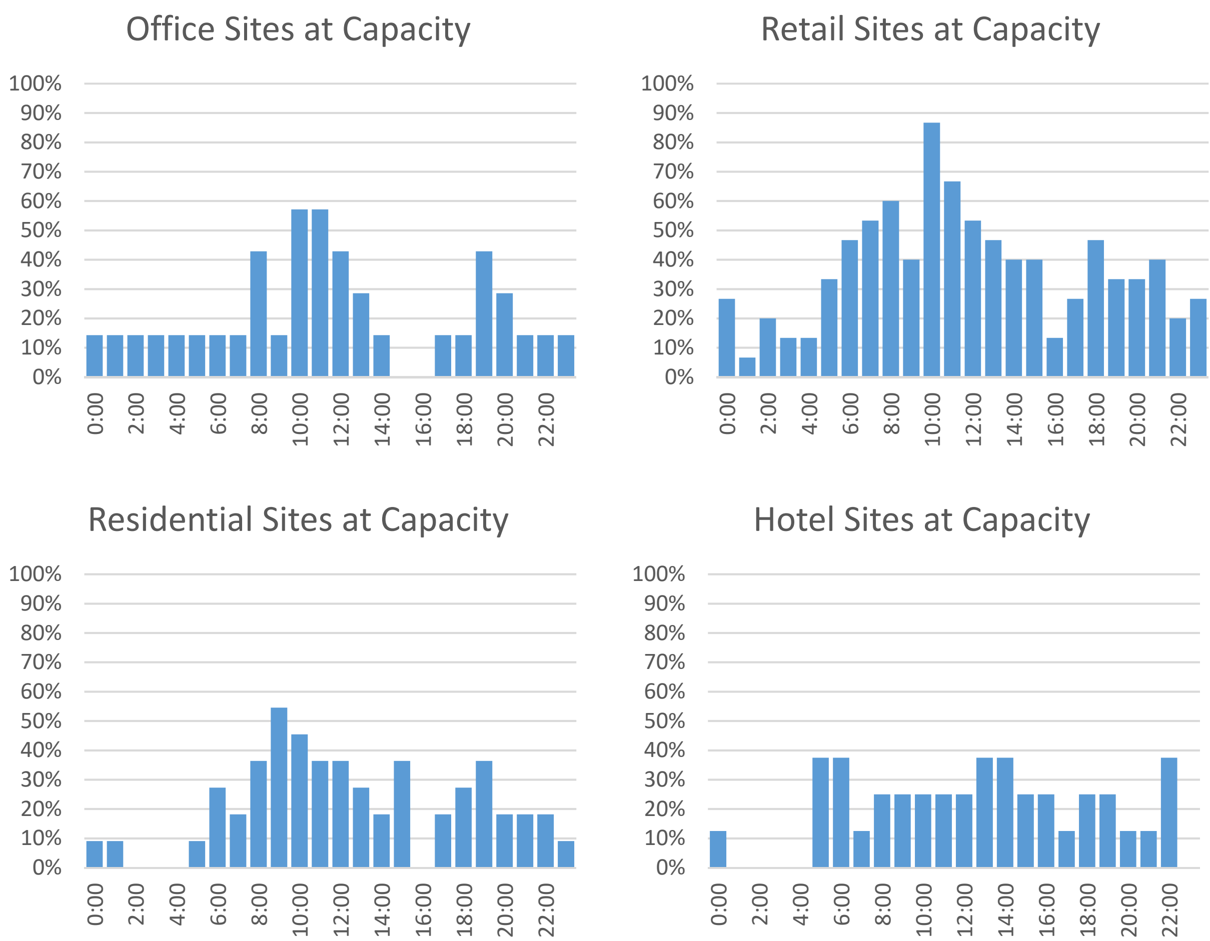
The insights available from the time-lapse loading zone observations are limited by the complexity of loading activity itself and of the loading facilities observed. The 41 sites included in loading observations had a mix of on-street and off-street facilities, some of whose designated uses changed over the course of the day. These changes are complex; for example, many downtown on-street loading zones shift from providing private car parking overnight to acting as travel lanes during the AM peak, then operate as passenger or freight loading (white or yellow curb) at midday, then return to travel lanes, then revert to parking or loading. Loading zones that converted to travel lanes were excluded from supply and demand during the relevant hours; however, conversion into parking outside of peak hours was *not* included as a factor in either loading demand or loading supply. The data collection approach of time-lapse photography, while representing a sensible compromise between level of effort and breadth of data collection, also made it infeasible to say with certainty whether a vehicle present in the loading facility was actually engaged in loading.[35] We can, however, reasonably assume that most "Other" vehicles observed overnight were parked, rather than actively loading

Figure 58: Average Loading Space Occupancy by Time of Day, Curb Spaces Only

Figure 59 shows the percentage of sites from each land use whose loading areas were at capacity over the course of the day. Sites at capacity are of particular interest, as a fully occupied loading zone is could result in overflow loading demand engaging in loading activities elsewhere (e.g., travel lanes, bicycle lanes) or they could adequately accommodate the loading demand. In particular, we have assessed the share of sites reaching capacity in a given hour in order to reflect at how many individual locations there is a chance of being unable to use a loading zone during each hour of the day. Each hourly bar represents the proportion of sites that were at capacity <u>at any point</u> during that hour, and excludes sites that never reached capacity during the hour in question.

[35] It was not within the scope to collect and reduce full-speed video footage of 41 loading zones for 24 hours each.

Figure 59: Percentage of Loading Zones at Capacity by Time of Day, All Loading Spaces



Overall, loading facilities are most likely to be at capacity during the mid-day period across all land uses. In addition, at non-retail land uses, during the peak hours for loading only around half of the studied loading zones ever reached capacity at any point. To the extent that loading zones are intended to provide dedicated space available for loading without generating any queuing behavior, this finding indicates that for non-retail uses, around half of available loading facilities meet this criteria during even the peak hour of the day. However, to the extent that allocating loading space is intended to provide a well utilized loading zone and serve consistent loading activity, the lack of spaces that reach full occupancy may indicate that loading activity is occurring elsewhere or that less loading activity is taking place. The former may be the case particularly at sites that include both curb-side loading zones and off-street loading areas; as discussed above, curb occupancy is generally higher than off-street occupancy due to restrictions on use of off-street loading zones.

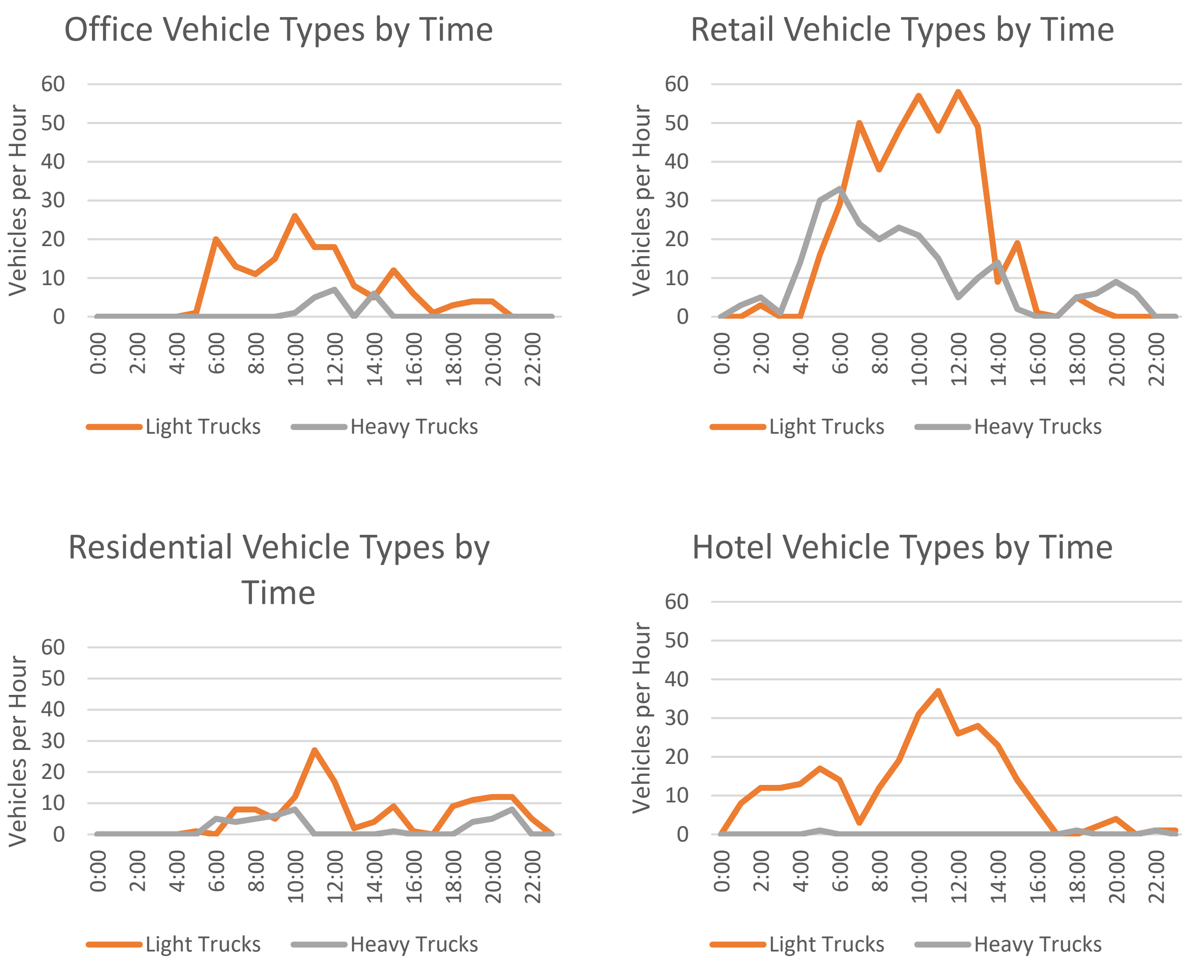
However, for retail land uses, the peak is sharply defined, and has a very high full occupancy rate of around 85 to 90 percent. This peak occurs during the mid-morning, which indicates a time period when retail businesses are typically open for business as well as the hours when commercial deliveries tend to be highest. The 10:00 am peak hour is also when two travel lanes near retail sites in central San Francisco convert to commercial loading zones. Finally, the retail loading zones are most likely to be located along busy retail corridors (sample sites include sites in the Financial District, on Valencia Street in the Mission District, and on Chestnut Street in the Marina District). As such, they may be more likely to experience loading activity associated with neighboring land uses.

7.3.2 Truck Loading Observations

Observations also confirmed common assumptions regarding the distribution of freight loading throughout the day. **Figure 60** shows the total number of vehicle observations across all sites in two freight- specific vehicle classes (light truck and heavy truck) in each hour, classified by land use type. These observations demonstrate that freight loading activity (represented by the presence of light and heavy trucks) is concentrated outside the AM and PM peak travel periods. A midday freight “peak” is visible for all land uses, as is a pronounced dip in freight loading around the extended PM peak period. For all uses except residential, the PM peak period represents less than 20% of loading zone occupancy at the mid-day peak. The increase in occupancy at residential loading zones may indicate that deliveries to residences are more likely to occur during the evening hours as compared to other land uses.

These figures confirm the standard preconceptions about which vehicle types serve which land uses: heavy trucks make up a substantial proportion of retail loading activity and appear only rarely at other land use types, while light trucks (including package delivery panel trucks) serve all land uses in significant numbers.

Figure 60: Total Observed Loading Zone Occupancy by Select Vehicle Classes at Each Land Use by Hour, All Loading Spaces



Finally, it is important to note that these observations indicate the presence of a vehicle in a loading zone at a given moment, and not necessarily an arrival rate of vehicles. Because these charts focus on vehicle types more likely to be involved in loading, the presence of a vehicle likely indicates that loading activity is actively occurring; however, this may not be the case, particularly during the overnight hours when parking may be permitted in the loading area.

While time lapse photography generally is insufficient to ascertain arrival rates, the relative scarcity of light and heavy trucks makes it possible to impute truck arrivals and departures by comparing the presence or absence of a truck across five minute periods. **Figure 61** is derived from observed instances of vehicle arrival in the time lapse data – essentially, cases where an empty space or space occupied by a passenger vehicle was occupied by a light or heavy truck in the next 5-minute data interval. As shown in the figure, arrival activity by larger vehicles is concentrated in the period from early morning to early afternoon, with a steep decline in instances during the PM peak period. **Table 24** shows the relative volume of truck activity during the peak hour of truck loading activity (from 10am to 11am) and during the 2-hour PM peak period (from 4pm to 6pm). Incorporating data from the two-hour peak period (a conservative approach), only around 25 percent of the peak hourly freight loading demand should be expected to occur during the PM peak period.

Figure 61: Observed Truck Loading Arrivals by Hour, All Data Collection Sites, All Loading Spaces

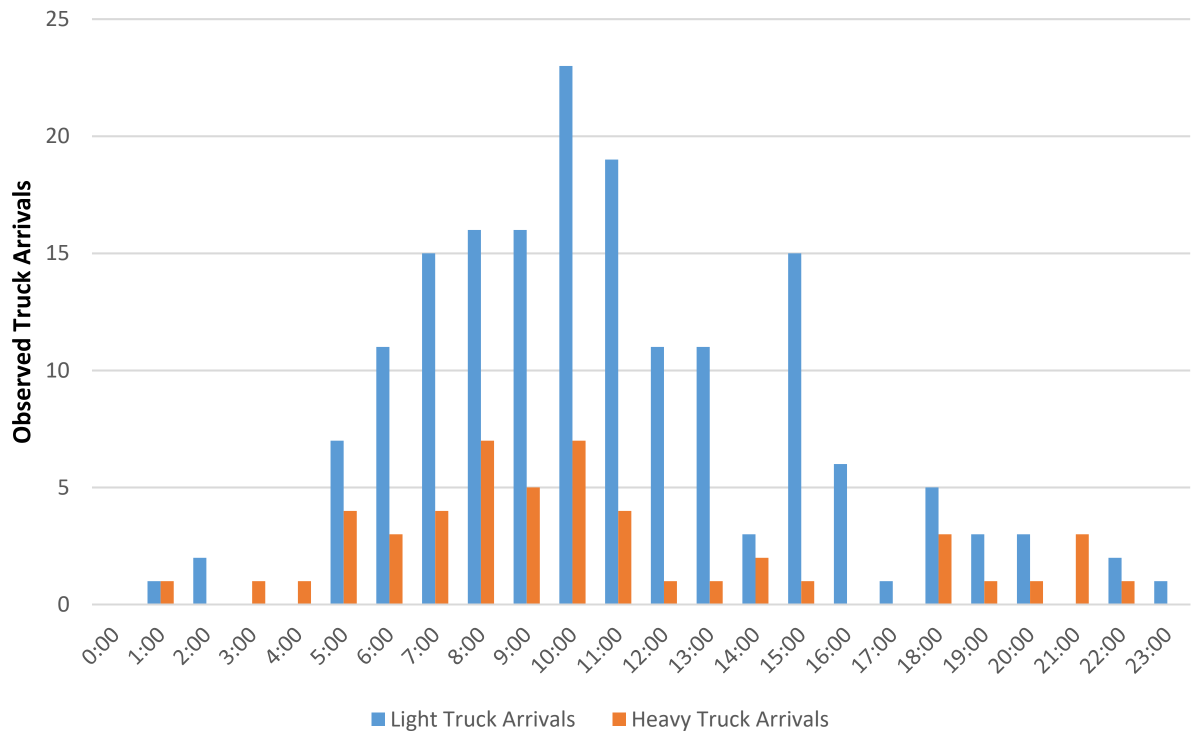


Table 24: Peaking Factors for Freight Activity

Period	Light Truck Arrivals	Heavy Truck Arrivals	Total Truck Activity
10AM – 11AM (Freight Peak)	23	7	**30**
4PM – 5PM (Peak Period, Two Hours)	6	0	**6**
PM Peak Period Demand as % of Freight Peak Period Demand			***20%***

Source: Fehr & Peers, 2018.

7.3.3 Intercept Survey Data

Intercept survey findings are presented in **Table 25**. Mode types presumed to involve a loading instance that occurs at the curb were all delivery trips made via driving, all taxi/TNC trips, and half of HOV passenger trips. This percentage of HOV passenger trips represents a conservative estimate of how many of those trips involved a drop-off/pick-up by a private vehicle, as opposed to groups of individuals including both drivers and passengers.[36] The table separately highlights the percentage of trips identified as delivery and as passenger loading.

Table 25: Curb Loading-type PM Peak Period Mode Splits by Land Use and Geography

Land Use	Geography	Number of Sites	Delivery %	*Taxi / TNC %*	*Private Vehicle Drop-off% (50% of HOV Passenger Mode)*	Passenger Loading %
Office	Place Type 1	8	**3.1%**	6.1%	1.2%	**7.3%**
	Place Type 2	7	**2.3%**	11.0%	2.4%	**13.4%**
	Place Type 3	3	**5.5%**	2.0%	5.1%	**7.1%**
Retail	Place Type 1	4	**5.9%**	4.6%	0.9%	**5.5%**
	Place Type 2	10	**2.3%**	1.4%	1.6%	**3.0%**
	Place Type 3	7	**0.5%**	1.0%	4.2%	**5.2%**
Residential	Place Type 1	4	**5.7%**	6.0%	2.8%	**8.8%**
	Place Type 2	9	**11.3%**	3.5%	3.7%	**7.2%**
	Place Type 3	2	**6.1%**	4.2%	2.7%	**6.9%**
Hotel	Place Type 1	4	**2.6%**	19.6%	2.2%	**21.8%**
	Place Type 2	5	**1.4%**	15.6%	4.1%	**19.7%**
	Place Type 3	2	**7.5%**	7.5%	6.0%	**13.5%**

Source: Fehr & Peers, 2018.
Note: "Delivery" mode acts as a modifier to the primary mode of the trip, and as such is not reported separately in other sections of this document (i.e., deliveries from a truck may appear as "Drive Alone" while those made by bicycle would appear as "bicycle"). "Passenger Loading %" equals the sum of "Taxi / TNC %" and "50% of HOV Passengers (Pax) %."

Overall, the share of person trips involving a loading instance ranges from around five percent for retail uses in Place Type 2 and 24 percent for hotel uses in Place Type 1. For several survey segments, there appears to be a very high rate of person trips involved with deliveries; for instance, at residential buildings in Place Type 2 around 11 percent of all person trips were involved with delivery activity. This is partially explained by the nature of delivery trips in urban environments: a delivery person generates a counted person trip both entering and exiting the building in a relatively short window of time, and may have responded to the surveyor in both directions. As such, the translation from delivery trips as a percentage of

[36] Because survey respondents were not asked to specify if they were dropped off or simply part of a group arriving in a single vehicle, we have chosen to select a 50% factor for HOV trips for purposes of loading analysis. This factor is conservative in that it likely slightly overestimates total passenger loading activity, as for most uses carpooling activity is likely among individuals traveling to the end location together.

total person trips to loading instances requires dividing by a factor of two, as each delivery trip creates one inbound and one outbound person trip across the screenline.

The high levels of variance between similar uses in different place types may represent the number of sites sampled, particularly in the case of deliveries. Because deliveries are presumed to have a longer length of stay in loading zones (see section 4.3), this high level of variance may be more likely to introduce some uncertainty into the total loading demand: due to the longer length of stay, the total loading demand will be more sensitive to delivery events than to passenger loading events when determining peak demand and loading zone length.

7.3.4 Length of Stay

Passenger loading length of stay was calculated from daylight hour video footage of five white-curb passenger loading zones at locations in Place Type 1 and Place Type 2; this data was collected for the SFMTA TNCs and Street Safety report (*forthcoming*) as described in section 7.2.3. The areas selected for calculating length of stay are those with the presence of a dedicated passenger loading zone, as this analysis focuses on the use of loading facilities and planning for the provision of future loading facilities. Data was processed by IDAX Data Solutions, and provided as a list of loading instances and duration of each instance, as well as whether the instance was a drop-off or pick-up, and if the vehicle remained in a loading zone beyond the permitted duration of time or left without loading or unloading passengers.

Length of stay for light and heavy trucks (i.e., delivery and service vehicles) was calculated based on the 5-minute time lapse data discussed in section 3.1 above. Because these light and heavy trucks tend to stay in loading zones for longer durations, use of the five minute loading data was sufficient to obtain an average length of stay. Loading instance duration is summarized in **Table 26**.

Table 26: Dwell Time by Vehicle Type and Activity (hours: minutes: seconds)

	Vehicle Type			
Activity	Passenger Car	Taxi	Light Truck	Heavy Truck
Pick up passenger	0:01:05[1]	0:01:00[2]	-	-
Drop off passenger	0:00:45	-	-	-
Freight loading (on-street)	-	-	0:27:00	0:17:00
Freight loading (off-street)	-	-	0:36:00	0:39:00

Source: Fehr & Peers, 2018.
Notes:
1. The passenger loading durations were rounded to the nearest 5 seconds; because the freight loading durations were based on

less temporally precise data (5 minute snapshots), these durations were rounded to the nearest minute.
2. Taxi data is based on a very small sample size, and is presented for informational purposes only.

Generally, passenger pick-up instances required around one minute to complete. Taxi drop-off instances appear to take longer; however, all available taxi data is from an existing taxi stand, where vehicles waited until a passenger approached to depart. Drop-off instances on average took about 45 seconds to complete; there were no drop-off instances observed by taxis. "Passenger Car" includes vehicles operating as TNCs, as it was not feasible for this study to distinguish between passenger cars operating as TNCs and cars in traditional private operation. Due to the scarcity of data on traditional taxis, we have opted to use the passenger car loading numbers for all passenger loading instances.

These passenger loading durations are shorter than the durations currently in use for hotel loading zones (90 seconds) in the 2002 SF Guidelines, Appendix H. The average length of stay used in the draft methodology is 60 seconds, which assumes that half of activity is pick-up activity (with estimated dwell time of 65 seconds as shown in Table 26) and half of activity is drop-off activity (with estimated dwell time of 45 as shown in Table 26), and rounds upwards to the nearest 10 seconds. In cases where activity is expected to comprise largely one or the other during the peak period (i.e., at event spaces where pre-event traffic is comprised largely of drop-off activity and post-event traffic largely involves pick-up activity), the appropriate directional rate should be used. Additionally, at land uses not included in this study, such as schools and institutions, available data or data from direct field observations should be used instead. It may also be of note that the sites used for length of stay observations are largely located in more urban areas; these were selected in order to increase the number of total loading observations per hour. However, the high level of loading activity at many of these zones may provide a subtle incentive to passengers and drivers to complete loading activity as quickly as possible, thereby reducing observed loading durations.

Average length of stay for light and heavy trucks is calculated based on time lapse footage by observing how long a space remained occupied by a light or heavy truck before becoming vacant; the average "block" of time was as reported in Table 26. Light and heavy trucks' loading instance durations depended on their location. Light trucks performing on-street freight loading had an average duration of approximately 27 minutes, while light trucks' off-street freight loading instances lasted about 36 minutes. Heavy trucks stayed slightly longer than light trucks in off-street contexts (39 minutes), but their average on-street length of stay (17 minutes) was shorter than that of light trucks. This length of stay for off-street facilities is longer than the duration already in use for trucks using loading facilities in the 2002 SF Guidelines, Appendix H; however, the observed length of stay may be longer for off-street facilities due to a lack of impetus for the truck to move (i.e., making a delivery to a loading dock for which no other trucks are waiting).

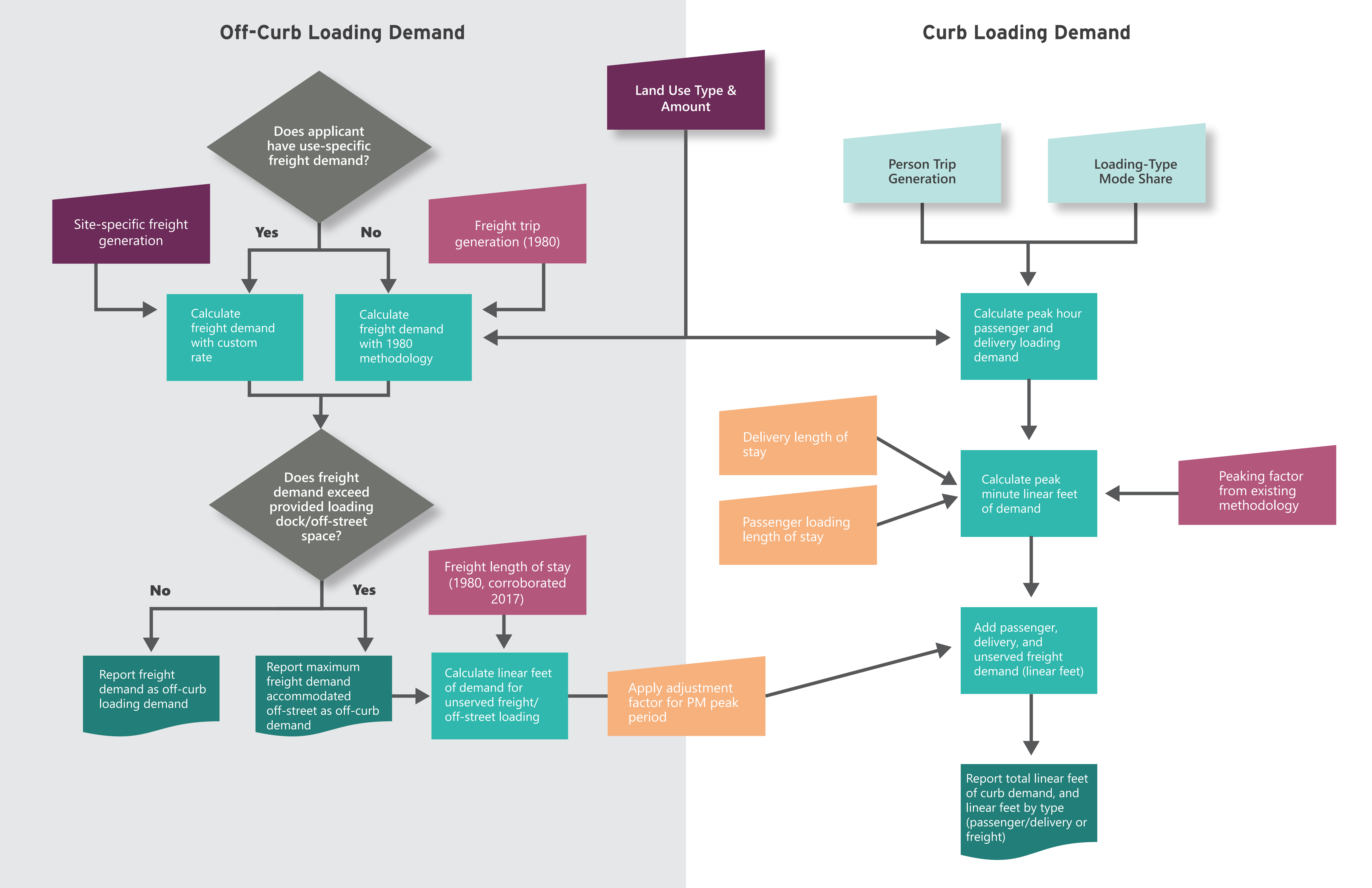
7.4 Recommended Methodology Updates

7.4.1 Recommendations

Based on the findings represented above, Fehr & Peers recommends revising the current methodology to allow for project sponsors and city staff to estimate anticipated loading demand either off-street or on-street as appropriate to a given site and its context. This requires several steps, including identifying which types of loading are likely to occur in each location; determining the expected number of loading instances for each type of loading (freight, passenger, and delivery / delivery service) during the analysis period; estimating the typical vehicle type that may be performing each type of loading activity; the typical duration of each type of loading activity; and, finally, the linear feet of curb space or number of loading bays that would be needed to accommodate demand derived from the cumulative effect of those assumptions.

Figure 62 shows a flow chart detailing how total loading demand can be calculated for both off-street loading and on-street loading. In summary, the draft methodology progresses as follows:

1. Off-Curb Loading Demand
    a. Analyst determines a project's freight demand using rates established in the 1980 goods movement study, or using use-specific rates in the event that the project is formula retail or grocery store. (This step mirrors the methodology in the 2002 SF Guidelines.)
    b. Analyst then determines if the available off-street loading space can accommodate the peak freight loading demand, based on the current loading methodology. (This step mirrors the methodology in the 2002 SF Guidelines.)
    c. If this demand cannot be met through off-street loading spaces, the unaccommodated freight demand (in linear feet) must be added to the total linear feet of peak passenger and delivery loading demand.



Off-Curb Loading Demand
Curb Loading Demand
Land Use Type & Amount
Does applicant have use-specific freight demand?
Site-specific freight generation
Yes
No
Freight trip generation (1980)
Calculate freight demand with custom rate
Calculate freight demand with 1980 methodology
Person Trip Generation
Loading-Type Mode Share
Calculate peak hour passenger and delivery loading demand
Does freight demand exceed provided loading dock/off-street space?
Delivery length of stay
Passenger loading length of stay
Calculate peak minute linear feet of demand
Peaking factor from existing methodology
No
Yes
Freight length of stay (1980, corroborated 2017)
Add passenger, delivery, and unserved freight demand (linear feet)
Report freight demand as off-curb loading demand
Report maximum freight demand accommodated off-street as off-curb demand
Calculate linear feet of demand for unserved freight/ off-street loading
Apply adjustment factor for PM peak period
Report total linear feet of curb demand, and linear feet by type (passenger/delivery or freight)

2. Curb Loading
    a. Analyst determines their curb loading demand by calculating peak hour person trips and applying the "loading-type" mode splits (incorporating both passenger loading and delivery loading) presented in Table 25 above**.** Combined with average vehicle occupancy rates, this provides the number of expected peak hour loading instances.
    b. Peak Minute loading demand is calculated as follows:
        i. Passenger Loading Linear Feet of Demand = [Peaking Factor][37] x [Total Person Trips] x [Taxi/TNC % + ½ x HOV Passenger %] x [1 / Average Vehicle Occupancy] x [Passenger Loading Length of Stay] x [Curb Length to Accommodate Average Vehicle] / [15 minutes]
        ii. Delivery Loading Linear Feet of Demand = [Peaking Factor][38] x [[Total Person Trips] x [Delivery Mode Split %] x [50% Adjustment from Person Trips to Loading Instances] x [Delivery Length of Stay] x [Curb Length needed for Average Delivery Vehicle] / [15 Minutes]
3. The sum of steps 1 and 2 represents the peak hour curb loading demand for the site, and indicates the recommended amount of curb space to be dedicated to loading to accommodate peak demand during the PM peak hour. This number should be rounded to the nearest multiple of an average loading space; i.e., 20 feet.

This methodology incorporates the following changes to the 2002 SF Guidelines based on site observations:

- Differentiating between off-street freight loading, passenger loading, and on-street delivery / delivery services
- Providing peak hour loading instance estimates for passenger loading and delivery / delivery services for a wider variety of land uses based on intercept survey data
- Updated passenger loading length of stay based on data collected for the SFMTA TNCs and Street Safety project, as presented in section 7.3.4.
- Updated delivery loading length of stay based on time lapse data for light trucks in curb loading spaces, as presented in section 7.3.4.
- Updated person trip generation based on person counts at sites throughout the city, as presented in section 6.1.

In development of the draft methodology, we used the average rates from each observed land use without modification. We also made no changes to the hourly peaking factors (i.e., how arrivals are distributed

[37] The 2002 SF Guidelines use a peaking factor of .5, i.e. half of all peak-hour loading instances are anticipated to occur within the peak 15 minutes.
[38] *Ibid*.

across the peak period), nor did we adjust the observed dwell times beyond rounding to the nearest 15 second interval.

Notes and Limitations

This methodology assumes that if there is off-street loading dock space available, small and large trucks will opt to use it rather than the curb. This may not always occur, particularly if drivers, based upon circumstances of the street and the facility design do not want to maneuver (e.g., back into) an off-street loading dock. The methodology also assumes that the peak hour for passenger loading and the peak hour for delivery and freight activity occur simultaneously. In the case of deliveries, the data is based on peak hour intercept surveys; however, other freight activity is still calculated based on the previous methodology in the 2002 SF Guidelines. Project sponsors may be given the opportunity to present alternative peak hours for the two types of deliveries through either data from similar projects, or through mitigation measures or improvement measures stating that deliveries and freight activity will not occur during the peak hour for passenger loading. When the PM peak hour is the primary period of concern, analysts may use a factor of 20 percent to adjust freight loading demand,[39] based on the data presented in Table 24.

The data for delivery mode share and passenger loading mode share are also based on a limited number of sites. As is currently practiced, if a project sponsor has data supporting alternative rates at similar land uses, those rates may be used in the place of the averages presented in Table 25. Similarly, there may be reason to provide an average rate of delivery trips, while maintaining specific rates for passenger loading based on the land use and place type cross-sections discussed above. We also observed that liveried taxis had a higher average dwell time than passenger vehicles; however, due to the scarcity of that data, and potential skew due to observations occurring at taxi stands, we have opted to use the passenger car loading numbers for all passenger loading instances.

This methodology also does not account for specific loading behaviors associated with private shuttles or private transit, as there were insufficient data to assess whether dwell times or loading behavior by these vehicle types differed substantially from existing methodology. In instances where a project proposes providing shuttle service as a mitigation measure or TDM measure, loading demand should be adjusted accordingly in consultation with the Planning Department and SFMTA.

Finally, this methodology is based upon observed conditions in San Francisco in 2016 and 2017. As transportation and mobility continue to evolve, the loading landscape may further adjust. Anticipated changes such as the introduction of automated vehicles to the vehicle fleet, as well as further growth in

[39] The 25% factor reflects observations showing that freight activity during the PM peak period is roughly 25 percent that of activity during the peak hour for freight activity (which occurs in the late morning). When analyzing the PM peak period, analysts may therefore adjust the rates derived from the SF Guidelines by multiplying them by 0.25.

TNCs and potential unmanned delivery via rovers or drones may all affect the use of curb space for loading in the near future.

7.4.2 Example Projects and Methodology Calibration

Following development of the draft loading methodology, Fehr & Peers applied the proposed methods to two example sites taken from the pool of data collection sites with time-lapse data of the loading zones. The intent of this application was to assess whether the draft methodology resulted in findings that roughly correlated to field observations at these sites, and, if they did not, to evaluate methods for addressing the discrepancies.

Two example sites were considered to compare projected loading activity with observed loading activity: TIA15 (the Walgreens at 2141 Chestnut Street) and TIA306 (a residential building at 2200 Sacramento Street). These sites were selected because they represent two different land uses, they have observed loading activities, and their loading facilities are on-street. Validation results are shown in Table 27.

Table 27: Initial Validation Results

	TIA15	TIA306
Name	Walgreens	residential building
Address	2141 Chestnut St	2200 Sacramento St
Geography	Place Type 2	Place Type 2
Land Use Amount	14,421 (sf)	127 (units)
Draft Loading Methodology Results [2]		
Peak Hour Delivery Loading Instances *Total Person Trips x Delivery Mode Share x 50% Factor*	5	4
Peak Hour Passenger Loading Instances [(*Total Person Trips x (TNC Mode Share + 50% HOV Passenger Mode Share)] / (Average Vehicle Occupancy)*[3]	11	5
Delivery Loading Spaces Required [[(*0.5 Peaking Factor) x (n Vehicles/Hour) x (27 minute length of stay) x (30 ft average vehicle length)] / (15 minutes)] / (20 foot standard space)*	7	6
Passenger Loading Spaces Required [(*0.5 Peaking Factor) x (n Instances/Hour) x (1.0 minute length of stay)] / (15 minutes)*	1	1
Combined Loading Spaces Required[4]	8	6
Observed Data		
Combined Loading Spaces Supplied	4	4
Maximum Observed Loading Demand	3	2

Source: Fehr & Peers, 2018.
Notes:
1. Initial validation was performed for TIA15 and TIA306 only. TIA47 was analyzed during the subsequent re-validation. TIA47's calculations are included here for comparison, but were not considered when evaluating the accuracy of the draft methodology.
2. All loading space counts given in terms of passenger car equivalents, i.e. units of 20 linear feet. All estimates of hourly loading instances are rounded up to the nearest integer.
3. Average vehicle occupancy for drop-off trips only was unavailable; as such, the average occupancy is assumed to be one.
4. "Combined Loading Spaces Required" assumes that a single curb designation could accommodate both delivery and passenger loading demand. Due to rounding, "combined loading spaces required" may not equal the sum of "delivery loading spaces required" and "passenger loading spaces required."

TIA15 has 14,421 square feet of retail space. Applying the PM peak hour trip generation rate, the delivery and passenger loading mode splits, and the average vehicle occupancy rate, the revised methodology would predict five delivery instances and eleven passenger loading instances per peak hour. Applying the remainder of the workflow described above would indicate that seven delivery spaces and one passenger loading space would be required to accommodate this delivery activity. In actuality, during the PM peak hour, no more than three vehicles, all passenger vehicles, were observed adjacent to TIA15, and the loading zone was not used to capacity. Thus the proposed methodology overestimates loading needs at this site.

TIA306 has 127 residential dwelling units. Applying the PM peak hour trip generation rate, the delivery and passenger loading mode splits, and the average vehicle occupancy rate, the revised methodology would predict four delivery instances and four passenger loading instances per peak hour. Applying the remainder of the workflow described above would indicate that six delivery spaces and one passenger loading space would be required to accommodate this delivery activity. In actuality, during the PM peak hour, no more than two passenger vehicles were observed adjacent to TIA306. Thus the proposed methodology substantially overestimates delivery and underestimates passenger loading needs at this site.

Across both sites, the unadjusted loading demand formula results in twice the level of demand observed during the data collection period. This is in spite of potential for loading instances unaffiliated with the site to use the loading zone. We hypothesize this is a result of overestimating both the typical vehicle class for curb loading delivery instances, as well as an overestimate of delivery dwell time at the curb. It is probable that there are differences between the kind of light-truck deliveries documented in the time-lapse loading observation dataset and the kinds of deliveries involved in a delivery-type intercept survey response. Many PM peak hour deliveries may be package deliveries from smaller vehicles or food deliveries in passenger-car-sized vehicles, or may be destined to a building other than the project site.

By re-examining the loading data and including only light truck arrivals between 4:00 to 6:00 PM, the average duration of an on-street light truck loading event decreased to approximately 11 minutes (from the 27 minutes for light truck deliveries made at the curb presented in **Table 26**). If this shorter duration, and a smaller vehicle type, were assumed to be the norm for peak-hour delivery instances, the space needs associated with such deliveries would fall by more than a factor of four. Then the sum of passenger loading and delivery spaces would be about three or four spaces, depending on whether the two categories' linear feet are combined prior to separating out into "spaces." This is approximately equal to the actual observed loading at these sites. Additionally, this may still overestimate the time needed for delivery loading, as it does not include any delivery observations occurring in passenger vehicles (such as many food deliveries). As such, to calibrate the model we have reduced the assumed duration of delivery loading events to 11 minutes, which likely still represents a conservative analysis for PM peak hour operations.

7.4.3 Validation via Alternative Methodology

In addition to identifying the overestimation of delivery loading demand, we examined the potential for vehicle arrival rates to affect the maximum observed loading demand, and applied a standard Poisson distribution to expected arrival rates to validate the use of the 0.5 peaking factor in the proposed loading demand formula.

In the real world, loading vehicles do not arrive at a constant rate, so chance also plays a role in determining how many loading spaces are needed to accommodate peak loading demand. The 2002 SF Guidelines use a high peaking factor of 0.5, i.e., half of the peak hour loading instances would take place within the peak 15 minutes. This factor is chosen to be intentionally conservative to attempt to reflect the variability of loading arrivals within a deterministic formula. A more robust statistical approach, borrowing from standard traffic engineering practice, would be to apply a more moderate peaking factor (such as .28, in accordance with Highway Capacity Manual (HCM) guidance on typical urban peak hour factors).[40] Then we can conservatively assume that a "busy" loading period would be a 15-minute period in which the number of instances was at the 95th percentile of the Poisson distribution whose mean is the peaked 15 minute number of loading instances. The table below shows the number of peak-15-minute loading instance for a range of hourly loading demands, according to the existing peaking factor, the existing peaking factor plus extraction of the 95th percentile of the corresponding Poisson distribution, and a .28 peaking factor plus extraction of the 95th percentile of the corresponding Poisson distribution.

The space needs associated with freight loading rapidly increase along with the number of freight loading instances per peak hour, due to the long duration of each freight loading instance. In practice, project sponsors might demonstrate how Transportation Demand Management (TDM) measures such as delivery-supportive amenities might reduce either the number of separate freight loading instances or the duration of each instance.

Table 28 summarizes the results of this process, showing the number of estimated loading instances and necessary loading spaces (in passenger car equivalents; i.e., 20-foot lengths) for a number of potential hourly loading demand levels. Generally, when examined at similar peaking factors, the Poisson distribution will result in a slightly higher level of demand; however, at a more realistic peak hour factor, using a Poisson distribution to estimate a true maximum demand level results in a slightly lower level of recommended loading space provision.

[40] HCM 2000 recommends a peak hour factor of 0.92 for urban areas; this equates to approximately .28 in the TIA Guidelines formulation.
https://www.researchgate.net/publication/245561343_Variability_of_Peak_Hour_Factor_at_Intersections

Table 28: Simple Peaking Factor vs. Poisson Distribution (Passenger Loading Case)

Loading Instances per Hour	Loading Instances per Peak 15 Minutes			Number of Loading Spaces (PCEs) Required		
	0.5 Peaking Factor	95th Percentile Poisson Distribution (with 2.0 Peaking Factor)	95th Percentile Poisson Distribution (with 1.1 Peaking Factor)	0.5 Peaking Factor	95th Percentile Poisson Distribution (with 2.0 Peaking Factor)	95th Percentile Poisson Distribution (with 1.1 Peaking Factor)
10	5	9	6	1	1	1
20	10	15	10	1	1	1
30	15	22	14	1	2	1
40	20	28	17	2	2	2
50	25	33	20	2	3	2
60	30	39	24	2	3	2
70	35	45	28	3	3	2
80	40	51	30	3	4	2
90	45	56	33	3	4	3
100	50	62	37	4	5	3
110	55	67	40	4	5	3
120	60	73	43	4	5	3
130	65	79	46	5	6	4
140	70	84	50	5	6	4
150	75	90	53	5	6	4
160	80	95	55	6	7	4
170	85	100	59	6	7	4
180	90	106	62	6	8	5
190	95	111	65	7	8	5
200	100	117	67	7	8	5

Source: Fehr & Peers, 2018.

This lower level of demand largely exerts a marginal effect, but generally demand estimates are within one space of the current formula. This indicates that while the existing formula may overestimate the amount of peaking occurring in loading zones, its results are roughly in line with estimates based on a more reasoned statistical distribution. Additionally, a deterministic formula may be simpler for analysts to apply than a method requiring use of extended tables to determine the 95th percentile of expected peak period arrivals. As such, Fehr & Peers conducted the second step of validation using the deterministic formula rather than the 95th percentile Poisson distribution method.

7.4.4 Validation Based on Additional Study Site

To validate the changes to the demand formula reflecting a reduction (from 27 to 11 minutes) in loading dwell time for deliveries, Fehr & Peers evaluated one additional site: the Hotel Carlton at 1075 Sutter Street. Additionally, updated results are presented for the previous two sites using the adjustments to delivery loading durations.

Table 29: Revised Curb Loading Demand Estimates Based on Reduced Delivery Loading Duration

	TIA15	TIA306	TIA47
Business Name	Walgreens	Residential Building	Hotel Carlton
Address	2141 Chestnut St	2200 Sacramento St	1075 Sutter St
Geography	Place Type 2	Place Type 2	Place Type 1
Land Use Amount	14.421 (sf)	127(units)	177 (rooms)
Loading Formula Outputs[1]			
Delivery Loading Instances	5	4	2
Passenger Loading Instances	11	5	23
Delivery Loading Spaces Required	3	3	2
Passenger Loading Spaces Required	1	1	1
Combined Loading Spaces Required[2]	4	3	2
Observed Data			
Combined Loading Spaces Supplied	4	4	3
Maximum Observed Loading Demand	3	2	2

Source: Fehr & Peers, 2018.
Notes:
1. All loading space counts given in terms of passenger car equivalents, i.e. units of 20 linear feet.
2. "Combined Loading Spaces Required" assumes that a single curb designation could accommodate both delivery and passenger loading demand. Due to rounding, "combined loading spaces required" may not equal the sum of "delivery loading spaces required" and "passenger loading spaces required."

As shown in **Table 29**, the revised methodology results in a more reasonable estimation of loading demand at TIA15 and TIA306, and accurately estimates the level of loading demand at TIA47. Delivery loading still accounts for the majority of loading demand due to its extended estimated duration; however, the resulting occupancy levels are in-line with field observations.

Limitations outlined from the previous analysis persist; there is no restriction on individuals accessing surrounding land uses from using a loading zone in front of one of the study sites. This may result in an increased level of passenger and delivery loading compared to the calculated demand at a single site. Given the urban, mixed-use nature of much of San Francisco, there are limitations on collecting data on loading instances tied to a single land use. Additionally, due to a lack of data surrounding loading times for deliveries occurring by passenger vehicle likely results in an overly conservative loading time for delivery instances, even following the adjustment based on peak hour observations of light trucks.

7.4.5 Summary of Validation

In summary, the validation exercise illustrates the following:

- Delivery loading demand was previously under-estimated in the 2002 SF Guidelines for many land uses, and much of existing delivery loading demand occurs at the curb.
- Use of the deterministic formula with a 0.5 peaking factor during the peak 15 minutes of demand likely does not reflect the true distribution of loading demand; however, it may serve as a reasonable proxy for assessing loading demand given the inherent uncertainty of vehicle arrival distributions. The formula using a 0.5 peaking factor found a loading demand within one space of a more refined method using the 95th-percentile Poisson variable for peak 15 minute arrivals at a more reasonable peaking level of 0.28.
- There may be little reason to assess demand from unaccommodated off-street freight loading during the same time period as peak passenger and delivery loading, as data show little to no heavy truck activity (a proxy for off-street freight activity) during the peak hours for passenger and delivery loading at the curb, with the exception of the late morning period for retail uses. A two-pronged approach may suffice depending on land use and location.

Overall, based on the flowchart presented as Figure 62, we recommend adjusting the anticipated loading times for delivery instances, and providing an option for analysts to assess unaccommodated off-street loading demand during a different time period from passenger loading demand, based on the distributions of person trips (for adjusting passenger and delivery loading demand) and freight loading instances (for adjusting off-street freight loading demand). If the analyst is presenting loading demand during the PM peak period, when it is most likely to affect the surrounding transportation network, unaccommodated off-street freight loading may be factored down using a multiplier of 25 percent, to reflect the relative volume of PM peak hour heavy vehicle and light truck activity relative to peak activity at 10 am.

Chapter 8. Conclusions and Next Steps

Travel behavior is complicated, on both an individual level and on a citywide level. There are many factors that influence how we choose to travel from place to place, and where we choose to travel to. This report details the methods and findings of a single concerted data collection effort, along with integration of some supplemental data from the CHTS. However, it does not directly compare mode share or trip distribution observed at land uses with the rates currently in use in the SF Guidelines. Rather, it notes where individual buildings or sites may be outliers when compared to other similar buildings and sites, as well as noting the wide range of trip generation rates and mode share percentages among the sites surveyed. Each individual site tells its own story of travel behavior based on its location, urban context, and other factors. In total, these sites provide insight into overall travel patterns associated with land use in San Francisco.

8.1 Limitations of this Study

As summarized in Chapter 6, this analysis found a wide range in trip generation, trip distribution, and mode choice across the study sites. These variations are both expected and normal due to the complexity of travel behavior and the focus on a small subset of all available development in San Francisco. By using the average rates, trip distributions and mode shares revealed through data collection, analysis will tend to treat each new site as a "typical" site, which helps to provide a reasonable check of its effects on the above considerations.

Nonetheless, several elements of this analysis merit the use of caution in applying its findings.

Potential Bias Due to Site Selection Process

The sites studied were selected based on a number of factors, including availability of detailed land use information, applicability to expected future development patterns, and suitability for the data collection methods used in this study. There is potential bias in that the sites meeting these criteria may not be representative of sites throughout San Francisco due to age of development, demographics or socioeconomic status of residents, or other unforeseeable characteristics. This may be particularly true for sites of a certain land use in some neighborhoods; for instance, Parkmerced was selected for study in Place Type 3 due to a general lack of large, multi-unit buildings in that Place Type; however, it may not be representative of typical household travel in that geographical zone.

Sample Size

While the total number of survey responses and person trips recorded was substantial, due to budget and logistical limitations the total number of sites studied was relatively modest compared to the total amount of developed property in San Francisco. As such, we see large levels of variability between sites, even sites that appear similar on their face. This also leads to some level of variability when applying rates from different sources during analysis (for instance, average vehicle occupancy as calculated through CHTS data when compared to person trips by HOV at individual sites).

Building Occupancy

Efforts were made to survey only buildings that had reached at least 80 percent occupancy, as assessed through site visits and initial outreach. However, there is potential for error in these occupancy assessments, particularly for residential condominium buildings, where occupancy was calculated based on the share of units sold. There is potential for individual units to be sold, but not occupied at the time that counts and intercept surveys were conducted.

Differing Use Types

For non-residential uses, many different types of land use are categorized in a single category for environmental analysis purposes. For instance, retail includes both drug stores and specialty retail, and does not differentiate between formula and non-formula retail; office uses include potential for a variety of business types with varying levels of visitors or even security; and hotels include facilities at a wide range of price points and purposes (i.e. business v. leisure travel). Assessing a single, average rate for each of these uses necessarily requires underestimating trips for some types of land use, and overestimating trips for others. Related to the above discussion of sample size, a small change in the share of sites in each category could potentially lead to differing average rates.

Reported Mode Share

While surveys were conducted by professional surveyors, there is potential for misunderstanding between the surveyor and the intercepted survey respondent. These misunderstandings can occur for a variety of reasons, but include language barriers or omission of elements of a trip. For instance, a person who traveled by BART but then walked to the intercepted location might respond that they walked, and omit the transit trip entirely.

Pass-By Trips and Non-Trips

Surveys provided a chance to collect data on if a trip was a pass-by trip occurring while the respondent was en route to another location, or if the trip was a "non-trip," such as an individual taking a fresh air break. However, there may be some potential misunderstanding on this question, and individuals may under-report the extent to which their trips are pass-by trips, or not report a non-trip. Additionally, camera counts at all buildings cannot distinguish between these two trips, and could potentially lead to a slight level of over-counting of trips generated by each use.

Trip Purpose

Because the survey did not ask respondents the purpose of their trip, we are unable to disaggregate work trips from non-work trips. Particularly in the case of trip distribution, work trips may differ substantially from non-work trips, as people are more likely to commute from outside of San Francisco compared to shopping or recreational trips. This issue has been partially addressed through presentation of CHTS trip distribution data.; however, the best data concerning the share of trips related to work and non-work purposes by land use remains survey data from the prior travel demand guidelines.[41]

Loading Duration

The use of time-lapse camera technology prevents extracting dwell time in loading zones at intervals smaller than five minutes. While this provides a fairly comprehensive look at average occupancy, the dwell time data have been supplemented with observations of passenger loading from other studies, and have been summarized for light and heavy trucks only for delivery loading. As such, loading durations may need to be adjusted based on individual land uses, particularly if there are anticipated to be a large number of deliveries with shorter than average durations.

Shared Loading Zones

The on-street loading zones studied were largely available for use by neighboring land uses or for unaffiliated loading activities. As such, the total loading demand for curb spaces may be somewhat overestimated due to use of the spaces by individuals accessing neighboring land uses.

[41] There is very little available data that examines trip purpose by land use. While the CHTS data can be used to assess a rough share of work and non-work trips for residential and office uses, it is less useful at estimating these numbers for retail and hotel uses. The most recent San Francisco-specific data on work and non-work trip purposes dates to 1990, and is the information used in the 2002 *Guidelines*.

8.2 Potential Uses of These Findings

The data collected here are intended for use in future updates of the city Travel Demand Guidelines, as used in environmental analysis and for other planning purposes. In particular, 24-hour person trip generation rates and updated mode split information for a variety of land uses and urban contexts can be used to update the existing travel demand rates.

Trip distribution data collected via this effort may be used as a comparison point to district- or neighborhood-based trip distribution data prepared by SFCTA. This data, based on the most recent CHTS, provides valuable information about distributions of trips by mode.

Finally, loading demand may be useful for estimating curb allocations at new development sites, particularly when balancing parking demand, loading demand, and other potential uses of the space (such as for pedestrian zones or transit stops). Mode splits for deliveries and loading instances may also be useful in assessing loading demand for larger projects and area plans, as they provide a generalized method of assessing the number of loading instances for a variety of land uses. The presented data may be supplemented with site-specific or use-specific data as appropriate to reach loading demands for individual sites.

Additionally, site-specific data will be provided to the San Francisco Planning Department for potential use in assessing similar buildings, and providing up-to-date trip generation and mode split data for similar buildings submitting environmental applications to the City.

ATTACHMENT C

San Francisco Trips Travel Demand Web Tool

How to Use This Tool

This tool estimates the number, type and common destinations of new trips that people would take to and from a new development project. The estimates are for daily and for weekday PM peak hour.

Step 1 – Please enter the project address in the entry bar. Note that Place Type of the address below the entry bar will self-update.

Step 2 – Enter project attributes by selecting the project's appropriate land use types and filling in the amount of land use (e.g., number of units, gross square footage, etc.).

Step 3 – Select travel attributes that you wish to query and display:

- 3.a: Mode: (e.g., All Auto Trips, Transit Trips, or TNC/Taxi Trips).
- 3.b: Purpose (e.g., Work Trips, Non-Work Trips, or All Trips).
- 3.c: Direction (e.g., Inbound or Outbound Trips to the Project Site).
- 3.d: Time period (e.g., Daily or PM Peak)
- 3.e.: Level of Trip Distribution (e.g., District, Place Type, City).

Based on your toggled attributes, the map interface displays the number of person trips between the project site and the neighborhood districts. The thresholds used by the interface to display the continuum of color scheme (light blue for the lowest group of person trips to dark blue for the highest group of person trips) self-updates based on the highest number of person trips using the toggled attributes.

Step 4 – Click on the "Download Data" button to retrieve the outputs in a spreadsheet form to save for your records.

Step 5 – Click on "Reset All" to start over.

Note: The results of your selections are displayed on the upper right corner of the map interface. The 'Total (Person Trips)' column displays all daily person trips by mode, regardless of trip purpose and direction and vehicle trips. The 'Filtered (Person Trips)' column displays the number of person trips filtered by the selected toggle buttons for mode, purpose, direction, and time period.

Note: Move your mouse cursor over the various neighborhoods on the map interface to see the results of your selections (filtered person trips, vehicle trips, and average vehicle occupancy) displayed per district (or selected level of distribution) located in the right corner of the map interface.

Disclaimer: For more information regarding guidance for how to use this tool and the data that went into this tool, please visit the San Francisco Planning Department's Transportation Impact Analysis guidelines webpage: http://sf-planning.org/transportation-impact-analysis-guidelines-environmental-review-update.

ATTACHMENT D

Trip Internalization Rate Best Practices Memo

Overview

Trip internalization: Refers to a subset of person trips where both the trip origin and trip destination are expected to be contained within the same area, or remain inside a development. A trip internalization rate applied during the travel demand modeling process would therefore prevent the double counting of a literal application of the SF Guidelines methodology for trip generation.

- Trip internalization is highly relevant to large, mixed-use developments that include various land uses that would be expected to produce a significant amount of trips that remain within the development. Some examples of these developments in San Francisco are: Mission Rock, Pier 70, 5M, Treasure Island/Yerba Buena Island redevelopment projects.

The Adavant Consulting Model Summary

There are a variety of methodologies that consultants use to calculate trip internalization rates. One method, the Adavant Consulting model summary is outlined below:

1. Determine the total number of person trips generated during the daily and peak hour time periods for each of the individual land uses proposed by the site using the trip generation rates presented in the SF Guidelines (or other substantiated sources, such as ITE for the AM peak period);
2. Estimate the number of project person trips by place of origin and destination and calculate their respective modal splits for each land use during each time period;
3. Identify the number of person-trips generated during each time period with an origin or destination in the district to represent the universe of project-related internal trips that will be calculated and shifted to transit, taxi/TNC, and other non-motorized modes;
4. Group these auto and transit person-trips during each time period by each individual land use into two categories: trip productions (e.g., residential uses) and trip attractions (e.g., office, retail uses);
5. Apply an initial linked trip factor and internal trip factor rates to each individual land use categorized within the production and attraction categories based on ITE, San Diego Association of Governments (SANDAG), or other similar substantiated sources and engineering judgement. See Table below for an example of Internal Trip Capture Rates within a mixed-use project. The most appropriate source should be substantiated with the department;
6. Iteratively adjust the linked trip factors and internal capture rates applied to each individual land uses until the number of production trips equals the number of attraction trips for each time period;
7. Shift the resulting number of attraction and production trips calculated for each land use from the original auto and transit modes to all other modes as they represent the additional person-trips that would be considered internal to the project; and
8. Perform a reasonableness check of the resulting internal person trip capture rates by comparing the data obtained at the completion of Step 7. Against similar results available from ITE, the Transportation Research Board (TRB), and other sources such as pervious EIR analysis).

Source: Adavant consulting memorandum re: Pier 70 Special Use District Project Case No. 2014-001272 Estimation of Project Travel Demand – Revised Project with Open Space, Pier 70 Transportation Impact Street - Technical

Maximum Internal Trip Capture Rates within a Mixed-Use Project from Various Sources

Land Use Type	Daily			AM Peak Hour			PM Peak Hour			
	NCHRP [a] & ITE [b]	Selected for Analysis [c]		ITE [d]	Selected for Analysis [c]		NCHRP [a] & ITE [b]	ITE [d]	Selected for Analysis [c]	
		Scenario A	Scenario B		Scenario A	Scenario B			Scenario A	Scenario B
Residential (all unit types)	38%	35%	38%	20%	18%	20%	53%	57%	30%	45%
General Office[e]	22%	15%	5%	32%	10%	5%	31%	20%	20%	15%
General Retail	30%	14%	8%	50%	24%	9%	20%	46%	20%	12%
Restaurant	30%[f]	14%	7%	31%[g]	18%	9%	20%[f]	50%[g]	20%	12%

Notes:

[a] *Enhancing Internal Trip Capture Estimation for Mixed-Use Development,* NCHRP Report 684, Table 3, p.11*;* transportation Research Board, Washington DC, 2011.

[b] *Trip Generation Manual, 9th Edition, Volume 1: User's Guide and Handbook,* Tables 7.1 and 7.2 (pp. 93-94); Institute of Transportation Engineers, Washington DC, 2012 (based on a limited sample size of mixed-use projects)

[c] The internal capture rates selected for the transportation analysis of the Pier 70 SUD Project are constrained by the need or each scenario to match trip origins with trip destinations (productions/attractions) within the project site. The differences in the selected trip capture rates reflect the mix of uses within each scenario and match potential residential trips with office trips, office trips with retail trips, etc.

[d] *Improved Estimation of Internal Trip Capture for Mixed-Use Development,* Tables 2 and 3 (pp. 26-27), ITE Journal, August 2010.

[e] PDR uses in San Francisco are typically assumed to have travel characteristics similar to those of General Office uses.

[f] Analyzed within the retail land use category by NCHRP and ITE.

[g] There is no distinction in the ITE analysis between sit-down and quick service restaurant uses.

Source: Adavant Consulting from various sources, as noted – July 2015