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Dr. Kelly J. Clifton (PI); Dr. Kristina M. Currans; Dr. Robert Schneider; Dr. Susan Handy

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Maseeh College of Engineering & Computer Science
Portland State University
1930 SW 5th Ave #500
Portland, OR 97201

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16. ABSTRACT

Assessment and mitigation of transportation impacts based on travel demand is required by state, federal, and local laws in California. Determining trip generation is typically the first step in preparing these transportation impact analyses, and current industry standard practice relies on trip rates published by the Institute of Transportation Engineers (ITE). However, ITE protocols emphasize vehicle trip rates without sensitivity to urban context or socioeconomic characteristics, which can exaggerate the impact of certain land uses like affordable housing developments, ultimately increasing mitigation fees. Updating trip generation methodologies is critical given the increasing demand for affordable housing, especially in urban contexts.

This study builds on previous trip generation research in California and elsewhere, and examines trip generation rates for affordable housing locations in Los Angeles and San Francisco Bay Area regions using a multi-method research design. Data were collected, assembled, and analyzed to provide a robust picture of trip making, vehicle ownership, and mode use as a function of development characteristics, household demographics, and urban setting. Results show a strong association between these factors and trip generation, and reiterate the need to revise current industry standard practices. A discussion of policy implications, as well as suggested next steps in research and development, are provided with this in mind.

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Affordable Housing Trip Generation Strategies and Rates

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Final report

by

Kelly J. Clifton (PI)[1]
Kristina M. Currans[2]
Robert Schneider[3]
Susan Handy[4]

with

Amanda Howell[5]
Gabby Abou-Zeid[2]
Edgar Bertini Ruas[1]
Sabina Roan[1]
Steven R. Gehrke[6]

[1]Portland State University; [2]University of Arizona; [3]University of Wisconsin-Milwaukee; [4]University of California-Davis; [5]University of Oregon; [6]Metropolitan Area Planning Council.

for

California
Department of Transportation (Caltrans)

September 13, 2018

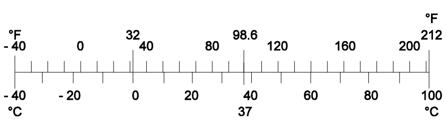
SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
NOTE: Volumes greater than 1000 L shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



* SI is the symbol for the International System of Measurement

(4-7-94 jbp)

Table 1 Common terms

Term	Definition
Person trip	The movement of one person between two activity locations.
Person trip generation rate	The total number of trips generated at the study location during a one-hour period per unit of development (e.g., DUs for residential buildings).
AM peak period	The morning data collection period: the hours between 7 a.m. and 10 a.m.
PM peak period	The evening data collection period: the hours between 4 p.m. and 7 p.m.
ITE-defined AM peak-hour person trip generation rate (AM Peak)	The highest person trip rate for a one-hour period between 7 a.m. and 10 a.m.
ITE-defined PM peak-hour person trip generation rate (PM Peak)	The highest person trip rate for a one-hour period between 4 p.m. and 7 p.m.
Motorized vehicle trip generation rate	The total number of automobile, truck, and motorcycle trips generated at the targeted activity location during a one-hour period per unit of development. If two people are traveling in the same automobile to a targeted activity location, they are making two person-trips by automobile but only one motorized vehicle trip.
Travel mode	Means of travel. For this project, the travel modes are motor vehicle (automobile, delivery car, motorcycle)*, transit (rail, bus, paratransit), bicycle, and pedestrian/walk (walk, wheelchair, skateboard). In some cases, these may be referred to as motorized (motor vehicle) and non-motorized (transit, bicycle, pedestrian). "Other" is a mode category that refers to any mode not falling into previously defined categories. *Ride-hailing or ride-sharing services (also transportation network companies TNCs) fall within the category of motor vehicle trips; however, they are sometimes designated as a separate mode category depending upon the analysis.
Primary travel mode	Generally defined as the mode used for the longest distance on the trip.
Mode split	Refers to the percentage of total person trips that move by a particular mode. For example, if 5-of-15 trips are by bus, the bus mode split is 33 percent.

Area Median Income (AMI)	Median income for households relative to county location and household size; used to determine affordable housing income thresholds.
Moderate-Income	Income level thresholds for households whose incomes exceed AMI
Low-Income (LI)	Affordable housing income level threshold for households whose incomes do not exceed 80% of the median family income for the area.
Very-Low Income (VLI)	Affordable housing income level threshold for households whose incomes do not exceed **50%** of the median family income for the area with adjustments for smaller and larger families and for areas with unusually high or low incomes or where needed because of facility, college, or other training facility; prevailing levels of construction costs; or fair market rents.
Extremely-Low Income (ELI)	Affordable housing income level threshold for households whose incomes do not exceed 30% of median family income for the area. Extremely low-income limits are calculated based on very-low income limits and reflect 60% of very-low income limits. HUD programs use “area median incomes” calculated on the basis of local family incomes, with adjustments for household size.

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- Members of the Technical Advisory Panel for their time and expertise. The individuals and their organizational officials are listed in Table 2.
- Linda Wheaton of the California Department of Housing and Community Development for providing information about Tax Credit Allocation Committee (TCAC) properties in the State of California.
- Staff at the Housing and Community Investment Department of Los Angeles for providing site-level information about affordable housing developments in Los Angeles.
- Jennifer West, Ann Cheng, Nina Rizzo, and staff at TransForm for facilitating connections with affordable housing developers and providing feedback on our data collection tools.
- David Somers of the Los Angeles Department of Transportation for sharing trip generation data for the City of Los Angeles.
- Carol Teall and staff of Teall Management Corporation, Inc. for data collection assistance with the on-site trip generation study.
- Jaime Orrego Oñate for translation services and data collection support.
- All of the affordable housing developers and property managers who worked with us on this project and granted permission for us to collect data at their properties.

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Executive Summary

Communities in California are facing a housing shortage, with an estimated 1.8 million units needed by 2025 to meet future demand. This shortage has led to increased housing costs. The majority of Californians pay more than 30% of their income for housing and nearly one-third pay more than 50% (California Department of Housing and Community Development, 2017). These costs hit low-income households the hardest, contributing to a need for more affordable multifamily housing in particular. Efforts are underway to understand and address these shortages; however, there are many challenges to overcome, including the development process itself.

The California Environmental Quality Act (CEQA), California Senate Bills 375 and 743, and other state, federal, and local laws require the assessment of travel demand due to proposed developments and mitigation of any negative impacts, including affordable housing projects. The development review process has often relied on a process called trip generation—the first step in determining the transport demand for a development. Historically, this process has focused solely on vehicle trips and relied on rates published by the Institute of Transportation Engineers (ITE), a national professional organization, in their analyses. While the ITE approach has been updated recently, trip generation rates for multifamily housing remain insensitive to a diversity of urban contexts, the built environment, socio-economic conditions, and non-motorized vehicle modes and there are no rates available specifically for affordable multifamily housing.

Building on the methodologies and findings of previous Caltrans studies, this study addresses the deficiencies in trip generation rates for affordable multifamily housing using a triangulated research approach. Unlike other trip generation studies that rely solely on trip generation data collected from on-site counts and intercept surveys, our research design included two unique data collection efforts in the Los Angeles and San Francisco Bay regions: an on-site trip generation study of 26 affordable multifamily housing developments and a household survey mailed to residents of 109 affordable housing developments (including the 26 sites in the on-site data collection). In addition, the statewide Caltrans 2012 Household Travel Survey (HTS) enabled the analysis of household trip rates, vehicle miles traveled (VMT), and automobile ownership using a robust number of predictor variables. Using these data, we developed a planning tool - the California Affordable Housing Trip Generation (CAT) Tool - that will provide person and vehicle trip generation estimates. A discussion of our findings and conclusions follows. More detailed information about the study can be found in the accompanying report.

- Low-income households living in multifamily housing own fewer vehicles, make fewer motorized vehicle trips, and generate fewer vehicle miles traveled than their similarly situated higher income counterparts.

- The built environment matters. Vehicle ownership and use declined with increasing urbanization (population & employment density, street connectivity, and mix of uses).

Employment density had a small but significant negative effect on motorized trip generation rates for affordable housing sites.

- Residents of affordable housing used walking and transit for nearly half of the trips generated in the morning and evening peak. Although the automobile was used for the majority of the trips, the high rate of non-automobile modes emphasizes the importance of planning for multimodal options. It also reinforces the need to collect person trip rates and mode information.

- Smart growth and transportation demand management (TDM) strategies may be more effective in curbing VMT if they target higher income households. But these strategies may provide critical multimodal transportation options for affordable housing residents. Lower income households generate 47% less vehicle miles traveled than their wealthier counterparts and it may be more challenging to realize larger reductions. Yet, affordable sites in this study generated more vehicle and person trips than smart growth and TDM sites during the morning and evening peak hour. This suggests that residents of affordable housing may have a reliance on the car but perhaps drive it for shorter distances overall. Higher person trip rates also may be due higher vehicle occupancy and greater use of transit and walking.

- The study revealed to important correlates with motorized trip generation at these sites. The greater the parking supply and the average number of bedrooms (as a proxy for household size) for a site were associated with higher rates of motorized vehicle trip making. These two attributes of the site have not been used in trip generation estimates in the past and the evidence here supports a change in the approach is needed.

- Trip making was more concentrated in the morning peak and the trip purpose information suggests that activities such as school and work with fixed start times may be the cause. Motorized vehicle mode shares were also higher for this period. Walking and transit were important modes in both peaks but walking mode shares were higher in the evening peak when more shopping and recreational activities were conducted.

- Affordable housing sites generate 35% fewer motorized vehicle trips in the PM peak hour, on average, than would be predicted using ITE data. There was little difference in the AM peak, however. Since the PM peak is more commonly analyzed in transportation impact studies, these findings support a greater reduction in ITE trip rates for affordable housing than currently given in models used to assess these impacts (e.g. CalEEMod).

- Further, the comparison of person trip data for affordable developments and those calculated from ITE's data using the recommended approach would underestimate this activity. Given the shortage of person trip data, current practice recommends relying on ITE vehicle trips rates (and assumptions about vehicle occupancy and mode share) to calculate an estimate of person trip rates. This finding warns that this approach may not be valid and should be exercised with caution.

- Our household survey revealed the merging use of shared mobility options, including ride hailing, car sharing, and bike sharing services. These services may provide an important substitute for personal vehicle ownership. These services may lend support for reductions in parking supply at affordable sites, given that vehicle ownership rates are lower for low-income households and shared mobility use is emerging. All of the sites had free parking included in rent as there is a regulation that prohibits unbundling of parking. This regulation should be reconsidered if households use less parking and if other options exist.

- The ITE definition of peak hour rate uses the maximum trip rate over the peak periods, which tends to be 35% higher than using the average rate across the peak period. Using this maximum vehicle rate in performance measures may results in more auto-oriented design than necessary over the course of the day.

The sum of this research reinforces the greater need to re-examine current methods for evaluating trip generation, in general, and their sensitivity to socioeconomic conditions, site characteristics, and urban contexts. The recent shift to collecting person trip information and multimodal data with counts and surveys provides better support for understanding the full array of travel demand generated at sites. Coupling a household survey in addition to these approaches provides much needed insight into residents' characteristics and resources. But these methods are far from adequate to capture the rapidly changing transportation landscape and researchers should be careful not to overlook new modes and travel options as they strive for compatibility with other data and studies.

Specific to affordable housing developments and low-income population, results strongly suggested that applying the data and methods often used in development review processes would over-estimate automobile use and VMT for residents of affordable, multifamily housing developments, even in rural or suburban settings. Analysts who are aware of these limitations can, and should, input more sensitive travel values for relevant developments.

Future trip generation studies for residential land uses should consider the total person occupancy of a development, and not just the number of bedrooms per unit. In the end, it is not the land use itself that generates trips but rather the people living in these developments traveling to their daily activities.

The lower rates of vehicle ownership among low-income households suggest that they may generate less demand for residential parking. Therefore, reducing the parking requirements for affordable development or the unbundling of parking provision could help to increase the supply of housing and lower development costs. However, the automobile may provide critical mobility for those low-income households living in locations with poor local accessibility and fewer transportation options. More research is needed to link these revealed travel patterns with overall levels of satisfaction and well-being, as one should not assume that the observed level of mobility is sufficient to meet their needs. Further research is needed to provide an assessment for an appropriate reduction rate for parking ratios.

1.0 Introduction

Communities in California are facing a housing shortage, with an estimated 1.8 million units needed by 2025 to meet future demand. This shortage has led to increased housing costs. The majority of Californians pay more than 30% of their income for housing and nearly one-third pay more than 50% (California Department of Housing and Community Development, 2017). These costs hit low-income households the hardest, contributing to a need for more affordable multifamily housing in particular. Efforts are underway to understand and address these shortages; however, there are many challenges to overcome, including the development process itself.

The California Environmental Quality Act (CEQA) and other state, federal, and local laws require the assessment of travel demand due to proposed developments and mitigation of any negative impacts, including affordable housing projects. The development review process has often relied on a process called trip generation—the first step in determining the transport demand for a development. Historically, this process has focused solely on vehicle trips and relied on rates published by the Institute of Transportation Engineers (ITE), a national professional organization, in their analyses. These were not appropriate to use in mixed use and urban contexts where the use of other modes is common. While the ITE approach has been updated recently, most available trip generation rates remain insensitive to a diversity of urban contexts, the built environment, socio-economic conditions, and non-motorized vehicle modes.

A number of studies (Tindale Oliver and Associates, 1993; Steiner R. L., 1998; Muldoon & Bloomberg, 2008; Cervero & Arrington, 2008a; Kimley-Horn and Associates, Inc., 2009 June 15; Bochner, Hooper, Sperry, & Dunphy, 2011) including two previous studies sponsored by Caltrans (Handy, Shafizadeh, & Schneider, 2013; Texas A&M Transportation Institute, 2017) indicate that ITE trip generation rates often significantly over-estimate the number of vehicle trips,. Additionally, little information is currently available to understand the transportation impacts of some land uses, including affordable multifamily housing where residents are likely to have lower than average rates of car ownership and use. This is a critical gap in current practice and may increase the costs of development for multifamily housing when cities base development fees and mitigations on these inaccurate demand estimates.

Building on the methodologies and findings of previous Caltrans studies (Handy, Shafizadeh, & Schneider, 2013; Texas A&M Transportation Institute, 2017), this study addresses the deficiencies in trip generation rates for affordable multifamily housing across a variety of urban built environments. This report will describe the multi-pronged research methodology, data collection and analysis process, and the findings. Using these data, augmented with other trip generation and built environment information, the team developed models to predict person-trip and vehicle-trip generation rates for affordable multifamily housing that can be used in future transportation impact studies.

1.1 The Need for New Trip Generation Rates

To combat the mounting environmental consequences of automobile dependence, many cities are adopting policies aimed at increasing both the residential density and land use mix within their neighborhoods. An anticipated product of these initiatives is the mitigation of many negative externalities related to automobile use through gained built environment efficiencies associated with ‘smart growth’, such as land use diversity and street network connectivity, that better support a multitude of transportation options (Ewing & Cervero, 2010). Yet, concurrently, urban housing markets are becoming increasingly expensive (Leopold, Getsinger, Blumenthal, Abazajian, & Jordan, 2015; Joint Center for Housing Studies, 2015). Therefore, a need exists to identify and analyze the transportation-related impacts of these strategies and understand the potential economic penalties these land use policies may place on certain priority populations, including low-income households.

Choices pertaining to mode and frequency of travel and housing location are narrowed for individuals of limited means. Those without access to a personal vehicle benefit from and often require a residential environment with good local accessibility and proximity to reliable public transit services (Blumenberg & Pierce, 2012; Glaeser, Kahn, & Rappaport, 2008) to afford a decent and financially sustainable quality of life. In contrast, individuals who own a private vehicle may have more housing choices given their increased mobility, but the associated costs of vehicle ownership may not offset their ability to find affordable housing. Accordingly, to help address the housing demands of individuals with low or modest household incomes, policies and programs have been introduced to support the construction of affordable multifamily housing developments.

The share of households in rental housing is on the rise nationally. Between 2005 and 2015, this proportion increased from 31 to 37 percent despite a concurrent decrease in household incomes to 1995 levels (Joint Center for Housing Studies, 2015). Both the economic recession and subsequent housing market collapse in the past decade reduced homeownership via widespread housing foreclosures. Worryingly, the current supply of affordable rental housing has failed to meet ever-growing demand; even as the rental market has tightened, rental vacancy rates continue to fall (Steffen, et al., 2015). A growing gap between construction costs and affordable rental rates has hindered developers in their ability to build new affordable housing developments without additional financial support from state and federal sources (Joint Center for Housing Studies, 2015). Although subsidies reduce the rental cost burden on low-income residents, these individuals may still face costs associated with transportation, decreasing their accessibility to necessities such as employment opportunities and medical needs (The Center for Neighborhood Technology, 2012).

The insensitivity of current trip generation methodologies to the characteristics of household location and demographics may result in increased mitigations and fees for new housing development, especially affordable housing development. Trip generation methods that over-estimate vehicle activity at affordable housing sites may serve to justify parking supply minimums, reduce the space available for additional housing units, and decrease potential profit for the developer. The cumulative effect of this loss of space and profit can be significant, given that an average parking space is typically around 330 square feet (just 100 feet shy of a typical studio apartment) and the cost of each required parking space can range from $17,000 to $50,000. Further, there are development costs associated with mitigations for the estimated automobile traffic, such as traffic signals, intersection widening, and curb cuts. These costs may be passed on to rental tenants (Rowe, Morse, Ratchford, Haas, & Becker, 2014) and can limit the availability of affordable housing in urban contexts with a variety of accessible transportation options (Rogers, et al., 2016).

Revised development review procedures that are more sensitive to various urban built environment (e.g. urban or suburban location, population and employment density) and socio-economic contexts (e.g. household income, vehicle ownership) have the potential to address several of these challenges. The costs associated with vehicle-based mitigations could be used to provide more affordable housing units or support non-motorized vehicle transportation modes. This could allow for an increase in affordable housing supply that provides safe, convenient transportation choices to people of limited means. While more research would be required to fully understand and assess how decreased transportation impact and mitigation fees might affect affordable housing availability, revision to current review methodology is a prerequisite to this investigation.

Prior research gives an in-depth review of current trip generation analysis methods and the need for the research in the current study. The annotated literature review of Caltrans Project P359 (Handy, Shafizadeh, & Schneider, 2013) provides insight on the dynamics between the built environment and travel demand as well as the current industry standards and tools used to measure those relationships. A comprehensive resource on the industry standard for evaluating transportation impacts, the need for new evaluation methodologies, and gaps in current literature and data are found in work by Currans (2017).

1.2 Project Goals and Objectives

Trip generation estimates that more accurately reflect the transportation benefits of affordable and multifamily housing are essential for the implementation of three important California initiatives: 1) Caltrans' Smart Mobility Framework; 2) Sustainable Community Strategies as mandated by California Senate Bill 375, The Sustainable Communities and Climate Protection Act of 2008; and 3) California Senate Bill 743 and the provision of more data points needed for Caltrans Local Development-Intergovernmental Review program to quantify VMT impacts/benefits from different kinds of development. In addition, better estimates of transportation impacts will help remove barriers to developing these affordable and multifamily projects and are an important policy instrument for attaining long-term environmental, social, and economic goals. The current Caltrans Project Affordable Housing Trip Generation Rate Strategies (AHTGRS) aims to build on and advance previous policy and research initiatives (e.g., Caltrans Project P359) through the following objectives:

1. Provide estimates of motorized vehicle trip and parking generation rates for affordable multifamily housing that are more accurate than existing ITE rates.
2. Capture pedestrian, bicycle, and public transit trips so that Caltrans and other agencies can conduct multimodal transportation impact analysis.
3. Make the research and developed user tools available to the public for free.
4. Test a cost-effective method of collecting data for residential transportation impact analysis.
5. Collaborate with existing studies in California.

1.3 Advisory Panel

Table 2 Advisory Panel Members and Affiliation

Representative	Organization
David Somers	*City of LA/DEPT*
Rubina Ghazarian	*City of LA/City Planning*
Eddie Guerrero	*City of LA*
Karina Macias	*City of LA*
Stephanie Dock	*Washington DC DOT*
Rachel Schuett	*San Francisco Planning Department*
Jamie Parks	*San Francisco Municipal Transportation Association*
Brian Bochner	*Texas Transportation Institute*
Ed Hard	*Texas Transportation Institute*
Annalisa Schilla	*ARB/CARP*
Maggie Witt	*ARB/CARP*
Chris Ganson	*Caltrans/OPR*
Neil Peacock	*Caltrans/ Environmental Management Office*
Linda Wheaton	*CDHCD*
Amy Martin	*University of California-Berkeley*
Karen Chapple	*University of California-Berkeley*
Daniel Chatman	*University of California-Berkeley*
Miriam Zuk	*University of California-Berkeley*
Paige Dow	*University of California-Berkeley*
Carol Galante	*University of California-Berkeley*

2.0 Research Approach

Unlike other trip generation studies that rely solely on trip generation data collected from on-site counts and intercept surveys, our research design utilized a triangulated research approach (See Figure 1). Each approach contributed unique analysis of trip generation and other travel patterns of low-income residents of multifamily housing and allows for comparison and complementarity of findings between them. These approaches include two unique data collection efforts in the Los Angeles and San Francisco Bay regions: an on-site trip generation study of 26 affordable multifamily housing developments and a household survey mailed to residents of 109 affordable housing developments (including the 26 sites in the on-site data collection). In addition, the statewide Caltrans 2012 Household Travel Survey (HTS) enabled the analysis of household trip rates, vehicle miles traveled, and automobile ownership using a robust number of predictor variables. These various travel measures and variables from these three approaches are summarized inTable 3**.**

The open-to-all, 100% affordable housing sites for the study were selected based upon the urban context of each location, as defined by four urban place types, listed here in increasing order of urbanization: suburban neighborhood, urban neighborhood, urban district, and urban core. The empirical approach for defining these place types can be found in Appendix Aand the site selection criteria and process for on-site data collection locations is described in Appendix B. Site summaries for each on-site data collection location can be found in Appendix C.

The on-site counts and intercept surveys follow the protocols for typical trip generation studies and are described in Appendix Cand Appendix E. The transportation measures of interest are person-trip and motorized vehicle-trip generation, as shown in the first row of Table 3. Here, cordon counts of person-trips (all persons accessing or egressing the site), motorized vehicle trips (automobiles, trucks, and motorcycles), and vehicle occupancy are recorded for the morning and evening peak hours at each of the 26 sites. Forms used to record these count data can also be found in Appendix Cand Appendix E.

The data from the cordon counts, which represent a complete census of persons entering and leaving the site, are supplemented with an intercept survey that asks additional trip information: mode of travel, group size, trip purpose, accessing/egressing the property, and trip distance (estimated). These are collected from a sample of groups traveling together (one person per sampled group was surveyed) using a survey instrument on a computer tablet. This instrument can be found in Appendix E. The process of deriving non-motorized vehicle trip rates is described in Appendix F.

This traditional approach was complemented by a household transportation survey, mailed to residents of 109 affordable housing developments, including the 26 developments where on-site data were collected. The purpose of this approach was two-fold. First, we wanted to test the ability of this survey to replace a traditional trip generation study and provide information about vehicle miles traveled, a new performance measure for transportation systems under California Senate Bill 743. Second, the survey allowed us to gather more information about vehicle ownership and use, use of non-motorized modes, participation in travel demand management (TDM) strategies, on-site parking utilization, and household characteristics. This survey instrument and mail-out survey data collection methodology can be found in Appendix G.

Finally, the third research strategy was to analyze household travel survey data for California, the Caltrans 2012 Household Travel Survey (HTS). This survey collected travel information for one day of a large sample of households (N= 42,426) from across the state of California. Using the same place type construct described in Appendix A, we were able to compare the travel patterns of households living in multi-family and single-family housing who would qualify for affordable housing programs (although the households are not necessarily living in affordable housing locations) with those with higher incomes. As shown in Table 3, the transportation measures collected here have some overlap with the other two methodologies and permits cross-comparison of the results. A comparison of vehicle ownership models developed between the mail-out household transportation survey and the Caltrans 2012 HTS can be found in Appendix H.

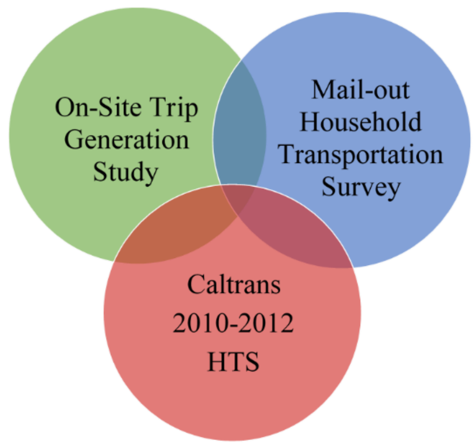

Figure 1 Research design

Table 3 Information provided by each methodological approach.

Data Source	Household Information	Trip Generation	VMT	Mode Use	Person Counts	Vehicle Counts	Parking	Vehicle Ownership
On-site trip generation study		x		x	x	x	x	
Mail-out household transportation survey	x			x			x	x
CA 2012 HTS	x	x	x	x	x	x		x

3.0 On-Site Trip Generation Study

The results from the on-site trip generation study of 26 affordable housing developments in California are described in this section, with more technical details provided in Appendix I. The approach follows the recommended practice for trip generation studies and includes cordon counts of person trips and motorized vehicle trips supplemented with an intercept survey of a sample of travelers. These data were collected for the AM and PM peak periods for one weekday (Wednesday through Thursday) in late August and early October of 2017. Note that all analysis of trip rates and mode shares for this study are for the ITE-defined AM and PM peak hour (i.e. 'peak hour' or 'peak'), as defined in Table 1 and below.

3.1 Count Data Analysis

Here we describe the count data collected on-site and the trip rate analysis. First, we describe how the on-site count data were processed for analysis. Then we identify archived trip generation data sources for affordable and market-rate multifamily housing and provide a descriptive comparison to the data collected in this study. Next, we provide a summary and discussion of the multivariate regression analysis of the data collected in this study. These models are validated using archived motorized vehicle trip counts from the Los Angeles Affordable Housing Trip Generation Study. From these models, we describe the underlying equations that form the bases of a spreadsheet application also produced by this project: The California Affordable Housing Trip Generation (CAT) Tool.

Data Sources and Processing

For each study site, motorized vehicle and person trip counts were collected during the AM peak (7:00AM to 10:00AM) and PM peak (4:00PM to 7:00PM) periods of the adjacent street using data protocols reflecting the guidelines presented in ITE's 3rd Edition *Trip Generation Handbook* (2014). The protocols are available in Appendix CTrip rates were then calculated for each peak period using ITE's approach (Institute of Transportation Engineers, 2014; Institute of Transportation Engineers, 2014). This approach to determine the AM and PM peak hours is summarized in the following three steps:

A. Summarize count information for 15-minute time increments (e.g., 7:00-7:15 AM, 7:15-7:30 AM);
B. Sum counts into moving hourly periods (e.g., 7:00-8:00 AM, 7:15-8:15 AM, 7:30-8:30 AM);
C. Determine the ITE-defined peak hour (i.e., the period with the greatest sum from B.) for both AM peak and PM peak for each development.

This process was completed both for person trip counts and motorized vehicle trip counts. The peak hour trip count summarized was then divided by the occupied dwelling units[1] to derive the "trip rate" or "trips per occupied dwelling unit". The statistical summary of observed counts for AM and PM peak hours, as well as the structural and locational characteristics used in analysis, are provided in
Table 4**.**

Table 4 Summary of Data

Trips per Occupied Dwelling Unit	Mean	Minimum	Maximum
AM Peak Hour (between 7:00-10:00AM)[a]			
Motorized Vehicle Trip Rate	0.53	0.10	1.35
Person Trip Rate	1.57	0.32	2.87
PM Peak Hour (between 4:00-7:00AM)[a]			
Motorized vehicle trip rate	0.40	0.11	0.78
Person Trip Rate	1.25	0.37	2.97
Site Characteristics			
Dwelling Units	73.0	23.0	121.0
Average Bedrooms[b]	2.0	0.0	2.8
Parking Ratio (Spaces to Total Units)	1.4	0.6	2.9
Built Environment & Location			
Population Density	30.2	3.1	176.7
Employment Density	27.0	1.0	273.4
Distance from Nearest Transit Station (Miles)	0.1	0	0.4
Bay Area (Dummy)	0.4	0	1

[a] Peak hour defined as peak period of the adjacent street, as per ITE.
[b] Studios counted as having zero bedrooms.

Comparison of Count Data with Archived Secondary Sources

Before we present our multivariate analysis of these data, we first compare the average rates from our study with the average rates from archived data collected from other studies in California and ITE.

[1] Most developments were nearly 100% occupied. A calculated 'per dwelling unit' rate would provide rates and results that only varied slightly.

Table 5 and **Error! Reference source not found.** compare the average motorized vehicle and person trip rates, respectively, by AM and PM peak hour. Similarly, comparisons of the distributions of the underlying data for this study with the data from ITE (using their format) and the LA Affordable Housing Study (Fehr & Peers, 2017) are shown in Figure 2 through Figure 5.

The average motorized vehicle trip rates from our study (0.53 for AM and 0.40 for PM) are comparable with those from the Los Angeles Affordable Housing study (0.52 for the AM 0.38 for the PM) (Fehr & Peers, 2017). These rates were lower than the PM rate taken from ITE (0.62). However, the AM peak for both of the affordable studies was commensurate with that provided by ITE (0.51). The other three California smart growth and TDM studies had much lower motorized rates for both peaks (as much as 56% lower). These smart growth sites are all market rate, making this finding more surprising. However, it may be that persons living in smart growth or TDM sites are motivated to so because of their desire to drive less. Further, these market rate sites likely have higher-income residents on average than the affordable sites and thus, may have greater ability to live proximate to work and take advantage of the multimodal options available.

The motorized vehicle rate is higher in the AM peak than the PM peak for all of the studies in

Table 5 except for those from the Institute of Transportation Engineers. The rates from previous California-based studies of developments with smart growth or TDM characteristics have more consistency between the AM and PM peaks than the other studies (Fehr & Peers, 2015; Handy, Shafizadeh, & Schneider, 2013; Texas A&M Transportation Institute, 2017). The PM peak rate is more commonly used to assess transportation impacts and based upon the PM rates, the affordable housing sites generate 35% fewer motorized vehicle trips, on average, than would be predicted using ITE data. This suggests that these sites merit a greater trip reduction in tools to estimate transportation impacts, such as the California Emissions Estimator Model (CalEEMod).

Comparisons of person trip rates shown in Table 6. The Los Angeles Affordable Housing Study did not collect this information, nor is this information available from ITE. For this reason, we compare the rates to the Caltrans Smart Growth and San Francisco TDM studies only. Contrary to the motorized vehicle rate, the person trip rate for the affordable housing sites is significantly higher than those for the smart growth and TDM sites. The AM Peak person trip rate was as much as 175% higher than the other studies, and 119% higher for the PM Peak.

The pattern for affordable housing was similar to those for motorized trips - the AM Peak had a higher person trip rate than the PM. However, for sites with smart growth or TDM characteristics and policies, the person trip rates for the PM peak were slightly higher. These large differences may be due to more families with children or larger numbers of people per unit living in the affordable units, just more people per trip. Many of the affordable sites had 3-bedroom units, for example. Without comparable data on numbers of bedrooms for the smart growth sites, we cannot examine the potential causes for this difference further.

Table 5 Comparison of motorized vehicle trip rates to other studies

	AM Peak Hour					PM Peak Hour				
	Average	Standard Deviation	Min	Max	N	Average	Standard Deviation	Min	Max	N
Caltrans Affordable Housing Trip Generation Study[**, a]	0.53	0.24	0.10	1.35	26	0.40	0.18	0.11	0.78	26
Los Angeles Affordable Housing Trip Generation Study[*,b]	0.52	0.22	0.24	1.10	14	0.38	0.19	0.14	0.87	14
Smart Growth Trip Generation Study Phase I[**,c]	0.24	0.20	0.00	0.99	25	0.25	0.18	0.03	0.86	25
Smart Growth Trip Generation Study Phase II[**,d]	0.33	0.10	0.21	0.57	16	0.32	0.06	0.22	0.44	16
San Francisco TDM Framework for Growth Study[**,e]	0.25	0.16	0.11	0.69	16	0.24	0.19	0.10	0.81	16
ITE - 220 Apartment [*,f]	0.51	0.17	0.10	1.02	78	0.62	0.23	0.10	1.64	90

Notes: *Trip rates by dwelling units; **Trip rates by occupied dwelling units

Sources: a Caltrans' Affordable Housing Trip Generation Rates and Strategies; b Fehr & Peers 2017; c Handy, Shafizadeh and Schneider 2013; d Texas A&M Transportation Institute 2017; e Fehr & Peers 2015, f Institute of Transportation Engineers, 9th Ed. 2017
Location type: a, b: open to all, 100% affordable housing; c, d, e, f: market-rate housing

Table 6 Comparison of person trip rates to other studies

	AM Peak Hour					PM Peak Hour				
	Average	Standard Deviation	Min	Max	N	Average	Standard Deviation	Min	Max	N
Caltrans Affordable Housing Trip Generation Study[**, a]	1.57	0.64	0.32	2.87	26	1.25	0.57	0.37	2.97	26
Smart Growth Trip Generation Study Phase I[**,b]	0.61	0.32	0.44	1.57	11	0.66	0.27	0.43	1.37	11
Smart Growth Trip Generation Study Phase II[**,c]	0.57	0.11	0.39	0.80	9	0.57	0.06	0.49	0.65	9
San Francisco TDM Framework for Growth Study[**,d]	0.61	0.32	0.30	0.14	16	0.65	0.35	0.30	1.73	16

Notes: *Trip rates by dwelling units; **Trip rates by occupied dwelling units

Sources: a Caltrans' Affordable Housing Trip Generation Rates and Strategies; b Handy, Shafizadeh and Schneider 2013; c Texas A&M Transportation Institute 2017; d Fehr & Peers 2015
Location type: a, b: open to all, 100% affordable housing;, d, e, f: market rate housing

To further explore how the average trip rates from this study compare with Los Angeles' affordable housing sites, four graphics are provided that include ITE's standard apartment rate (ITE Land Use Code 220: apartment) for AM and PM motorized vehicle trips (see Figure 2 and Figure 3, respectively). Although the motorized vehicle trip rates from this study tend to be slightly below (AM peak) and largely below (PM peak) the ITE average apartment trip rates, it is difficult to discern a pattern of variation when looking at the differences in trip rates by urban place types (see Figure 2 and Figure 3). There is one possible suburban outlier in AM motorized vehicle trips—this site is tested as a possible outlier in the multivariate regression analysis in Appendix I.

Figure 4 and Figure 5 provide a comparison of the average person trip rates collected in this study with ITE's average motorized vehicle trip rates converted into person trip rates using their recommended guidelines (Institute of Transportation Engineers, 2014). Los Angeles did not collect person trip rates in their study. The graphical results suggest that using ITE's methodology for converting vehicle trips to person trips may result in under-estimation of the person trip activity at a site. Thus, it is not an appropriate methodology for understanding the multimodal transportation impacts of a development.

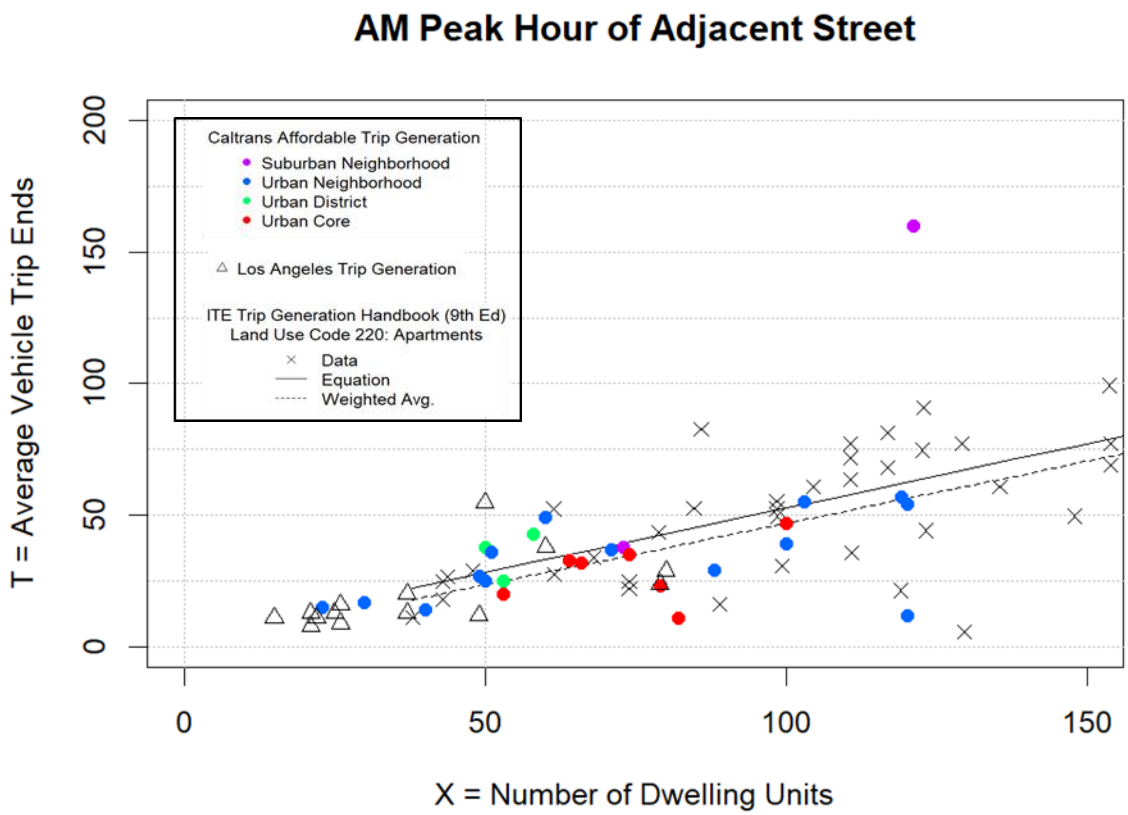

Figure 2 Affordable Housing Study Data (Caltrans Trip Generation, Los Angeles) Superimposed on ITE Data for AM Peak Hour Motorized Vehicle Trips

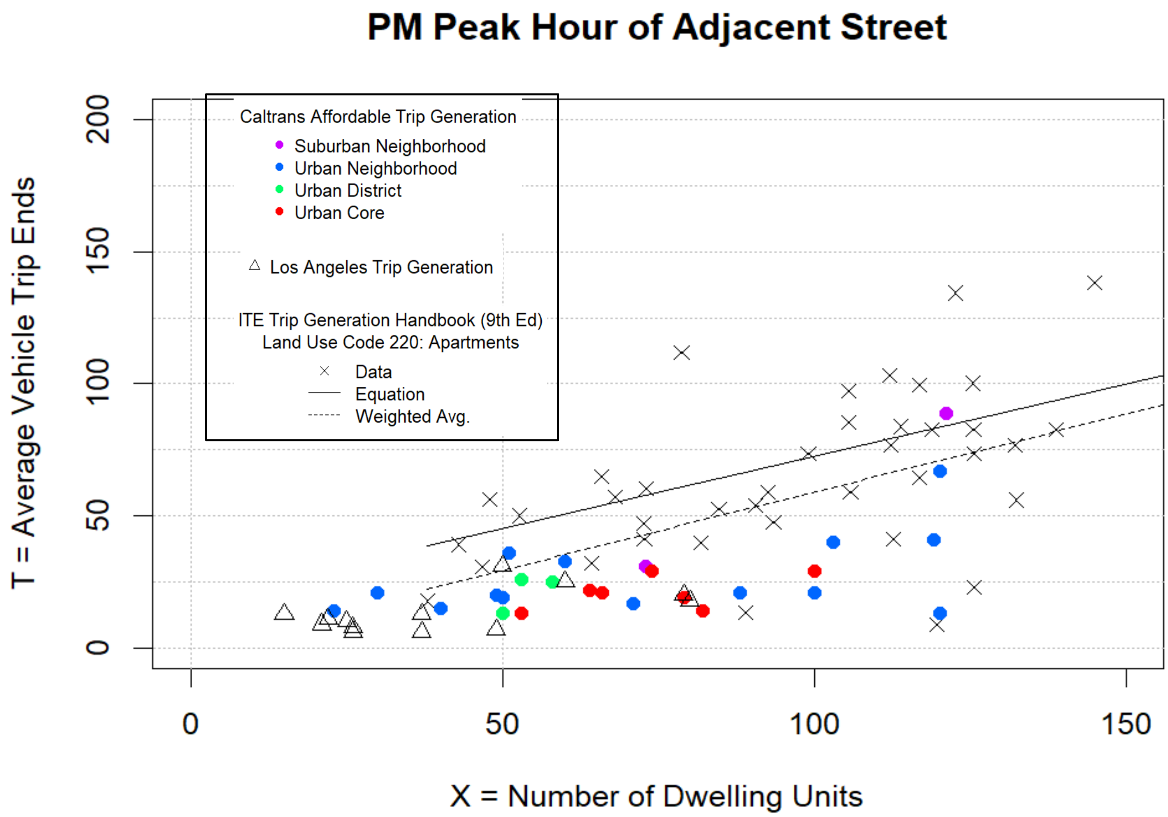

Figure 3 Affordable Housing Study Data (Caltrans Trip Generation, Los Angeles) Superimposed on ITE Data for PM Peak Hour Motorized Vehicle Trips

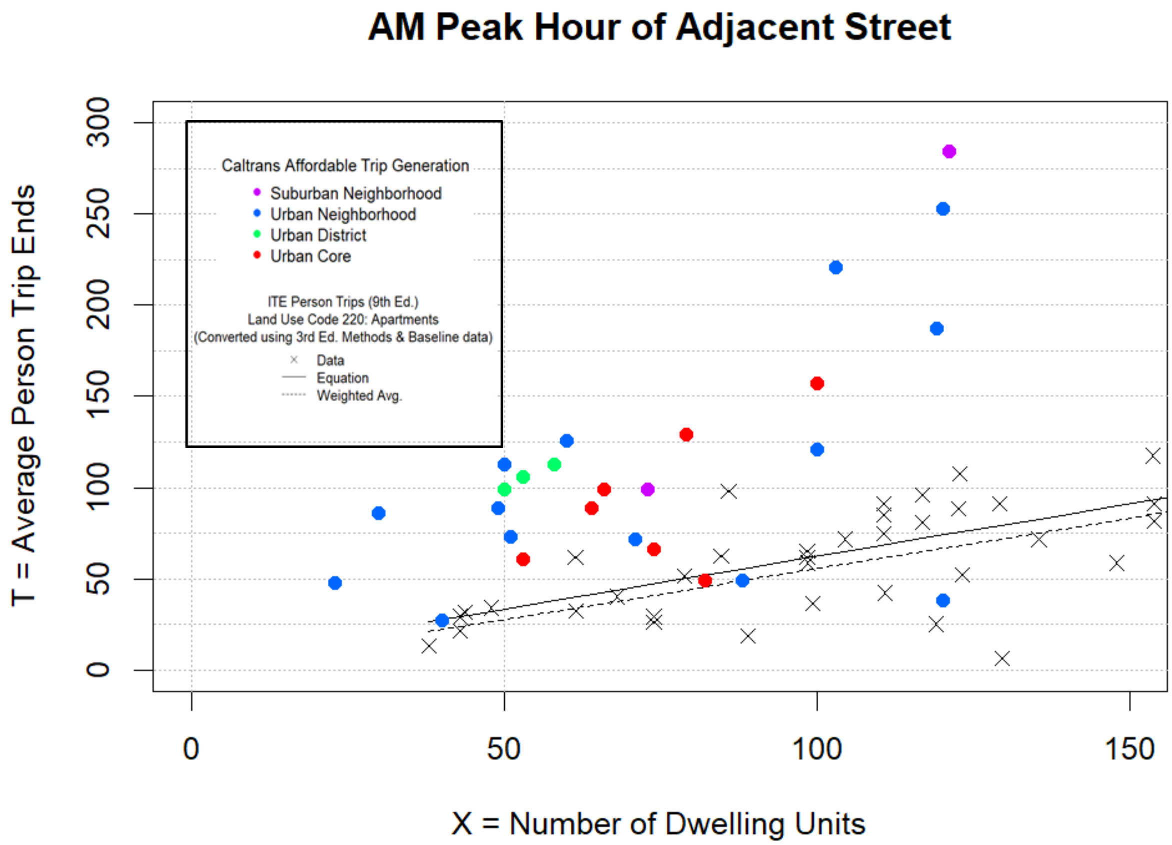

Figure 4 Caltrans Affordable Housing Trip Generation Study Data Superimposed on ITE Data for AM Peak Hour Person Trips

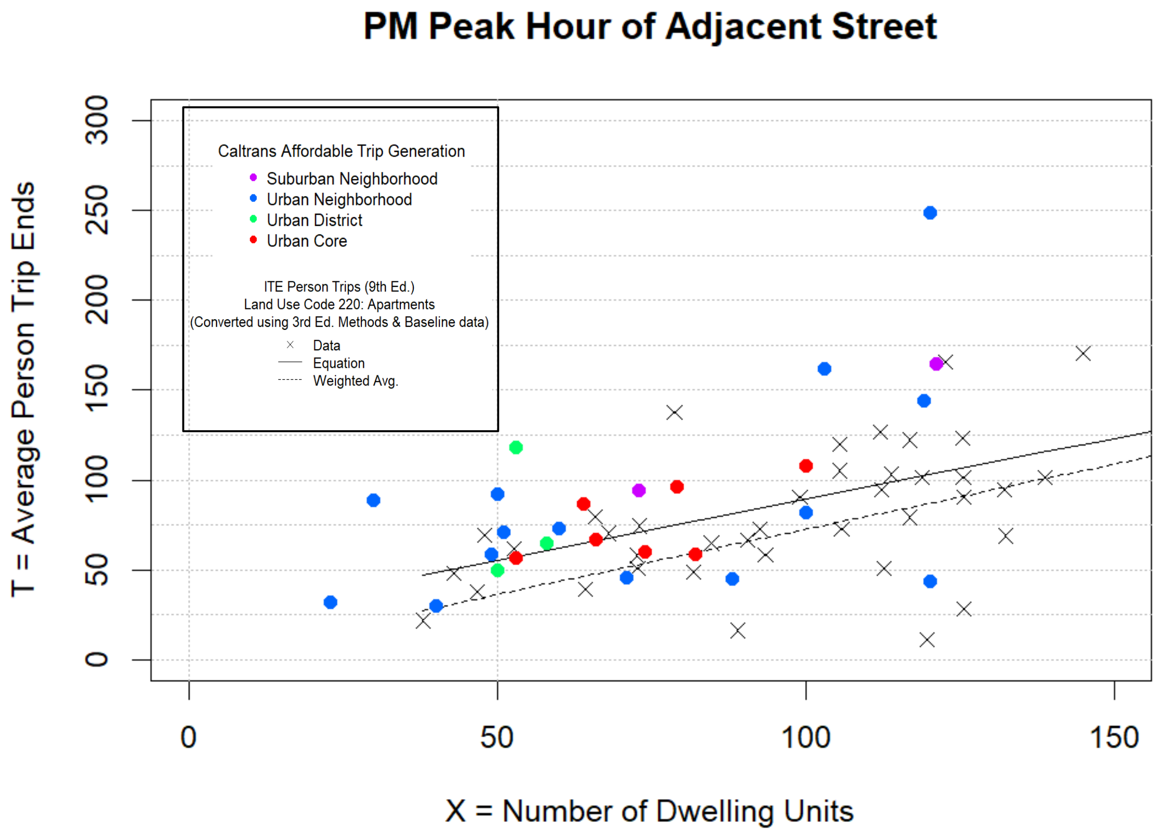

Figure 5 Caltrans Affordable Housing Trip Generation Study Data Superimposed on ITE Data for PM Peak Hour Person Trips

While interesting, comparisons such as these do not capture the complexity of the relationships between the characteristics of residents, the urban built environment, and these trip rates. The multivariate regression analysis in the following section controls for the various factors influencing the affordable housing trip rates from this study.

Motorized Vehicle and Person Trip Analysis

In this subsection, we describe a more comprehensive analysis of motorized vehicle and person trip rate that controls for additional factors that may explain variations in trip rates. In this analysis, motorized vehicle and person trip rates (each for the AM and PM peak) are regressed upon the development and built environment characteristics around the site, listed in

Table 4**.** The results of the ordinary least squares (OLS) linear regression analysis are shown in Table 7 . Because of the low sample size and behavior-based outcomes of this analysis, we denote marginal significance (p-value < 0.2) in all regression tables.

ITE's typical trip rate regression examines trips or the natural log of trips relative to the number of occupied dwelling units. In this analysis, we control for the count-based nature of the data by predicting trip rates (trips per occupied dwelling units or ODU). An estimated coefficient, β_x, can be interpreted as the expected change in trip rate for each incremental unit increase of the variable X.

For all of the sites in the study, parking was bundled into the rental rate for residents. The ratio of parking spaces to total dwelling units was both positively and significantly related to motorized vehicle trips for both the AM and PM peaks. The positive relationship indicates that the more parking spaces there are relative to total units, the higher the motorized vehicle trip rate will be. The results also indicate that parking supply explains more of the variation in motorized vehicle trip rates than any other variable. Assuming a causal relationship between parking supply and trip rates, striking results are revealed by this analysis. An increase in parking supply from 1.0 to 2.0 parking spaces per dwelling unit would result in an increase of approximately 0.23 motorized vehicle trips per dwelling unit in the AM peak and 0.15 motorized vehicle trips per dwelling unit in the PM peak. A decrease in the parking supply by the same margin would result in reduction in trips by the same magnitude. Although these effect sizes appear to be small, the aggregate impact of an entire development could be significant. For example, a 100-unit development could see a reduction of 23 trips in the morning peak and 15 trips in the evening if the parking ratio was reduced by an average of 1 parking spot per dwelling unit. Taken over an entire neighborhood of similarly situated multifamily dwellings, the impact is even more pronounced. However, the relationship may also be driven by the car-orientation of the population- that parking attracts residents with cars, rather than encouraging residents to get cars

Both of the density measures (population and employment) were expected to have negative outcomes on motorized vehicle trip rates. Their relationship to total person trips was less certain a priori. As these densities increase, origins and destinations are closer together and more concentrated, making non-motorized vehicle modes more viable. Population density was not significant in any of the models. The coefficient for employment density was significant and negative for both AM and PM motorized vehicle and person trips. The model suggests that as employment density in the block group where the site is located increase by 1%, motorized vehicle trip rates decrease by 0.1% in the AM peak and 0.07% in the PM peak. Similarly, person trip rates decrease by approximately 0.1% and 0.06% in the AM and PM peaks respectively.

To control for differences that may exist between the San Francisco Bay Area and Los Angeles County in our results, we added an indicator variable for the Bay Area sites. It had a significant and positive relationship with AM and PM motorized vehicle rates and the AM person trip rates. This result was counter-intuitive, as automobile ownership and use were expected to be lower in the Bay Area sites. Further analysis indicated that the sample of developments in the Bay Area had significantly smaller average bedroom sizes—approximately 0.7 fewer average bedrooms—than Los Angeles (One-way ANOVA, $F=10.3$, p-value < 0.01). The Bay Area sample also tended to have approximately 11 more dwelling units per development than Los Angeles, although this difference was not significantly different (One-way ANOVA, $F=0.955$, $p=0.34$). This post hoc analysis seems to point toward a conflated relationship between Bay Area locations and trip rates. The location indicator variable may be a proxy for some other characteristic that has a greater presence (or bias) in the Bay Area sites. However, to more fully test for these differences, a larger sample size with high confidence in representation of the population in both regions would be necessary. While the coefficient for the indicator variable is significant, we recommend that it be excluded from any applications, and we have left it out of the predictive tool due to its potentially misleading results.

The average bedroom size of dwelling units (summarized to a development-level) was significant in all four models (AM and PM, motorized vehicle and person trips). The results indicate the intuitive finding that as the average bedroom size of developments increases, we observe a higher average trip rate. For motorized vehicle trip rates, a one-unit increase in average bedrooms (going from a studio to a one-bedroom, or a one-bedroom to a two-bedroom) increases the motorized vehicle trip rate by 0.2 and 0.1 motorized vehicle trips per occupied dwelling unit for AM and PM peaks, respectively. For a 100-unit development, converting the floor plans from a one-bedroom to two-bedroom (on average) would result in 20 and 10 additional motorized vehicle trips per dwelling unit for AM and PM peaks, respectively. Average bedroom size seems to be a proxy for the size of each household, for which data are not available; an increased trip rate would be expected with an increased number of household residents. It should be noted that average bedroom size might be a more appropriate variable to capture the number of people living in the development than the number of total units, which was only significant in predicting PM motorized vehicle trips.

Table 7 Model results of motorized vehicle and person trips per occupied dwelling unit[2,3]

	AM Peak Hour[a]								PM Peak Hour[a]							
	Motorized Vehicle Trips per ODU				Person Trips per ODU				Motorized Vehicle Trips per ODU				Person Trips per ODU			
	Coef	Elasticity	p-value		Coef	Elasticity	p-value		Coef	Elasticity	p-value		Coef	Elasticity	p-value	
Total Dwelling Units	-0.001	-0.14	0.48		-0.002	-0.19	0.28		-0.002	-0.37	0.07	*	-0.005	-0.29	0.27	
Average No. of Bedrooms[b]	0.19	0.75	0.01	**	0.78	1.04	0.00	***	0.11	0.56	0.07	*	0.50	0.84	0.05	*
Population Density (100s residents per acre)	-0.03	-1.73	0.74		-0.03	-0.58	0.91		-0.10	-7.63	0.31		-0.03	-0.72	0.94	
Employment Density (10s of jobs per acre)	-0.02	-1.03	0.01	**	-0.05	-0.86	0.03	**	-0.01	-0.68	0.05	*	-0.03	-0.65	0.17	.
Distance from Nearest Transit Station (Miles)	-0.36	-0.09	0.33		-0.45	-0.04	0.71		-0.32	-0.11	0.32		-0.76	-0.08	0.59	
Parking Ratio (Spaces to Total Units)	0.24	0.63	0.00	***	0.14	0.12	0.49		0.15	0.52	0.01	**	0.02	0.03	0.92	
Bay Area (Dummy)	0.23	0.19	0.02	**	0.55	0.15	0.06	*	0.13	0.14	0.10	.	0.31	0.11	0.36	
Constant	-0.12		0.48		0.05		0.92		0.15		0.32		0.62		0.34	
Observations				26				26				26				26
R^2				0.75				0.63				0.65				0.35
Adjusted R^2				0.66				0.49				0.52				0.09
Residual Std. Error (df)				0.14 (18)				0.46 (18)				0.12 (18)				0.54(18)
F Stat (df)				7.86 (7; 18)***				4.36 (7; 18)***				4.86 (7; 18)***				1.37 (7; 18)

Notes:

[a] Peak hour defined as peak period of the adjacent street, as per ITE.

[b] Studios were counted as zero bedrooms.

[2] See Appendix GOutlier Testing for Caltrans Affordable Housing Trip Generation Study for notes on testing outlier sites.

[3] See Appendix GVariable Significance for Caltrans Affordable Housing Trip Generation Study for additional notes on coefficient significance.

Validation of motorized vehicle trip rate models

In this section, we use the motorized vehicle trip generation counts from the Los Angeles (LA) Affordable Housing Trip Generation Study to validate the motorized vehicle models developed above. Archived data from 9 developments that were 100% affordable in the LA study matched the family housing definition used in this study and were used for the validation exercise. The data for these 9 sites are summarized in Table 8 below.

Table 8 Description of data from Los Angeles' Affordable Housing Study (N=9) used for validation

	Median	Mean	Minimum	Maximum
Trips per Occupied Dwelling Unit				
AM Peak Period (between 7:00-10:00AM)[a]				
Motorized vehicle trip rate	0.38	0.44	0.24	0.63
PM Peak Period (between 4:00-7:00AM)[a]				
Motorized vehicle trip rate	0.35	0.31	0.14	0.43
Site Characteristics				
Dwelling Units	38.0	45.4	20	80
Average Bedrooms[b]	2.24	2.20	1.65	2.60
Parking Ratio (Spaces to Total Units)	1.05	1.20	0.35	2.21
Built Environment & Location				
Population Density	27.0	40.7	8	155
Employment Density	3.0	21.0	1	85
Distance from Nearest Transit Station (Miles)	0.10	0.11	0.01	0.20
Bay Area (Dummy)	0	0	0	0

Note:
Sources: (Fehr & Peers, 2017)
[a] Peak period defined as peak period of the adjacent street, as per ITE.
[b] Studios were counted as zero bedrooms.

Data plots showing the predicted and observed Los Angeles Affordable Housing motorized vehicle rates for AM and PM peak hour motorized vehicle trips using our Table 7 model can be seen in Figure 6 and Figure 7, respectively. The results of the validation exercise are summarized in Table 9. We used the LA affordable housing data to validate our current models, exploring the bias (mean error)[4], precision (standard deviation of the predictions)[5], and accuracy (root mean square error)[6] (Walther and Moore 2005).

Bias can be interpreted as the average deviation from the observed value; both models underestimated vehicle trips by a very small amount (~0.01 AM and 0.07 PM motorized vehicle trips per dwelling unit). In a 100-unit development, this would account for a difference of approximately 1 AM and 7 PM motorized vehicle trips total. The definition of peak hour motorized vehicle trips is the highest number of counts for four consecutive 15-minute periods of time during the AM or PM study hours (7:00AM to 10:00AM and 4:00PM to 7:00PM, respectively)—these are equivalent to the ITE-defined peak hours. The use of this definition builds in a bias for overestimating motorized vehicle trips of between 4% and 60% of the trip rate (Currans K. M., 2017). In contrast, the bias indicated while using this model predictively is minor in comparison (1% to 7%).

Precision can be described as the spread of error for the predicted values. Table 9 suggests that 95% of the predictions will fall within 0.26 vehicle trips per occupied dwelling unit of the actual vehicle trip rate for the AM peak hour and 0.16 for the PM peak hour (two standard deviations of 0.13 or 0.08 each).

The accuracy measure considers the squared error in prediction, normalizing it with the size of the sample thereby making it sensitive to outliers. The performance of the validation sample will indicate whether there are large outliers in either AM or PM peak; however, the results suggest relatively similar performances in terms of accuracy.

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[4] Calculated as $BIAS = \frac{\sum_{i=1}^{n}(Y-\hat{Y})}{n}$, where Y and $\hat{Y}$ are observed and predicted values, respectively, for observations $i \in \{1, n\ observations\}$.

[5] Calculated as $PRECISION = sd(\hat{Y})$, where $\hat{Y}$ are predicted values and $sd()$ is the standard deviation.

[6] Calculated as $ACCURACY = \sqrt{\frac{\sum_{i=1}^{n}(Y-\hat{Y})^2}{n}}$, where Y and $\hat{Y}$ are observed and predicted values, respectively, for observations $i \in \{1, n\ observations\}$. This is also known as root mean squared error (RMSE).

Figure 6 Table 7 Model Validation for AM Peak Hour Motorized Vehicle Trips with Los Angeles Affordable Housing Data

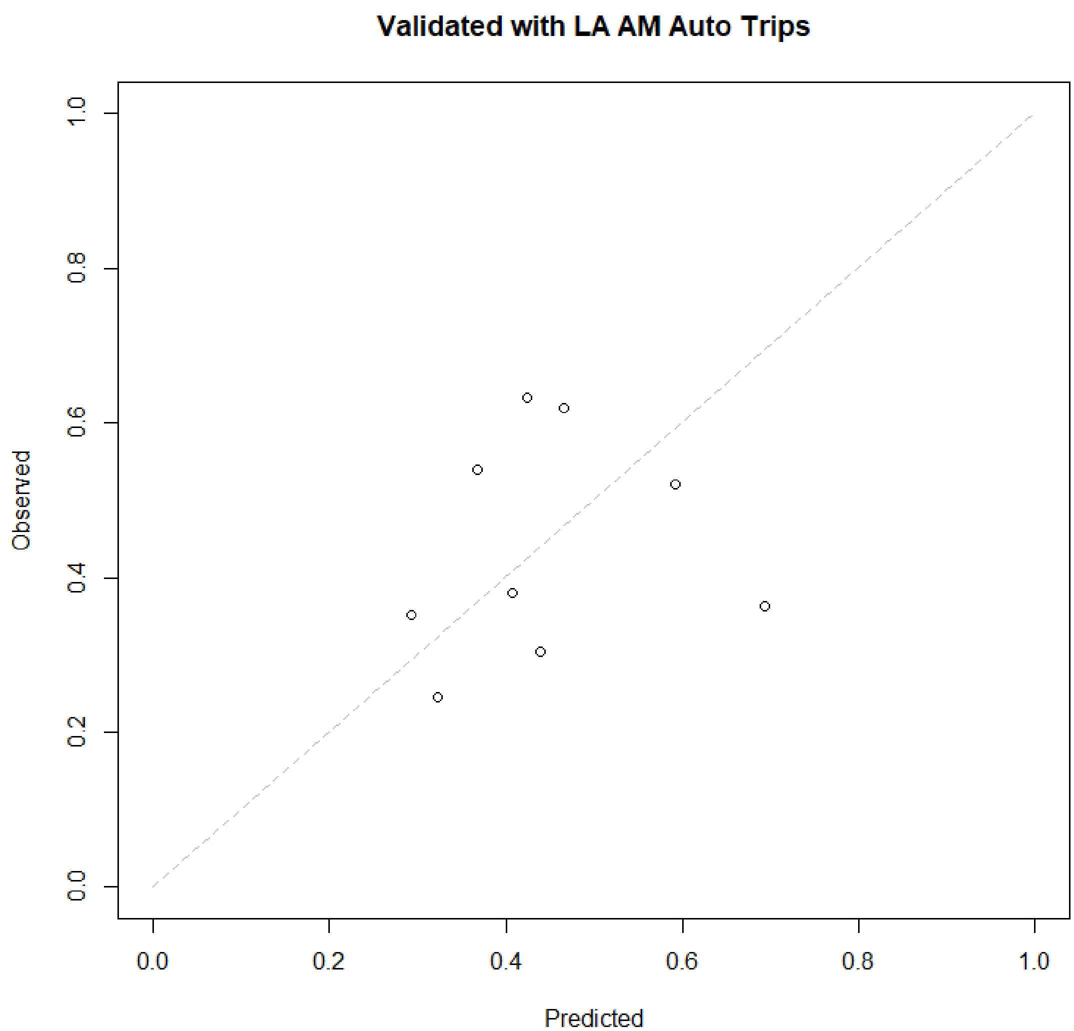


Figure 7 Table 7 Model Validation for PM Peak Hour Motorized Vehicle Trips with Los Angeles Affordable Housing Data

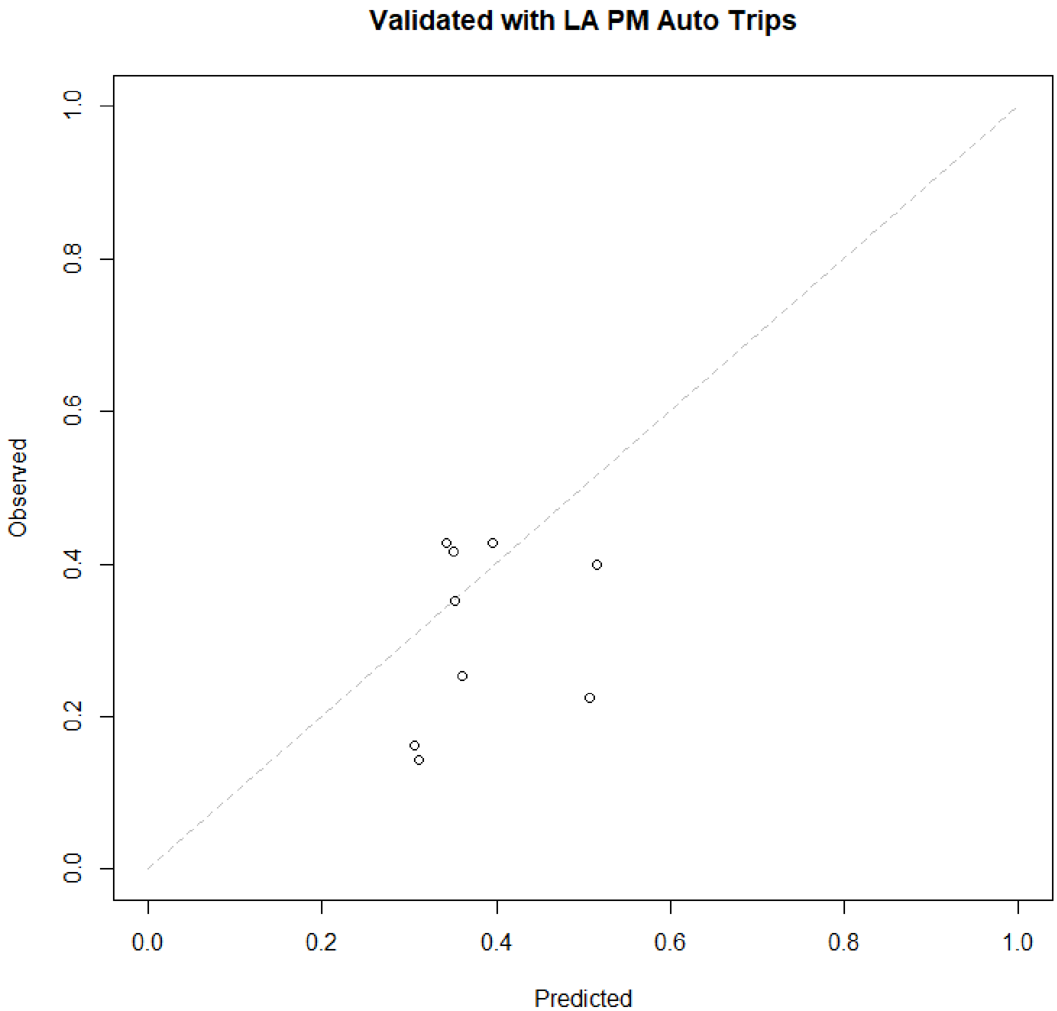


Table 9 Los Angeles' Affordable Housing Study model validation measures

	AM	PM
Bias	-0.01	-0.07
Precision	0.13	0.08
Accuracy	0.16	0.14

Note:
Source of method: (Walther and Moore 2005).

Overall, the low level of bias and narrow spread of prediction and accuracy error found through this validation indicate that the model presented in Table 7 performs well for predicting trip generation rates in affordable housing developments. An additional exploration of the Caltrans and Los Angeles' Affordable housing data modeling can be found in Appendix G.

Application: Caltrans Affordable Housing Trip Generation (CAT) Tool

Based upon our model findings above, we developed a planning tool, called the Caltrans Affordable Housing Trip Generation (CAT) tool. The results from Table 7 can be summarized by four equations below: Equation 1 through Equation 4. Each model predicts the trip rates per occupied dwelling units for either motorized vehicle (MV) trips or person trips. These four equations are the bases for the CAT tool. Only variables that were deemed significant and theoretically sound were included in the models.

Equation 1 Motorized vehicle trips (MV) per occupied dwelling unit (ODU) for the AM peak hour

$$\frac{AM\ MV\ Trips}{ODU} = 0.19 * Average\ Bedrooms + 0.24 * Parking\ Ratio - 0.002 * Employment\ Density$$

Equation 2 Motorized vehicle trips (MV) per occupied dwelling unit (ODU) for the PM peak hour

$$\frac{PM\ MV\ Trips}{ODU} = 0.11 * Average\ bedrooms - 0.002 * Dwelling\ Units + 0.15 * Parking\ Ratio - 0.001 * Employment\ Density$$

Equation 3 Person trips per occupied dwelling unit (ODU) for the AM peak hour

$$\frac{AM\ Person\ Trips}{ODU} = 0.78 * Average\ bedrooms - 0.005 * Employment\ Density$$

Equation 4 Person trips for occupied dwelling unit (ODU) for the PM peak hour

$$\frac{PM\ Person\ Trips}{ODU} = 0.50 * Average\ bedrooms - 0.003\ Employment\ Density$$

Each variable in these equations represents an input the analyst will need to provide in order to approximate the corresponding trip rate. CAT requires the following information for each development to estimate the trip generation rates:

- An estimate of the number of occupied dwelling units in the development;
- The number of occupied units in the development by bedroom size (studios, 1-bedrooms, 2-bedrooms, etc.);
- The total number of parking spaces in the development that are dedicated for residents); and

- Employment density (jobs per acre) for the Census block group where the development is located.

3.2 Intercept Survey Data and Analysis

This section describes the analysis of the data from the intercept survey that was collected concurrently with the count data described above. The purpose of this complementary data is to provide additional information on mode share that cannot be inferred from count data and critical for multimodal planning. Additional data were collected pertaining to group size and trip purpose. Details about how these data were collected and the methods used to expand the sample to reflect the population are described in Appendix E and Appendix F.

The count data described above represent the universe of travelers to and from each site during the study period. The intercept survey, however, captured only a sample of these travelers, including those who drove but parked off-site. The intercept survey collected additional information (e.g., alternative modes as well as mode share, group size, trip purpose, trip distance) that could not be captured in the count. The motorized vehicle and person trip rates described in the previous section were calculated from the entire population of site visitors. The mode shares described here were calculated based upon the sample of persons interviewed in the intercept survey, weighted to reflect the known population of person and motorized vehicle trips.

Mode Shares and Trip Purpose

The distribution of peak-hour mode shares for the 26 sites are shown in

Table 10, while trip purpose by location is reported in Table 11. On average for both AM and PM peak hours, more than half of all trips were made by motorized vehicle (57% and 51% respectively). Across all sites, motorized vehicle mode share ranges from 27% to 83% in the AM, and from 30% to 78% in the PM. Yet, these results also reveal the importance of non-motorized vehicle mobility for residents of these affordable housing developments. Walking was the second most frequent mode in both AM and PM peaks (24% and 33%, respectively), followed by transit (17% and 13%, respectively). Walking mode shares ranged from 0% to 62% in the AM, and from 0% to 67% in the PM. Transit mode shares ranged from 0% to 63% in the AM, and from 0% to 34% in the PM. Cycling was a very small portion of the total trips.

There are also notable differences between AM and PM mode shares. Walking becomes more pronounced in the evening peak at the expense of motorized vehicles and transit. When the site-specific data are examined, we see significant variation in these shares across the sites. When these mode shares are examined by the urban context (or place type) where the site is located, important trends emerge that speak to the role the built environment has on mode choice.

The average mode shares by place type are reported in the tables and visualized in Figure 8 for the AM peak and Figure 9 for the PM peak. There are differences in the motorized vehicle mode shares across urban context, with a more pronounced trend in the PM peak. The more urban the location, the lower the motorized vehicle mode share. Sites in the Urban Core place type exhibited the lowest motorized vehicle mode shares on average at both peaks (AM Peak=52%, PM Peak=44%), while suburban neighborhood sites exhibited the highest (AM Peak=83%, PM Peak=78%). It should be noted that there are only two sites in suburban locations.

Trip purpose varied less across place types than did mode share; however, there were clear temporal differences in trip purpose. For the AM peak, school travel accounted for 36% of trips, compared to only 15% in the PM peak. Non-work travel dominated in the PM peak at 47%, but comprised a lower proportion of trips in the AM peak at 28%. The high proportion of school travel in the AM provides some insight into the larger AM trip rate, as school and work tend to have scheduled start times and thus, may result in trips being more concentrated within the peak hour. Non-work travel tends to be more flexible, which may explain the temporal dispersion of trip making in the PM peak. Surprisingly, work travel comprised the exact same percentage of trip purposes in the AM and PM peak hours, at 32% of trips for both.

Transit mode share was greatest for the Urban Core place type at the AM peak (19%) and for the Urban Neighborhood place type at the PM peak (16%). It is somewhat surprising that the sites in Urban Districts did not have higher transit use. Transit has a lower mode share in the evening than in the morning. This is consistent with the use of transit primarily for commuting in the morning, while other modes are used for the large number of non-work trips in the evenings. Four sites gave free transit passes to residents, as noted in the table below. Of these, two had a greater than average transit mode share in the AM peak (Cathedral Gardens and Guadalupe) and two in the PM peak (Fourth Street and Guadalupe), compared to the other sites in their place type. The transit mode share for Guadalupe is small for the PM peak (4%); however, it appears that the walk mode share (42%) is compensating for the AM/PM differences.

Walking is an important mode for these residents but there are often large variations between sites within place types. The highest walk mode shares were observed at Urban District sites for both peaks (33% in the AM, 44% in the PM). The lower walk mode share in the morning could be linked to trip purposes with scheduled activities such as work and school which place a time constraint on travel even when school locations are relatively close by.

3.3 Summary

These spatial and temporal differences may have important implications for how we plan these sites, the potential for policies impacting mode share, and health outcomes of residents. These results emphasize the need for new trip generation estimate methodologies to capture non-motorized vehicle trips, as concluded in a previous Caltrans studies (Handy, Shafizadeh, & Schneider, 2013) (Texas A&M Transportation Institute, 2017); without sensitivity to non-motorized vehicle modes, just over half of all person trips made at more urban sites would go unaccounted for. The major contribution of this analysis is quantifying the relationship between trip generation and parking ratios, number of bedrooms, and the built environment. These characteristics are important predictors of trip generation rates and to date, have not been adequately captured in the data and methods used to evaluate transportation impacts of new development.

Table 10 Mode shares by location

	AM Peak Hour				PM Peak Hour			
Site	Motorized Vehicle	Transit	Walk	Bike	Motorized Vehicle	Transit	Walk	Bike
OVERALL	0.57	0.17	0.24	0.02	0.51	0.13	0.33	0.03
Urban Core (N=7)	0.52	0.19	0.27	0.02	0.44	0.13	0.38	0.04
Cathedral Gardens*	0.66	0.32	0.02	0.00	0.51	0.04	0.42	0.04
Confidential Site 1	0.27	0.34	0.33	0.06	0.31	0.32	0.22	0.15
Parkside	0.32	0.63	0.05	0.00	0.30	0.21	0.45	0.05
Puerto del Sol	0.55	0.01	0.44	0.00	0.33	0.00	0.67	0.00
Selma Community Housing	0.62	0.05	0.34	0.00	0.57	0.05	0.34	0.05
The Paseo at Californian	0.62	0.10	0.25	0.02	0.44	0.17	0.37	0.02
Villas del Lago	0.74	0.09	0.12	0.04	0.68	0.14	0.17	0.00
Urban District (N=3)	0.57	0.09	0.33	0.01	0.48	0.06	0.44	0.02
801 Alma	0.80	0.02	0.16	0.03	0.58	0.00	0.40	0.02
Mariposa Place	0.42	0.22	0.35	0.00	0.43	0.14	0.41	0.03
Sol y Luna	0.49	0.04	0.47	0.00	0.44	0.05	0.51	0.00
Urban Neighborhood (N=14)	0.56	0.18	0.22	0.03	0.54	0.16	0.26	0.03
Alta Vista	0.74	0.11	0.15	0.00	0.71	0.08	0.21	0.00
Athens Glen	0.81	0.13	0.06	0.00	0.72	0.14	0.14	0.00
Casa Rita	0.45	0.06	0.50	0.00	0.38	0.15	0.46	0.02
Fourth Street*	0.60	0.14	0.27	0.00	0.38	0.18	0.44	0.00
Guadalupe*	0.52	0.48	0.00	0.00	0.59	0.41	0.00	0.00
Harbor View	0.39	0.06	0.45	0.11	0.49	0.16	0.33	0.02
Kern Villa	0.40	0.36	0.12	0.12	0.63	0.05	0.32	0.00
Lenzen Park	0.78	0.03	0.16	0.03	0.56	0.05	0.30	0.10
Pico Gramercy	0.67	0.00	0.17	0.17	0.54	---	---	---
Presidio	0.63	0.25	0.12	0.00	0.63	0.07	0.15	0.15
Rio Vista	0.38	0.00	0.62	0.00	0.42	0.14	0.44	0.00
San Antonio Place	0.34	0.31	0.35	0.00	0.41	0.26	0.24	0.08
Confidential Site 2	0.60	0.37	0.03	0.00	0.52	0.34	0.14	0.00
Troy*	0.41	0.12	0.47	0.00	0.52	0.04	0.40	0.04
Suburban Neighborhood (N=2)	0.78	0.06	0.13	0.03	0.64	0.01	0.34	0.02
Mission Gateway	0.83	0.00	0.12	0.06	0.78	0.02	0.17	0.03
Sherman Village	0.74	0.12	0.14	0.00	0.49	0.00	0.51	0.00

Note: *Sites provided free transit passes to residents, ---: Information unavailable.

Table 11 Trip purpose by location

	AM Peak Hour				PM Peak Hour			
Site	Work	School	Non-work	Refused	Work	School	Non-work	Refused
OVERALL	0.32	0.36	0.28	0.04	0.32	0.15	0.47	0.06
Urban Core (N=7)	0.36	0.29	0.31	0.04	0.30	0.18	0.43	0.10
Cathedral Gardens*	0.39	0.49	0.12	0.00	0.13	0.25	0.31	0.31
Confidential Site 1	0.32	0.20	0.43	0.05	0.46	0.19	0.35	0.00
Parkside	0.46	0.19	0.29	0.05	0.30	0.16	0.43	0.11
Puerto del Sol	0.21	0.56	0.24	0.00	0.30	0.28	0.34	0.08
Selma Community Housing	0.43	0.25	0.32	0.00	0.32	0.11	0.39	0.18
The Paseo at Californian	0.31	0.17	0.48	0.03	0.27	0.15	0.58	0.00
Villas del Lago	0.38	0.18	0.26	0.17	0.29	0.09	0.58	0.03
Urban District (N=3)	0.31	0.36	0.30	0.03	0.27	0.15	0.55	0.03
801 Alma	0.38	0.38	0.24	0.01	0.25	0.23	0.49	0.04
Mariposa Place	0.32	0.26	0.39	0.03	0.30	0.09	0.60	0.00
Sol y Luna	0.22	0.45	0.29	0.04	0.26	0.13	0.55	0.06
Urban Neighborhood (N=14)	0.31	0.39	0.25	0.05	0.35	0.14	0.46	0.05
Alta Vista	0.24	0.50	0.26	0.00	0.32	0.26	0.39	0.04
Athens Glen	0.26	0.41	0.24	0.09	0.30	0.17	0.52	0.00
Casa Rita	0.30	0.40	0.23	0.06	0.36	0.16	0.39	0.08
Fourth Street*	0.21	0.51	0.19	0.09	0.28	0.23	0.47	0.02
Guadalupe*	0.29	0.48	0.24	0.00	0.56	0.17	0.28	0.00
Harbor View	0.19	0.53	0.26	0.02	0.34	0.17	0.49	0.00
Kern Villa	0.36	0.41	0.09	0.14	0.27	0.08	0.54	0.12
Lenzen Park	0.60	0.21	0.14	0.05	0.57	0.04	0.36	0.04
Pico Gramercy	0.23	0.47	0.30	0.00	---	---	---	---
Presidio	0.42	0.08	0.50	0.00	0.23	0.05	0.64	0.09
Rio Vista	0.36	0.43	0.17	0.03	0.45	0.20	0.33	0.02
San Antonio Place	0.36	0.05	0.45	0.14	0.15	0.00	0.70	0.15
Confidential Site 2	0.41	0.41	0.17	0.00	0.35	0.22	0.41	0.02
Troy*	0.15	0.62	0.19	0.04	0.35	0.07	0.48	0.11
Suburban Neighborhood (N=2)	0.24	0.33	0.41	0.01	0.29	0.15	0.55	0.01
Mission Gateway	0.23	0.23	0.53	0.00	0.33	0.13	0.54	0.00
Sherman Village	0.26	0.44	0.28	0.03	0.26	0.17	0.56	0.01

Note: *Sites provided free transit passes to residents

Figure 8 Mode shares for AM peak hour

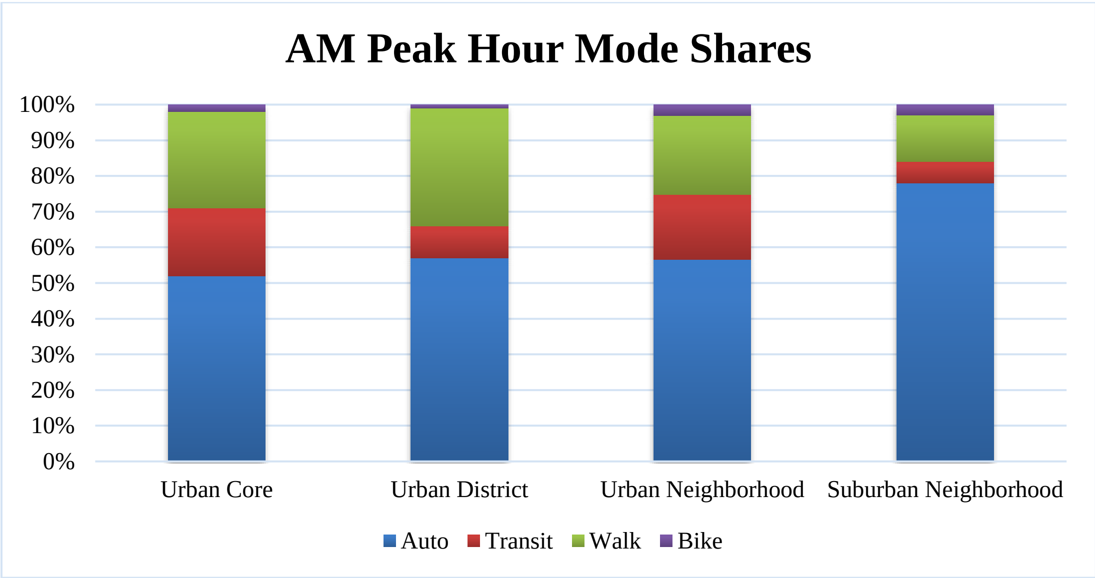
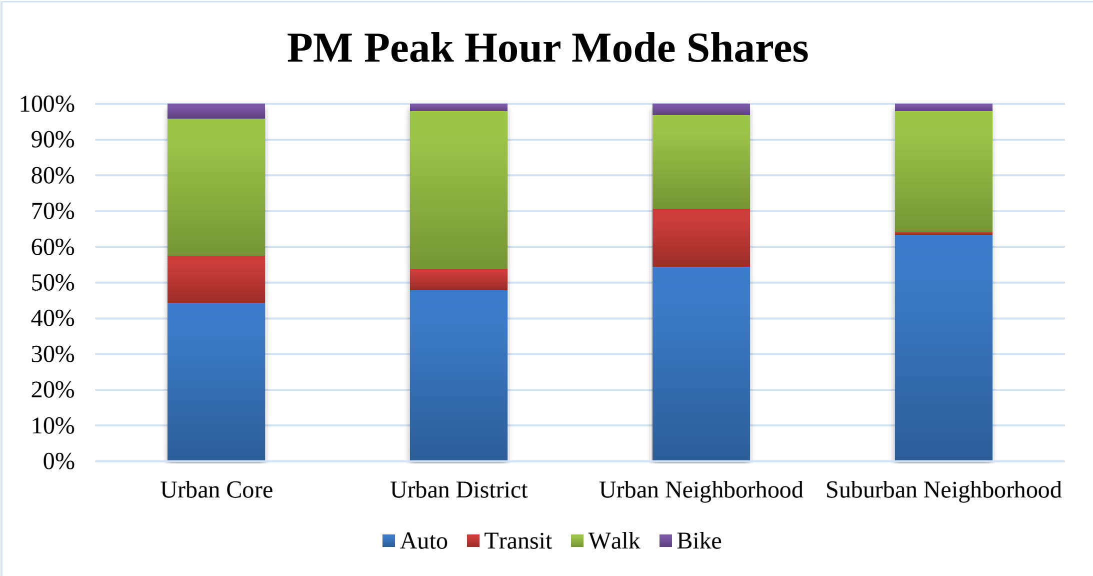


Figure 9 Mode shares by PM peak hour



4.0 Household Travel Survey Data and Analysis

In this section, we examine the relationship between trip generation and automobile ownership using the 2012 California Household Travel Survey (CHTS) to examine these relationships. This large sample of households (N=42,426) from all of the 58 counties in the state of California provide a robust dataset in which to understand the relationships between travel outcomes and the characteristics of the household and their residential location. This complementary approach allows for examination of more detailed information about the travelers and their households than permitted with count data.

The goal of this work was to analyze the correlates with home-based vehicle trips and home-based person trips measured at the household level. These measures are commonly used in evaluating the transportation impacts of a land use in the development process. This effort was published in the Journal of Transport and Land Use, an open-access, a peer-reviewed journal, and the article can be accessed online (Howell, Currans, Gehrke, Norton, & Clifton, 2018). In addition to the analysis reported in the article, the research team also examined the relationship between two other transportation outcomes: vehicle ownership and vehicle miles traveled. Here, we present only a summary of the work and the results. More information can be found in the paper.[7]

4.1 Analysis of trip generation, vehicle ownership and vehicle miles traveled

A one-day travel diary recorded travel by all members of each household in the sample. From this, the transportation outcomes of interest were constructed at the household level: number of home-based person trips, home-based motorized vehicle trips, vehicle ownership, and vehicle miles traveled. Each household in the sample was categorized into groups based upon their income and the various income-qualifying limits used for affordable housing for their county. The data provided the residential location of each household which was assigned to the corresponding place types described in Appendix A as a means of characterizing the built environment. The dwelling type, multifamily or single-family, was also provided. In addition, the number of people in the household and the day of the week that travel was recorded were considered in the models.

Results of the models for home-based trips and vehicle ownership are shown in Table 12 and a visualization of these results for a family of four living in multifamily housing is shown in Figure 10, Figure 11, and Figure 12. This analysis reveals that home-based person trips varied less across place types than home-based vehicle trips. Both home-based person and vehicle trips are significantly impacted by and positively correlated with income (i.e., trips rates increase with increasing income). The urban context of the home location (as characterized by place types) had

[7] Amanda Howell, Kristina Currans, Steven Gehrke, Gregory Norton, and Kelly Clifton. 2018. "Transportation impacts of affordable housing: Informing development review with travel behavior analysis", *Journal of Transport and Land Use*, 11(1):103–118. http://dx.doi.org/10.5198/jtlu.2018.1129 https://www.jtlu.org/index.php/jtlu/article/view/1129

significant impacts on home-based vehicle trips, with trip rates generally increasing with decreasing urbanization.

Household vehicle ownership also varied by place type and economic status. In general, households with higher incomes in less urban settings owned more household vehicles on average than their lower income, more urban counterparts. A negative binomial model was developed to estimate vehicle ownership, while a linear regression was used to model ln(VMT).

Table 12 Models of vehicle ownership, home-based motorized vehicle trips, and person trips

	Home-based Vehicle Trips	Home-based Person Trips	Vehicle Ownership
	1-exp(B)	1-exp(B)	1-exp(B)
HOUSING TYPE			
Multifamily	**-0.16**	**0.00**	**-0.26**
INCOME			
Extremely Low-Income	**-0.45**	**-0.21**	**-0.43**
Very Low-Income	**-0.29**	**-0.19**	**-0.26**
Low-Income	**-0.15**	**-0.11**	**-0.14**
Median/Moderate Income	**-0.08**	**-0.07**	**-0.07**
Above Moderate Income	-	-	-
PLACE TYPE			
Non-Urban	**0.69**	**-0.24**	**0.49**
Suburban Neighborhood	**1.00**	**-0.08**	**0.37**
Urban Neighborhood	**0.90**	**0.00**	**0.27**
Urban District	**0.60**	**0.00**	**0.16**
Urban Core	-	-	-
HHSIZE	**0.70**	**1.01**	**0.45**
HHSIZE SQUARED	**-0.04**	**-0.05**	**-0.03**
WEEKEND DAY (FRI-SUN)	**-0.17**	**-0.09**	**n/a**

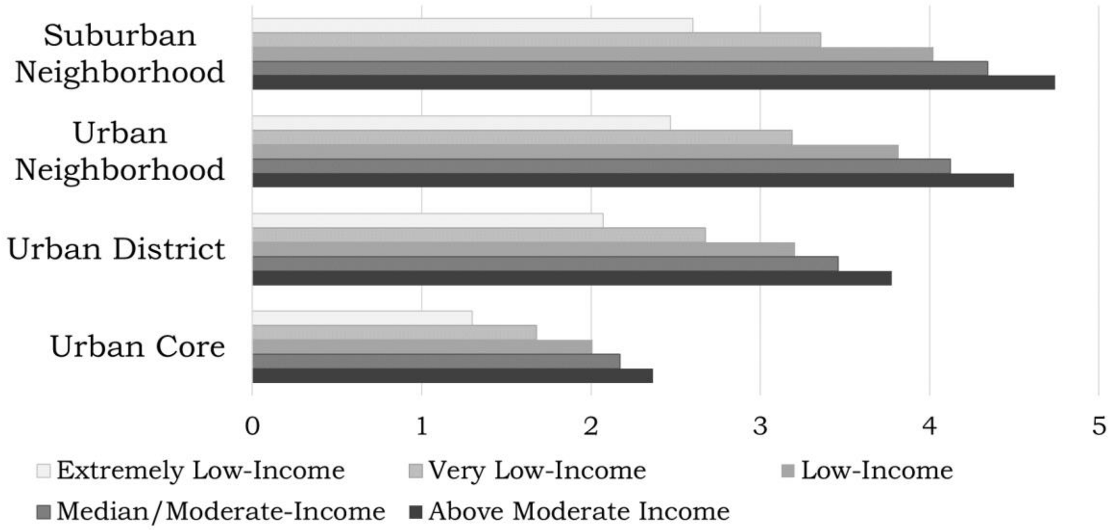


Figure 10 Number of home-based vehicle trips for households living in multifamily housing

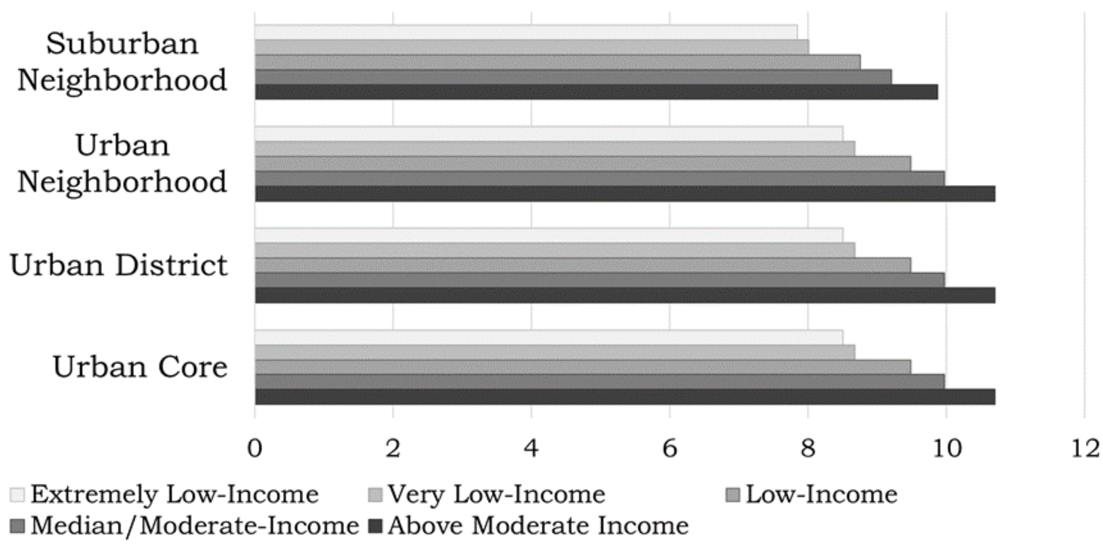


Figure 11 Number of home-based person trips for households living in multifamily housing

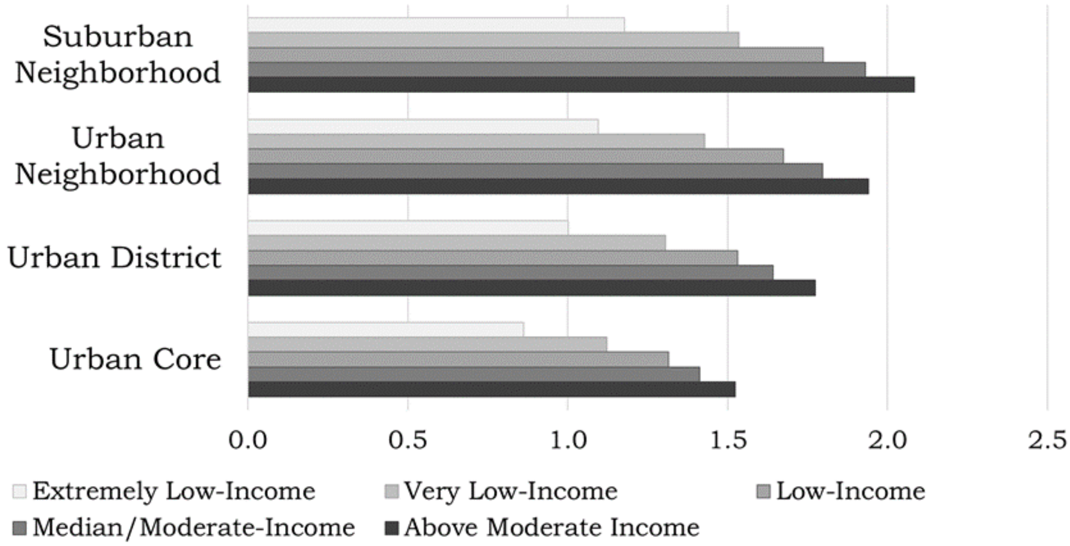


Figure 12 Number of vehicles owned by households living in multi-family housing

Models of household-level vehicle miles traveled (not included in the published paper) are shown in

Table 13. Models 1 and 2 show linear regressions of the natural log of VMT upon the independent variables, with the later including interactions of place type and income. To interpret the effect size of the model coefficients, we examine the exponent of the coefficients, which, for both model types, allows us to examine the relationship of each variable with the respective travel outcome.

While the main effects of household size indicated a positive relationship with VMT, the effect of the square of household size was negative, indicating a diminishing relationship between each additional member of the household and each outcome. This potentially represents transportation efficiencies in multi-member households.

The results show that as households locate further from the urban core (treated here as a base case), they are increasingly likely to drive more. As their income decreases relative to the county median, households drive less. Compared to their single-family housing counterparts, households that live in multifamily units generate 47% less VMT. When controlling for the interaction effects of income and place type, the results indicate additive positive effects for moderate- to extremely low-income categories, particularly in non-urban and suburban places.

Table 13 Linear regression model estimates for vehicle miles traveled (VMT)

Travel Outcome:	Model 1: ln(Vehicles Mile Traveled)				Model 2 ln(Vehicles Mile Traveled)			
Variable	B	SE	p	e^B	B	SE	p	e^B
Intercept	**-2.32**	0.22	0.00	0.10	**-1.73**	0.32	0.00	0.18
County								
San Francisco	**-1.22**	0.15	0.00	0.30	**-1.30**	0.15	0.00	0.28
Los Angeles	**0.13**	0.06	0.02	1.14	**0.14**	0.06	0.02	1.15
Multifamily Housing Unit	**-0.65**	0.06	0.00	0.52	**-0.67**	0.06	0.00	0.51
Household Size	**1.60**	0.05	0.00	4.94	**1.59**	0.05	0.00	4.92
Household Size^2	**-0.14**	0.01	0.00	0.87	**-0.14**	0.01	0.00	0.87
Weekend Travel (Fri-Sun)	**-0.75**	0.04	0.00	0.47	**-0.75**	0.04	0.00	0.47
Household Income Category								
Above Moderate-Income	(base)							
Moderate-Income	**-0.41**	0.06	0.00	0.66	**-1.73**	0.60	0.00	0.18
Low-Income	**-0.91**	0.06	0.00	0.40	**-0.94**	0.51	0.06	0.39
Very Low-Income	**-1.92**	0.07	0.00	0.15	**-2.99**	0.56	0.00	0.05
Extremely Low-Income	**-3.12**	0.07	0.00	0.05	**-4.18**	0.44	0.00	0.02
Refused or Unknown	**-1.21**	0.07	0.00	0.30	**-1.31**	0.70	0.06	0.27
Place Type Category								
Urban Core	(base)							
Urban District	**1.15**	0.21	0.00	3.15	**0.62**	0.36	0.09	1.86
Urban Neighborhood	**1.70**	0.19	0.00	5.48	**1.23**	0.32	0.00	3.43
Suburban Neighborhood	**1.95**	0.20	0.00	7.01	**1.37**	0.30	0.00	3.93
Non-Urban	**1.78**	0.21	0.00	5.95	**1.15**	0.32	0.00	3.15
Interaction Variable								
Moderate-Income *								
Urban District					**1.57**	0.78	0.04	4.82
Urban Neighborhood					**1.33**	0.65	0.04	3.76
Suburban Neighborhood					**1.27**	0.60	0.03	3.57
Non-Urban					**1.56**	0.61	0.01	4.77
Low-Income *								
Urban District					0.27	0.64	0.69	---
Urban Neighborhood					0.39	0.55	0.48	---
Suburban Neighborhood					-0.01	0.52	0.99	---
Non-Urban					-0.02	0.53	0.97	---
Very Low-Income *								
Urban District					0.87	0.71	0.22	---
Urban Neighborhood					**1.39**	0.60	0.02	4.03
Suburban Neighborhood					**1.10**	0.57	0.05	3.00
Non-Urban					0.74	0.59	0.21	---
Extremely Low-Income *								
Urban District					0.66	0.56	0.24	---
Urban Neighborhood					0.38	0.48	0.42	---
Suburban Neighborhood					**1.22**	0.45	0.01	3.37
Non-Urban					**1.58**	0.49	0.00	4.86
Refused or Unknown *								
Urban District					0.47	0.85	0.58	---
Urban Neighborhood					-0.44	0.74	0.55	---
Suburban Neighborhood					0.12	0.70	0.87	---
Non-Urban					0.31	0.73	0.68	---
Observations (n)				41,025				41,025
Adjusted R^2				0.14				0.15

To better examine the magnitude of these effects of the independent variables, model 2 from

Table 13 is used to predict the VMT for a four-person household. Results are shown in **Error! Not a valid bookmark self-reference.** and presented relative to the base case: a four-person household with an income above the moderate level, living in a single-family housing unit in a suburban place. The results emphasize the significant reductions in the observed VMT attributed to increasing urban context, living in multifamily dwellings, and/or declining incomes. For those households with incomes designated as “low-income” and below, living in multifamily dwellings, located in and around the urban core, the resulting estimation for VMT is only 7% of the base case (<7%). Even moderate-income households living in multifamily dwellings in urban neighborhoods drive a quarter the VMT than suburban, single-family dwelling households with average income.

Table 14 Predicted travel outcomes relative to base case (using Model 2 in

Table 13)

Place Type:	Non-Urban	Suburban Neighborhood	Urban Neighborhood	Urban District	Urban Core
Vehicle Miles Traveled: Single-Family Housing Unit	Percent of Base Case Scenario*:				
Household Income Category					
Extremely Low Income	6%	5%	1%	1%	0%
Very Low Income	4%	15%	18%	2%	1%
Low Income	31%	39%	34%	18%	10%
Median/Moderate Income	68%	63%	58%	41%	5%
Above Moderate Income	80%	100.0% (45 mi)	87%	47%	25%
Vehicle Miles Traveled: Multifamily Housing Unit	Percent of Base Case Scenario*:				
Household Income Category					
Extremely Low Income	3%	3%	1%	0%	0%
Very Low Income	2%	8%	9%	1%	1%
Low Income	16%	20%	17%	10%	5%
Median/Moderate Income	35%	33%	30%	21%	2%
Above Moderate Income	41%	51%	45%	24%	13%

NOTE: * Base case scenario is a four-person household earning an above moderate income and living in a single-family housing unit located within a suburban neighborhood (denoted in this table with a box).

4.2 Summary

The results of this analysis, denoted by quotation marks below, gave insight on gaps in the current development review process with regard to multifamily affordable housing developments:

> "With an interest in contributing to affordable housing development policies, this analysis examined and quantified the relative influences of urban place type, residential dwelling type, and income on the travel outcomes that are most relevant in evaluating the transportation impacts of new developments. These results show significant differences in these travel outcomes between income groups and a strong association with place type, as well as contribute to understanding the interaction effects between the two. This strongly suggests that applying traditional methods and data to evaluate the transportation impacts of affordable housing developments will overestimate vehicle use and likely result in excessive fees and unwarranted mitigations.
>
> The significant mediating relationship of Los Angeles County on place type also indicates that there is something about the relationship between residents and the built environment that results in significantly different home-based vehicle trips, even with a similar built environment. This may indicate that metropolitan structure or regional accessibility should be considered in addition to the local contextual variables. Another possible interpretation may have to do with the variation existing in categorical definitions of place—a common simplification of continuous, highly correlated variables to derive something more easily applied and assessed in practice. Either way, these results suggest that aggregating

> nationally collected data without providing more detailed contextual information—e.g., city or county, continuous built environment measures—may result in severe over- or under-estimation of behavior due to regional differences in how residents interact with similar built environments" (Howell, Currans, Gehrke, Norton, & Clifton, 2018).

Additional results strongly suggested that applying the data and methods often used in development review processes would severely over-estimate VMT for residents of affordable, multifamily housing developments, even in rural or suburban settings. This reinforces the importance of the built environment on the generation of VMT for all income groups. As places become more urban, develop more densely, and support more transportation choices, households drive significantly less. This has broad implications for housing development and land use policies, and not just affordable housing, since it suggests that if reductions in VMT—and therefore greenhouse gases (GHGs)—are an important goal, increasing the overall activity density and investing in non-automobile modes is key. Generally, lower-income households contribute less to overall VMT and thus generate less transportation-related greenhouse gas emissions; thus, programs and policies aimed at the reduction of VMT will obviously have greater potential for gains in higher income households. Further, pricing policies may end up imposing additional burdens on those households that are already traveling less by automobile.

The lower rates of vehicle ownership among low-income households suggested that they generate less demand for residential parking. Therefore, reducing the parking requirements for affordable development or the unbundling of parking provision could help to increase the supply of housing and lower development costs. Further research is needed to provide an assessment for an appropriate reduction rate for parking ratios.

While there were some limitations in the analysis, the results suggested that current practice methods do not accurately capture travel behavior at affordable housing developments:

> "First, our analysis was not conducted with explicit data from residents of affordable housing. Rather, we used income designations to identify households that would qualify to live in affordable housing in their area and discriminated by dwelling type. As a result, our conclusions may overstate the trip making differences because residents of affordable housing may have lower housing costs than similarly situated households living in market-rate housing and thus may have more resources to devote to activities and travel.
>
> Second, our models are not intended to be sensitive to the full complement of household resources, environmental conditions and policies known to impact travel behavior. Despite having access to much of this information for the households in our data, we specifically limited our choices of independent variables to those that would be available to an analyst at the time a new development is proposed and under review. In those cases, the development is not yet built and thus the specific characteristics of the household are unknown, other than the targeted income qualifying limits for the housing.
>
> Third, we do not consider the role of self-selection bias in these results. However, low-income households have more constrained choices in where to live and perhaps self-section bias considerations can be relaxed.

Fourth, while we considered on-site parking requirements in our discussion we were not able to include parking information as a variable in our model. Any data collected for an alternative rate study will be submitted to the City as a part of the official record and may be used in future rate calculations. The relationship between on-site parking requirements, vehicle ownership, and trip generation warrants additional study.

Finally, the development of place types was based upon the context of California and thus, may not fully represent the environments in other locations. Regardless, the findings here offer important direction for housing and transportation policy in the United States more broadly" (Howell, Currans, Gehrke, Norton, & Clifton, 2018).

Another limitation of the analysis is that we cannot equate travel outcomes directly to the wellbeing of lower-income households and that these lower levels of travel may be associated with less satisfaction and more unmet needs. CalEEMod, for example, does not provide adjustments according to the target income market of dwelling unit, and their estimates of VMT are based on suburban vehicle trip rates provided by ITE's *Trip Generation Handbook* combined with local estimates of average vehicle trip length (ENVIRON International Corporation, California Air Districts, 2013).

However, analysts who are aware of these limitations can, and should, input more sensitive travel values for relevant developments. The models estimated in this paper are sensitive to regionally-adjusted household incomes and the characteristics of the proposed sites and are based upon the observed travel behavior of residents, rather than vehicle counts that are insensitive to these important factors. Therefore, using these results to estimate the travel outcomes for new housing developments may provide more robust estimates than the existing tools available today.

5.0 Mail-out Household Transportation Survey

This component of the research design had two goals: a) test the viability of using a mail-out survey to residents as a substitute for on-site counts in a trip generation study, particularly as a mechanism for collecting information on vehicle miles traveled (VMT), and b) collect additional household-level data to inform patterns of automobile ownership and use, evaluate the success of travel demand management policies, and provide information about household composition and characteristics.

The survey was administered to all of the units across 109 affordable housing developments in the Bay Area Los Angeles regions. It gathered information on household characteristics (e.g., income, size), transportation resources (e.g., transportation options available), travel to work and school, as well as self-reported daily VMT and vehicle information. All of the developments selected to receive the survey had affordable units reserved for families earning less than the Average Median Income (AMI) for that region. More information about site selection, survey distribution, and response rates, as well as a copy of survey materials, can be found in Appendix G. In this section, we present our analysis of the information collected from this survey.

5.1 Descriptive Information

Overall, 360 households from 82 developments responded out of the 7,836 units that were mailed the survey. The response rate was low despite offering an incentive to participate, cooperation of building mangers, and two attempts to reach participants. There were not sufficient responses from any one development to permit use of the survey to characterize the travel patterns of residents of each development.

Table 15 and Table 16 offer descriptive information about the households responding to the survey. Not every respondent provided answers to each question asked; the revised sample size is provided for each question. The average and median household incomes were in the $25,000-$34,999 range and $10,000 to $24,000 range respectively, indicating a right-sided skew in the distribution of incomes. The average monthly rent was approximately $500-$999 for each household, but some households paid as much as $3,500 or more. Our sample included an average household of 2.5 people, with children less than 16 years old in 41% of households. Respondents averaged one vehicle per household and no household owned more than three vehicles.

Table 15 Survey respondents summary

	Mean	Range
Household Income - 2017 USD (n=357)	$25,000-$34,999	$0-$50,000 or more
Rent - 2017 USD (n=355)	$500-$999	$0-$3,500 or more
Parking per unit (n=307)	0.9	0-3
Vehicle Ownership (n=360)	1.0	0-3
VMT (n=304)	19.3	0-198
Bicycle Ownership (n=360)	0.5	0-4
Number of household adults (>16y) (n=351)	1.8	0-6
Household size (n=351)	2.5	1-6

Table 16 Household characteristics by place type

		Urban Core (n=83)	Urban District (n=17)	Urban Neighborhood (n=127)	Suburban Neighborhood (n=133)	TOTAL
	% of households relative to place type	23%	5%	35%	37%	100%
Household income category	Refused or Unknown	8%	18%	9%	12%	10%
	Extremely Low Income	86%	76%	76%	80%	80%
	Very Low Income	5%	6%	9%	4%	6%
	Low-income	1%	0%	6%	4%	4%
Region	Los Angeles	73%	94%	31%	13%	37%
	Bay Area	27%	6%	69%	87%	63%
Household vehicles	0 vehicles	25%	29%	23%	28%	26%
	1 vehicle	60%	35%	54%	50%	53%
	2 or more vehicles	14%	35%	23%	22%	21%
Household bicycles	0 bicycles	77%	59%	59%	70%	67%
	1 bicycle	17%	12%	28%	18%	21%
	2 bicycles	5%	12%	10%	6%	8%
	3 bicycles	1%	18%	2%	5%	4%
	4 bicycles	0%	0%	0%	1%	0%
Households with Transit Passes		52%	41%	39%	37%	41%
Households with children <16		45%	65%	30%	43%	40%
Single person households		16%	18%	38%	32%	30%

Commuting

We asked respondents to approximate the commute distance to work and school for everyone in the household; results are summarized in Table 17. The average distance to work for all respondents was 11.3 miles, but the standard deviation was high. There appeared to be a pattern with place type, where more urban places tended to have lower commute distances; however, an analysis of variance (ANOVA) indicated no statistical significance[8]. As expected, distance to

[8] ANOVA comparing work distances across place types. F-stat = 1.45 (df= 3, 251), p = 0.217.

school was much smaller with an overall average of 1.6 miles but also with high variability. The distances do not show a trend by place type. However, students living in the urban core have half the school commute distance than those in suburban neighborhoods.

The survey also asked respondents to provide any of the modes of travel they use for commuting to work and school (see

Table 18). Not surprisingly, fewer urban core respondents indicated they drive a personal vehicle to get to work compared with those living in suburban neighborhood and urban neighborhood place types (65% versus 86% and 82%, respectively). Similarly, fewer urban core respondents indicate they drove to school compared with suburban neighborhood (27% versus 45%). Residents of urban core exhibited the highest use of transit for getting to work (49%) and school (47%).

Table 17 Average reported commute distance to work and school

Destination & Place Type	Reported Distance (miles)			
	Mean	Standard Deviation	Min	Max
Work (N = 255)[1]	11.3	11.6	0	71.0
Urban Core (N=63)	9.1	10.2	0	44.0
Urban District (N=12)	8.5	6.9	0.5	23.3
Urban Neighborhood (N=96)	11.8	13.5	0	71.0
Suburban Neighborhood (N=84)	12.8	10.4	0	45.0
School (N = 133)[2]	1.6	2.1	0	13.3
Urban Core (N=32)	1.1	1.1	0	4.7
Urban District (N=11)	1.2	1.9	0.1	5.8
Urban Neighborhood (N=36)	1.1	1.4	0	5.3
Suburban Neighborhood (N=54)	2.3	2.7	0	13.3

Notes:
[1] Average reported distance of all members of the household.
[2] Distance to school used only the data from persons under 16 years.

Table 18 Work and school commute mode use by place type

Place Type	Percentage of Persons Indicating Mode Use (row can exceed 100%)					
	Drive	Get a ride	Walk	Bike	Transit	Rideshare
Mode to Work (N=372)	78%	19%	17%	3%	35%	8%
Urban Core (N=94)	65%	17%	27%	1%	49%	5%
Urban District (N=18)	67%	6%	11%	0%	22%	0%
Urban Neighborhood (N=146)	82%	16%	16%	3%	26%	14%
Suburban Neighborhood (N=114)	86%	25%	13%	6%	37%	4%
Significance of Proportion Across Place Type[1]	n.s.	n.s.	p<0.01	n.s.	n.s.	n.s.
Mode to School (n=261)[2]	36%	50%	21%	4%	32%	5%
Urban Core (N=60)	27%	28%	23%	2%	47%	0%
Urban District (N=31)	29%	39%	29%	10%	13%	10%
Urban Neighborhood(N=73)	34%	55%	23%	4%	30%	12%
Suburban Neighborhood (N=97)	45%	64%	16%	3%	30%	1%
Significance of Proportion Across Place Type[1]	n.s.	n.s.	p<0.01	n.s.	p<0.05	n.s.

Notes:
[1]n.s.: Not significant (p-value > 0.1).
[2] Distance to school used only the data from persons under 16 years.

Mobility-sharing Options

One major focus of the mail-out survey was to capture use of transportation demand management programs and use of modes that support lower vehicle ownership rates, such as shared mobility programs (e.g., carshare, rideshare, bikeshare). Rideshare or ride-hailing services were the most popular of the mobility sharing services, with 41% of households reporting use overall. A carshare membership was held by 24% of the households in the study, yet only 9% of households reported participation in a bikeshare program (see
Table 19).

Membership in one of these types of shared-mobility programs does not necessarily determine that households will actively (or frequently) make use of them, and not every shared mode requires a membership. Further, when we examine the use of these modes in
Table 19, it appears that many may be relying on others' memberships to access these services. Nine percent of households reported using carshare daily or almost every day, but only 3% of households reported the same frequency of use for rideshare despite the program's larger overall use.

Results of our survey show differing levels of reliance on these programs by place type. The frequency of use across place types was significantly different for carshare and ride share ($p<0.05$ and $p<0.05$, respectively), but there was not enough information to indicate whether the frequency of use for bikeshare varied across place types (p~0.26).[9] Households living in the urban core were more likely to use carshare, and 19% of households reported using it daily or almost every day and 16% reported use a few times per week or month. For the 9% of respondents that reported bikeshare use, there was no trend in use by urban place type.

There was a trend in the use of rideshare services with place type. Those living in more urban areas were more likely to use the service with 53% of households living in urban core and urban districts reported having used the service compared to 45% of those living in urban neighborhoods and 28% of those living in suburban neighborhoods.

Table 19 Household use of shared mobility options by place type

Shared Mode & Place Type	Sample Size of HHs (N)	% of Sample	Number of Individual Users	Percentage Using Shared Mobility				
				Never	Less than once a month	A few times per month	A few times per week	Every day or almost every day
Carshare	331		81	76%	5%	7%	4%	9%
Urban Core	75	23%	28	63%	3%	12%	4%	19%
Urban District	16	5%	3	81%	13%	6%	0%	0%
Urban Neighborhood	118	36%	31	74%	7%	6%	5%	8%
Suburban Neighborhood	122	37%	19	84%	2%	6%	2%	5%
Bikeshare	323		28	91%	4%	2%	2%	1%
Urban Core	70	22%	4	94%	1%	1%	1%	1%
Urban District	17	5%	1	94%	0%	6%	0%	0%
Urban Neighborhood	114	35%	11	90%	7%	2%	1%	0%
Suburban Neighborhood	122	38%	12	90%	2%	1%	4%	2%
Rideshare	329		135	59%	16%	16%	5%	3%
Urban Core	73	22%	39	47%	15%	27%	4%	7%
Urban District	17	5%	9	47%	24%	24%	0%	6%
Urban Neighborhood	118	36%	53	55%	19%	15%	8%	3%
Suburban Neighborhood	121	37%	34	72%	13%	10%	4%	1%

[9] Chi-Squared test for shared mode use frequency categories across place types. For Carshare, $\chi^2(12) = 24.5, \mathrm{p} = 0.017$. For Bikeshare, $\chi^2(12) = 14.7, \mathrm{p} = 0.256$. For Rideshare, $\chi^2(12) = 24.8, \mathrm{p} = 0.016$.

[redacted] Models of vehicle ownership

While the previous subsection provides a descriptive analysis of results, this section analyzes vehicle ownership for these households and the correlates with various household and location characteristics. This is important as affordable housing developers are struggling to balance the current and future supply of parking with the associated costs, including the opportunity costs of foregoing housing density for parking spaces. To help understand the extent to which residents of affordable housing own vehicles, we developed a model of household vehicle ownership based upon the responses to our mail out survey, which is a small sample of affordable housing residents living the Bay Area and Los Angeles regions. The results of this model estimation are shown in Table 20. In Section 4.0, we estimate models of vehicle ownership using the California Household Travel Survey (CHTS), which is a large sample of all households across California (see Table 12). We offer a comparison of these two vehicle ownership models from these two sources, also in Table 20. Both of these models use a similar model specification (i.e. similar independent variables), but different model forms (i.e. different types of regression).

First, we consider the mail-out survey responses for vehicle ownership regressed upon the independent variables described in Table 15 and Table 16. Given the categorical nature of the data—and as there were only eight responding households that owned three vehicles—vehicle ownership was recoded into three categories: 0 cars, 1 car and 2 or more cars. The categorical nature of the dependent variable determined the selection of an ordinal probit model.

The parameters of the vehicle ownership model using the mail out data are presented in Table 20 below, together with the parameters developed for the CHTS 2010 model for comparison. It is important to note that the model shown in Table 20 does not considers Multifamily Unit as an independent variable, as it was not available in the NHTS dataset. Also, some categories from “region”, “household income”, and “place type” were omitted from Model 2, as they do not apply for our comparison, for example, buildings outside the Los Angeles and Bay Area regions, income levels above median income and non-urban place types. Because Model 2 was discussed in the previous section, we focus this discussion on the results of the mail-out survey (Model 1) and how they compare to the model developed using household travel survey data (Model 2).

The results indicate the main effects of household size, household size squared and household income to be significantly related to vehicle ownership. Model 1 and model 2 have similar relative patterns in the direction of the coefficients. Due to the low response rate and sample size, there was not enough information in the mail-out model to determine a significant difference in vehicle ownership rates between the region of household. The findings of the mail-out model suggest that only one place type (urban core) differed significantly from suburban neighborhood (base case).

The parameters for income levels of low income and very low income should be interpreted with caution. The number of observations for both categories was small (13 low income households and 21 very low income), whereas the reference category, extreme low income, accounted for more than 80% of the observed data.

We use data from the California sample of 2017 National Household Travel Survey (Federal Highway Administration, 2017) (NHTS) (N= 26,095 households) to validate the predictive ability of both of these models developed from different samples (data collected through this study and through the 2012 CHTS). These results are shown in Appendix H. The findings of this process reveal that as suspected, the models developed on larger sample sizes (CHTS) provide more reliable prediction. The model developed using the mail-out survey tends to under-predict vehicle ownership based upon the validation exercise using the 2017 NHTS data for all of California. However, the models developed with this mail-out survey of affordable housing residents are more appropriate for urban areas such as the Los Angeles and San Francisco regions, where vehicle ownership rates maybe lower and there are more transportation options.

Table 20 Vehicle Ownership Models

	Model 1					Model 2				
Travel Outcome:	Vehicle Ownership (0, 1, 2 +)					Vehicle Ownership				
Origin of data:	Mail-out survey					CHTS 2010				
Model form:	Ordinal Probit					Negative Binomial				
	Coef	Std. Error	p-value	exp(B)		Coef	Std. Error	p-value	exp(B)	
Region										
Bay area	-0.15	0.16	0.36	0.9		**-0.19**	0.03	0.00	0.8	***
Los Angeles	(base)					0.01	0.01	0.39	1.0	
Household Size	**1.58**	0.22	0.00	4.9	***	**0.40**	0.01	0.00	1.5	***
Household Size ^{2}	**-0.18**	0.03	0.00	0.8	***	**-0.04**	0.00	0.00	1.0	***
Household Income										
Refused or Unknown	0.00	0.24	1.00	1.0		**0.51**	0.02	0.00	1.7	***
Low Income	**1.19**	0.35	0.00	3.3	***	**0.46**	0.02	0.00	1.6	***
Very Low Income	**0.59**	0.28	0.03	1.8	**	**0.29**	0.02	0.00	1.3	***
Extreme Low Income	(base)					(base)				
Place Type										
Urban Core	**-0.40**	0.20	0.04	0.7	**	**-0.54**	0.05	0.00	0.6	***
Urban District	-0.33	0.33	0.33	0.7		**-0.32**	0.03	0.00	0.7	***
Urban Neighborhood	0.13	0.15	0.39	1.1		**-0.15**	0.02	0.00	0.9	***
Suburban Neighborhood	(base)					(base)				
Constant						**-0.61**	0.02	0.00	0.5	***
1 car over 0 cars category	**1.55**	0.36	0.00	4.7	***					
2 or more cars over 1 car category	**3.48**	0.40	0.00	32.4	***					
Observations (n)					350					42,425
Nagelkerke Pseudo R2					0.09					0.006
Deviance					136					16,680
Alkaline Information Criterion					255					117,442
Log Likelihood					128					2,039

Notes:
"***": p-value < 0.01; "**": p-value < 0.05; "*": p-value < 0.1; “.”: p-value < 0.2

6.0 Discussion of Findings

This research employed a triangulated approach in order to present a more complete picture of the trip generation, travel patterns, and vehicle ownership of residents of affordable housing. Findings were complementary and where there was overlap in methodology, the results were mostly consistent. Here we reiterate some of the key findings and the implications for policy.

- Low-income households living in multifamily housing own fewer vehicles, make fewer motorized vehicle trips, and generate fewer vehicle miles traveled than their similarly situated higher income counterparts.

- The built environment matters. Vehicle ownership and use declined with increasing urbanization (population & employment density, street connectivity, and mix of uses). Employment density had a small but significant negative effect on motorized trip generation rates for affordable housing sites.

- Residents of affordable housing used walking and transit for nearly half of the trips generated in the morning and evening peak. Although the automobile was used for the majority of the trips, the high rate of non-automobile modes emphasizes the importance of planning for multimodal options. It also reinforces the need to collect person trip rates and mode information.

- Smart growth and transportation demand management (TDM) strategies may be more effective in curbing VMT if they target higher income households. But these strategies may provide critical multimodal transportation options for affordable housing residents. Lower income households generate 47% less vehicle miles traveled than their wealthier counterparts and it may be more challenging to realize larger reductions. Yet, affordable sites in this study generated more vehicle and person trips than smart growth and TDM sites during the morning and evening peak hour. This suggests that residents of affordable housing may have a reliance on the car but perhaps drive it for shorter distances overall. Higher person trip rates also may be due higher vehicle occupancy and greater use of transit and walking.

- The study revealed to important correlates with motorized trip generation at these sites. The greater the parking supply and the average number of bedrooms (as a proxy for household size) for a site were associated with higher rates of motorized vehicle trip making. These two attributes of the site have not been used in trip generation estimates in the past and the evidence here supports a change in the approach is needed.

- Trip making was more concentrated in the morning peak and the trip purpose information suggests that activities such as school and work with fixed start times may be the cause. Motorized vehicle mode shares were also higher for this period. Walking and transit were important modes in both peaks but walking mode shares were higher in the evening peak when more shopping and recreational activities were conducted.

- Affordable housing sites generate 35% fewer motorized vehicle trips in the PM peak hour, on average, than would be predicted using ITE data. There was little difference in the AM peak, however. Since the PM peak is more commonly analyzed in transportation impact studies, these findings support a greater reduction in ITE trip rates for affordable housing than currently given in models used to assess these impacts (e.g. CalEEMod).

- Further, the comparison of person trip data for affordable developments and those calculated from ITE's data using the recommended approach would underestimate this activity. Given the shortage of person trip data, current practice recommends relying on ITE vehicle trips rates (and assumptions about vehicle occupancy and mode share) to calculate an estimate of person trip rates. This finding warns that this approach may not be valid and should be exercised with caution.

- Our household survey revealed the merging use of shared mobility options, including ride hailing, car sharing, and bike sharing services. These services may provide an important substitute for personal vehicle ownership. These services may lend support for reductions in parking supply at affordable sites, given that vehicle ownership rates are lower for low-income households and shared mobility use is emerging. All of the sites had free parking included in rent as there is a regulation that prohibits unbundling of parking. This regulation should be reconsidered if households use less parking and if other options exist.

- The ITE definition of peak hour rate uses the maximum trip rate over the peak periods, which tends to be 35% higher than using the average rate across the peak period. Using this maximum vehicle rate in performance measures may results in more auto-oriented design than necessary over the course of the day.

The sum of this research reinforces the greater need to re-examine current methods for evaluating trip generation, in general, and their sensitivity to socioeconomic conditions, site characteristics, and urban contexts. The recent shift to collecting person trip information and multimodal data with counts and surveys provides better support for understanding the full array of travel demand generated at sites. However, there is a tremendous need for these data across all land uses. To help fill this gap, a national, coordinated data collection plan that considers strategic sampling of land uses by characteristics of location and socio-economics of residents (in the case of housing) and site visitors (for other uses) is necessary.

Coupling a household survey in addition to these approaches provides much needed insight into residents' characteristics and resources. But these methods are far from adequate to capture the rapidly changing transportation landscape and researchers should be careful not to overlook new modes and travel options as they strive for compatibility with other data and studies.

The temporal differences in trip rates between AM and PM peaks raise questions about current practice, which tends to focus more attention on the PM peak hour for transportation impact studies. If trip rates are higher in the morning, then perhaps more emphasis should be placed on this time period. However, the concentration of trips within the morning peak hour also highlights the need to reconsider how peak-hour rates are calculated using ITE methodology, where the four consecutive 15-minute intervals that sum to the highest rate define the peak hour. This approach takes the “peak of the peak”, and the resulting rate inflates the actual amount of trip making that actually occurs in the 3-hour data collection period, particularly when trips are not evenly distributed across time. At a minimum, this approach should give policymakers pause before setting policy based upon this definition of the peak-hour rate.

Additionally, the methods of measuring activity and travel at a site depends heavily on how they will be used in evaluating performance. As many communities are moving away from automobile level of service or adding performance measures related to access, environment, health, and equity, these traditional calculations of trip rates may be less useful. Because new methods emphasize person trips and multimodal travel, there is an opportunity to rethink how these new data can best inform the planning process to meet desired outcomes.

Specific to affordable housing developments and low-income population, results strongly suggested that applying the data and methods often used in development review processes would over-estimate automobile use and VMT for residents of affordable, multifamily housing developments, even in rural or suburban settings. Analysts who are aware of these limitations can, and should, input more sensitive travel values for relevant developments.

The lower rates of vehicle ownership among low-income households suggest that they may generate less demand for residential parking. Therefore, reducing the parking requirements for affordable development or the unbundling of parking provision could help to increase the supply of housing and lower development costs. However, the automobile may provide critical mobility for those low-income households living in locations with poor local accessibility and fewer transportation options. More research is needed to link these revealed travel patterns with overall levels of satisfaction and well-being, as one should not assume that the observed level of mobility is sufficient to meet their needs. Further research is needed to provide an assessment for an appropriate reduction rate for parking ratios.

One of the major contributions of this study is the affirmation that parking supply matters. Parking ratios or the number of parking spaces per dwelling unit explained the most variation in motorized vehicle trip rates for our affordable housing sites and had a significant and positive relationship. Current ITE practice does not include parking information about the site, and parking generation rates are divorced from trip generation rates. All of the sites in our study bundled parking with rent, including the sites in most urban locations such as the site in central San Francisco with high local accessibility and frequent transit service. Residents paid the same whether parking was utilized or not. This practice tends to make housing more expensive to build and to rent, and allocates more available land inventory to automobiles, rather than housing units.

Another contribution was that average bedroom size (or household size, in the case of the travel survey analysis) was also an important predictor for both person trip and motorized vehicle trip generation and had significant, positive relationships to trip rates. Average bedroom size seems to be a proxy for the number of people living in a development, and thus the number of trips being made. Currently, the number of stories/units of a development are used to distinguish between multifamily land-use types in ITE and rates are reported as a function of the number of (occupied) dwelling units. However, average bedroom size may be a better way to classify multifamily developments for trip generation and transportation impact evaluation.

Future trip generation studies for residential land uses whether affordable or market rate housing, should consider the total person occupancy of a development, and not just the number of bedrooms per unit. In the end, it is not the land use itself that generates trips but rather the people living in these developments traveling to their daily activities.

As other studies have found, the built environment around the site (or urban context) also influences the travel patterns of residents. All three of our approaches (Figure 1 and Table 3) found significant built environment correlates with trip generation, vehicle ownership, mode use, and vehicle miles traveled. In the case of the on-site trip generation study, employment density was found to be significant and negatively associated with person (except PM peak hour) and vehicle trip rates. Providing more contextual information is critical for research and practice. For the former, this is useful in pooling data across the US and elsewhere to better understand how transportation choices relate to the environment. For the latter, it can be helping in finding data with comparable attributes to the site being developed and planning to support the desired travel outcomes.

The motorized vehicles had the largest mode share overall for residents of affordable housing; yet, there was a large and significant proportion of non-motorized mode use reported and accounted for nearly half of all trips. These high rates of active transportation use provide strong evidence that multimodal planning is needed for these developments and that mitigations for transportation impacts need to include pedestrian infrastructure with connections to transit. These findings also affirm the critical need to shift to a person-trip framework that includes data collection of all modes of travel. In the past, these non-automobile trips would not have been accounted for in trip generation studies and here would be more circumscribed characterization of transportation activity at a site. The ability to appropriately plan for multiple modes is hampered by the lack of information and the needs of these residents traveling on foot or by transit would be ignored in the land development process.

7.0 Conclusions

Demand for affordable housing is rapidly increasing in California, as in other states in the nation. This demand is exacerbated by increased housing shortages and costs, and priority populations, such as low-income households, bear much of this burden. Development of affordable housing can be hindered by increased costs associated with fees and mitigations that arise in TIAs. Trip rate estimates produced by the ITE are the industry standard for use in these studies of transportation impacts, despite their lack of sensitivity to urban context and socioeconomic factors. As a result, motorized vehicle trips are often overestimated, while the full scope of non-motorized vehicle trips is not captured. The results of this study build on those found in previous Caltrans studies (Handy, Shafizadeh, & Schneider, 2013; Texas A&M Transportation Institute, 2017) and point to a need to adapt trip generation methodology to account for this gap in current practice. The findings here emphasize that it is the characteristics of the site (parking supply and average number of bedrooms), its location (the built environment), and the people living there (socio-economics) that are the most important to consider. Future research that continues to shift existing methods toward those that more accurately predict multimodal travel patterns will help to better inform developers, policymakers, and other stakeholders such that the needs of their communities can be met.

This triangulated research has made significant contributions to our understanding of trip generation, automobile ownership, and use of multiple modes. However, it is not without limitations and the study helped to identify additional areas of research needed for this topic. The following sections discuss these limitations and future opportunities.

[redacted] Limitations

Affordable Housing vs. Housing Affordability

Because the state income limits are calculated based on county AMI, some of the differences in affordability between regions is accounted for. However, one of the critiques of HUD's 30% rule, known as the shelter poverty critique, is that lower income households may not be able to afford other basic needs after paying 30% of their income towards housing costs (Pivo, 2013). This points to the important distinction between *affordable housing* and *housing affordability*. The definition of affordable housing as it is applied at both the national and state level is limiting since subsidized units are not necessarily affordable in the broader sense. Behavior observed at study sites is tied to resident characteristics, transportation option availability, and environmental variables (e.g. built environment, transit accessibility) but not necessarily affordable housing program-participation. Because of this, the rates derived from a study of affordable housing residents may be transferable to housing that serves lower-income neighborhoods, regardless of whether or not the development subsidizes units. However, by constraining the study sample to 100% subsidized affordable housing, observations are restricted to households with specific income thresholds relative to the region of observation and the corresponding purchasing power.

Place Types

In some cases, place types previously assigned by census block groups were changed after on-site visits. Some unique built environment features in the areas surrounding each site were not captured by assessment on the block level, and so some place type labels seemed inaccurate or misleading given the real special context of the development. For example, some sites may have been labeled “Urban core” or “Urban district,” but a site visit revealed that a major arterial, highway, or other infrastructure spatially separated the site from a more urban context. While these place types offer insight into the variety of urban contexts based on a number of built environment variables, it should be noted that some of these more nuanced elements may not be captured when assigning place types to define urban context in place of on-site visits.

Mail-out Household Transportation Survey

The intention of the mail-out household transportation survey was to act as a complement to on-site data collection efforts. Additionally, the research design aimed to determine if the mail-out household transportation survey could potentially serve as a substitute for on-site data collection, which is more expensive to collect. Best practices in survey methodologies (Salant & Dillman, 1994) were utilized to return reliable and sufficient responses including: providing reminders to residents, building relationships with property managers, who could better promote the survey to their residents, translating the survey to multiple languages based upon ethnic composition of residents, and piloting and testing instruments. Entrance into a raffle for a number of $25 Visa gift cards was added as an incentive to boost survey response rates.

Despite these efforts, the response rate and data quality were disappointing. The very low response rate meant that the samples sizes from any one location were not sufficient to characterize the travel patterns of a site and thus, the survey could not be used as a substitute for on-site trip generation data collection efforts. Further, the sample sizes limited the ability to do a robust multivariate analysis. Inconsistencies in some of the responses, particularly estimates of vehicle miles traveled, also limited the ability for this survey to inform this study. However, the information that was collected had value.
Future efforts may consider using passive technology to collect data on vehicle and person miles traveled; however, this approach has its own challenges. One possibility is to work closely with a few sites in-person, building relationships with residents and managers, explaining what information is needed and why it is important.

Transportation demand management (TDM)

An in-depth evaluation of the effects of TDM strategies on trip rates was not fully captured in this study. Low response rates for the mail-out household transportation survey also made capturing information about TDM for the larger sample of sites reached difficult. Of the on-site data collection locations, only four (see Table 25) had TDM policies in the form of free transit passes. The transit-mode share of these sites was not found to be significantly different from those sites without TDM strategies. Only one was located in an urban core place type, which would have the highest transit accessibility. The remaining three were located in urban neighborhoods. The availability of free parking on sites may influence personal vehicle use over public transportation, even if TDM strategies are in place.

Motorized vehicle counts and transportation network companies (TNCs)

Survey methodologies for collecting count data, including those employed in this study, were ill equipped to capture the use of ride-hailing services or TNCs. Motorized vehicle counts captured vehicles that drove and/or parked on-site. If vehicles were parked on an adjacent site, picking up/dropping off individuals, or if a TNC service was used, this was not reflected in the count data (unless the cordon line was crossed and the drop-off point was on-site).

Some of this activity is captured by the intercept survey in the questions about mode but it would not be counted in the motorized vehicle mode share or trip rates calculated from the cordon count data. Data collection protocols need to be developed to capture and analyze this mode in trip generation studies. Use of ride-hailing services is growing nationwide and there are increasing interest in their mobility benefits, the transportation impacts generated by them, and the potential for them to support low vehicle ownership.

[redacted] Future work

The study identified several issues that would benefit from future research, including:

- Trip generation of housing targeting special needs populations, including the elderly, those with physical and mental impairments, single mothers, and recovering addicts.
- The interaction between housing affordability (not specifically affordable housing) and transportation choices.
- The effectiveness of travel demand management strategies (travel education versus new infrastructure) in curbing automobile use.
- An examination of different ways of calculating trip rates for the peak hour impact results, specifically ITE's definition that emphasizes using the "peak of the peak".
- The expanding role of mobility sharing options for low-income households and their relationship with car ownership.
- The relationship between parking supply and utilization and vehicle ownership and use.
- Determining the minimum level of participant incentive needed to get valid and credible travel behavior data in various contexts.
- Determining the minimum cost method to get valid and credible travel behavior results to guide a revision of methods that are currently high cost and high effort.
- Linking observed travel patterns to satisfaction and well-being to understand to what degree there are suppressed trips and thus unmet needs.

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[redacted] Development of Place Types

In order to capture sensitivity to urban context, place typologies were developed and assigned to sites in the site selection process. These place typologies were assigned at the Census Block Group level. The development of place types across urban and suburban contexts allowed the study to capture variation in travel behavior and outcome patterns based on certain influential features of the built environment. For this study, places deemed to be non-urban were excluded from site analysis. Then, based on six built environment features known to influence travel patterns and behavior, four place type categories were defined: suburban neighborhood, urban neighborhood, urban district, and urban core. The development of these place types, namely the data sources and classification scheme used to indicate contextual variation in the built environment, is briefly outlined in the following subsections.

Data Sources

Both community design and regional accessibility measures were selected to reflect the built environment of all 23,190 US Census blocks groups in California. The choice of built environment measures with these two themes ensured the concept of location efficiency, or the fit between the physical environment and transportation system, was adequately represented in any place typology. In *Smart Mobility 2010: A Call to Action for the New Decade* (Caltrans, 2010), the many mobility benefits of this potential harmony between complete community design and strong regional accessibility are illustrated by using Figure 13.

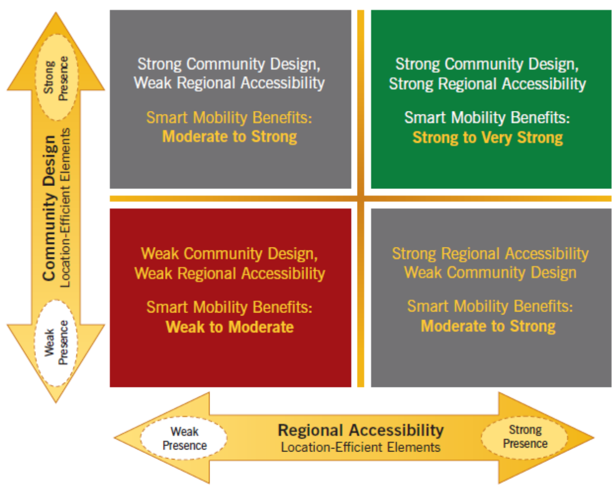


Figure 13 Location Efficiency Factors and Smart Mobility Benefits (Source: Smart Mobility 2010)

Accordingly, a parsimonious set of four community design and two regional accessibility measures were collected in order to produce an array of place types across this spectrum of location efficiency potential. Four chosen community design measures encompassed the oft-studied elements of density, diversity, and design, while the measures calculating job accessibility via automotive and fixed rail transit were chosen to describe a neighborhood's regional accessibility (See

Table 21).

Table 21 Description of Built Environment Indicators and Data Sources used to Develop Place Typology

Built Environment Indicator	Data Source
Community Design Measures	
1: Number of persons per acre	Census 2010 (U.S. Census Bureau, 2010)
2: Number of jobs per acre	LEHD 2014 LODES v7.0 (U.S. Census Bureau, 2014)
3: Percent of single-family housing units	ACS 2014 (5-year Estimates) (U.S. Census Bureau, 2014)
4: Street intersections per square mile	EPA Smart Location Database v2.0 (U.S. Environmental Protection Agency, 2014)
Regional Accessibility Measures	
5: Proportion of jobs within 0.5-mile of fixed transit service	EPA Smart Location Database v2.0 (U.S. Environmental Protection Agency, 2014)
6: Number of jobs within 45 minutes via motorized vehicle travel time	EPA Smart Location Database v2.0 (U.S. Environmental Protection Agency, 2014)

Comparison to Smart Mobility Place Types

The proposed place typology consists of four exclusive place types: suburban neighborhood, urban neighborhood, urban district, and urban core. A non-urban place type was assigned to those block groups that fell out of the designated urban setting. These empirically developed place types symbolize the collective performance of six built environment factors describing the activity intensity, housing stock, street network design, and access to employment via transit and private vehicle. Results of the introduced interval classification strategy enable these place types to be situated along a continuum describing the location-efficiency of a block group. Figure 14 displays the performance of these five place types along a unidimensional spectrum of location-efficiency; adopted from the smart mobility framework.

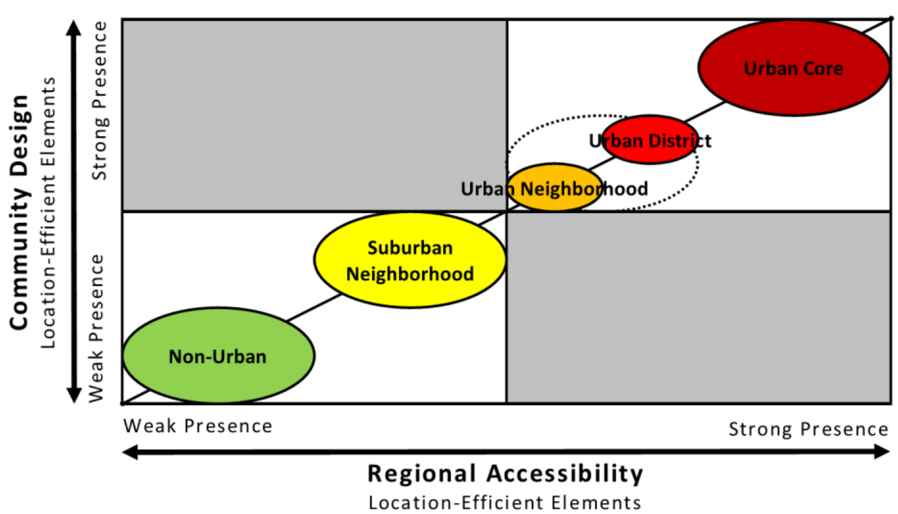


Figure 14 Proposed Place Typology and Location Efficiency Potential

Along this spectrum, the urban core describes an area with a dense population residing in predominately multifamily housing stock situated in a traditional street network design with strong local and regional multimodal access to employment. Block groups classified as urban district and urban neighborhood are placed lower on the location-efficiency spectrum but exhibit an above-average combined performance for the four community-design and two regional accessibility indicators. In terms of location-efficiency, a suburban neighborhood is the lowest-performing place type found in a census-defined urban area. Those block groups located outside a census-defined urban area generally have the lowest levels across the six built environment indicators. Table 22 provides a comparison of this empirically-determined place typology to the conceptual smart mobility typology, while Figure 15

Figure 15 Map of the proposed place typology for California

offers a visualization of the five place types across California with insets for the Los Angeles and Bay Area metropolitan regions.

Table 22 Association between Smart Mobility Place Types and Proposed Place Typology

Smart Mobility Place Type		Proposed Place Type
Urban Centers	~	Urban Core
Close-in Compact Communities	~	Urban District
Compact Communities	~	Urban Neighborhood
Suburban Communities	~	Suburban Neighborhood
Rural Towns	~	Non-Urban
Rural and Agricultural Lands	~	Non-Urban
Protected Lands and Special Use Areas	~	(not identified)

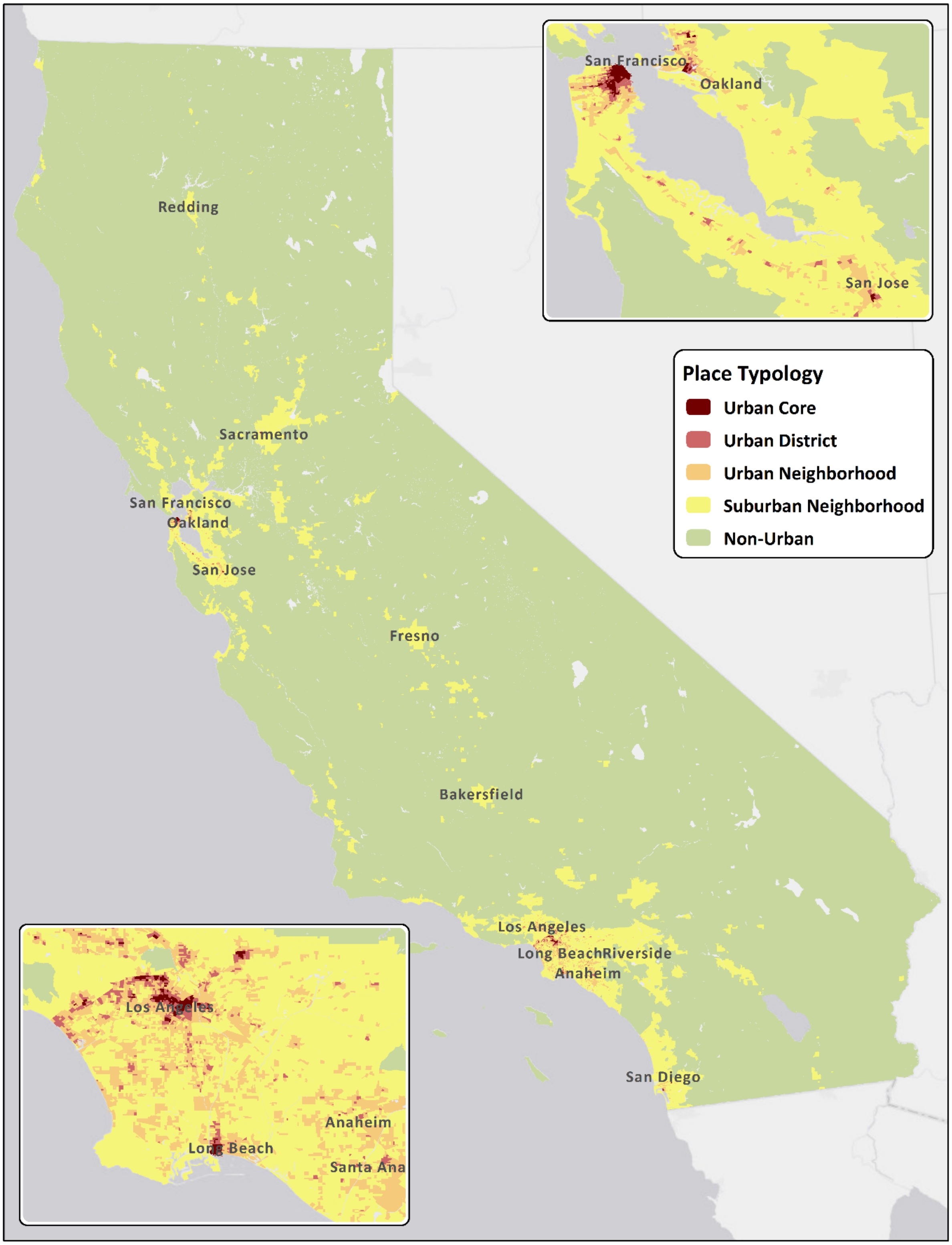


Figure 15 Map of the proposed place typology for California

Place Typology Development Procedure

After selecting a suite of measures to reflect location efficiency, a process was undertaken to understand the spatial variation of these six attributes across all block groups in the study area. The procedure began by differentiating urban areas from non-urban areas, where landscapes in the former context are thought to portray greater built environment variation. Provided that block group geographies do not necessarily coincide with metropolitan regional boundaries, a heuristic was adopted to determine block groups within a US Census urban area. For a block group to be considered urban, at least 20% of the block group must be located inside a census-defined urban area. Those block groups which did not meet this criterion were deemed non-urban. Additionally, all block groups in which less than 80% of the block group's area was designated as land were excluded to filter out floodplain and offshore geographies that may bias results.

Using all blocks groups defined as urban, a top-bottom approach was next adopted to manually classify the block groups as exemplifying one of four unique place types. The first step of the interval classification strategy was to measure the community design and regional accessibility of these block groups based on the aforementioned indicators. For each of the six selected indicators, all block groups were divided into four categories based on its measurement of the built environment. Each block group was then assigned a value between one and four depending on the category in which the calculated value of the measure was situated. For instance, a block group with no jobs would be given a value of one because it is situated in the category representing the lowest level of employment density. Table 23 provides a summary of the breakpoints used in this assignment of interval values.

Table 23 Built Environment Measurement Breakpoints and Associated Interval Value

	Interval Value			
Built Environment Indicator	**4**	**3**	**2**	**1**
Community Design Measures				
1: Number of persons per acre	80	40	20	< 20
2: Number of jobs per acre	100	25	10	< 10
3: Percent of single-family housing units	0.15	0.50	0.75	> 0.75
4: Street intersections per square mile	250	175	100	< 100
Regional Accessibility Measures				
5: Proportion of jobs within 0.5-mile of fixed transit service	0.95	0.50	0.10	< 0.10
6: Number of jobs within 45 minutes via motorized vehicle travel time	400,000	300,000	200,000	< 200,000

Once all block groups were assigned an interval value for each indicator, these values were then summed and divided by the number of indicators (six). The resulting mean interval scores were used to determine the place type that each block group exemplified.

Table 24 provides an overview of the breakpoints used to determine the place typology and description of the built environment for each of the four place types.

Table 24 Mean Interval Score Breakpoints and Built Environment Indicators

Place Type:	Urban Core	Urban District	Urban Neighborhood	Suburban Neighborhood	Non-Urban
Mean Interval Score	3.0	2.5	2.0	1.0	---
Number of Block Groups	317	714	3,074	17,151	1,934
Built Environment Indicator (mean)					
Community Design Measures					
1: Population density	67.09	41.71	27.35	11.22	0.28
2: Employment density	58.12	17.29	7.07	2.28	0.07
3: Single-family housing	0.06	0.19	0.39	0.76	0.81
4: Intersection density	212.49	165.10	126.35	84.89	4.80
Regional Accessibility Measures					
5: Transit access to jobs	0.93	0.45	0.19	0.03	0.00
6: Motorized vehicle access to jobs	509,569	513,498	466,294	211,857	26,942

[redacted] Site Selection for On-Site Trip Generation Study

To ensure parity with previous Caltrans trip generation studies (e.g., Smart Growth Trip Generation (SGTG), Handy, Shafizadeh and Schneider 2013, Texas A&M Transportation Institute 2017), the protocols for site selection (on-site and mail-out site) were largely adopted from these studies. In some cases, word-for-word translations of the procedures have been included for consistency. The SGTG protocols were built upon the national standards for trip generation data collection, developed within the 3rd Edition of the *Institute of Transportation Engineers (ITE) Trip Generation Handbook,* to make the resulting analysis compatible with national rates and ensure the data may be provided for inclusion in these national standards. The same standard for data collection protocol holds for the Caltrans Affordable Housing Trip Generation study. Protocols were then compared to external methods developed by Washington, D.C. Department of Transportation (DDOT), who completed several rounds of data collection at housing and lodging developments.

Candidate sites were identified in regions of interest (i.e., Los Angeles, Bay Area) by first referencing a list of California Tax Credit Allocation Committee (TCAC) program sites provided by Linda Wheaton from the California Department of Housing and Community Development. All TCAC site locations were geocoded using ArcGIS and then overlaid with place types developed during the initial phase of this project (See Appendix AFrom there we identified sites that matched our sampling criteria: "open to all" (e.g., units not reserved for specific populations) and 100% affordable (e.g., no mixed-income developments). We also prioritized larger developments over smaller ones wherever possible. In addition, we were looking for sites with varying depths of affordability, as determined by the California income qualifying limits for affordable housing programs. Most of the properties on the TCAC list include a mix of units at varying depths of affordability; for instance, 20 units might be available to those making up to 40% of the area median income (AMI) while an additional 20 units in the same development are available to those making up to 60% AMI.

Once we narrowed the list down to sites that matched our sampling criteria we identified the developers whose names appeared most frequently on the list as many affordable housing developers own and/or operate multiple sites. The developers of interest were identified, and introductions were facilitated by Jennifer West of TransForm. Capitalizing on the relationships TransForm had already established with local developers in the San Francisco Area yielded much more positive results than cold call or emails. Additionally, Jennifer West connected the project team with Alan Greenlee of the Los Angeles Housing Partnership to help make further connections with developers in Southern California. These introductions to developers enabled the project team to expand the sampling frame in the Los Angeles area after a series of outreach attempts without introductions proved unsuccessful. Additionally, the project team leveraged data and relationships from previous work (e.g., 54 sites from the TransForm parking study), as well as local affordable housing databases including one provided by the Los Angeles Housing and Community Investment Department. Market rate developments were compiled to act as control cases.

Initial discussions with developers allowed us to confirm whether sites fell into the selection criteria outlined above (e.g., 100% affordable, "open to all," and with varying depths of affordability). Developers, if willing to do so, identified other sites within their portfolios that matched selection criteria that were not on the original TCAC list, resulting in an iterative site selection process. Suitable sites were narrowed down from the original search to ensure each of the developed urban place types in both regions were represented.

From there, a short list of potential sites for the Bay Area and Los Angeles was compiled, and the team scheduled in-person visits with property staff in June 2017. The team spent two days in the Bay Area touring sites and three days in Los Angeles. At the majority of sites, the visits included a discussion with the property manager as well as a short tour of the property to catalog all access and egress points and understand the flow of building traffic, which helped determine feasibility for on-site data collection. The visits also enabled us to determine how many staff members we would need per site in order to accurately count all person and vehicle trips, as well as conduct intercept surveys at key building locations.

After the site visits, twenty-two sites were selected for the first phase of on-site data collection. An additional four sites were added after it was determined that there was enough room in the budget to expand the sampling frame, so twenty-six sites were surveyed in total. Collection dates were confirmed with on-site property management as well as developers to ensure that we would be granted access to the property. The site locations by place type are mapped for the Los Angeles and Bay Area regions in Figure 16 and Figure 17, respectively. Final sites for on-site collection and some built environment characteristics are listed in Table 25 and Table 26. It should be noted that all developments included parking for residents, and all sites were categorized as 223 (mid-rise apartments) by the ITE Land Use Code, except for sites 10 and 25, which were low-rise apartments (221).

Figure 16 Los Angeles Region Sites

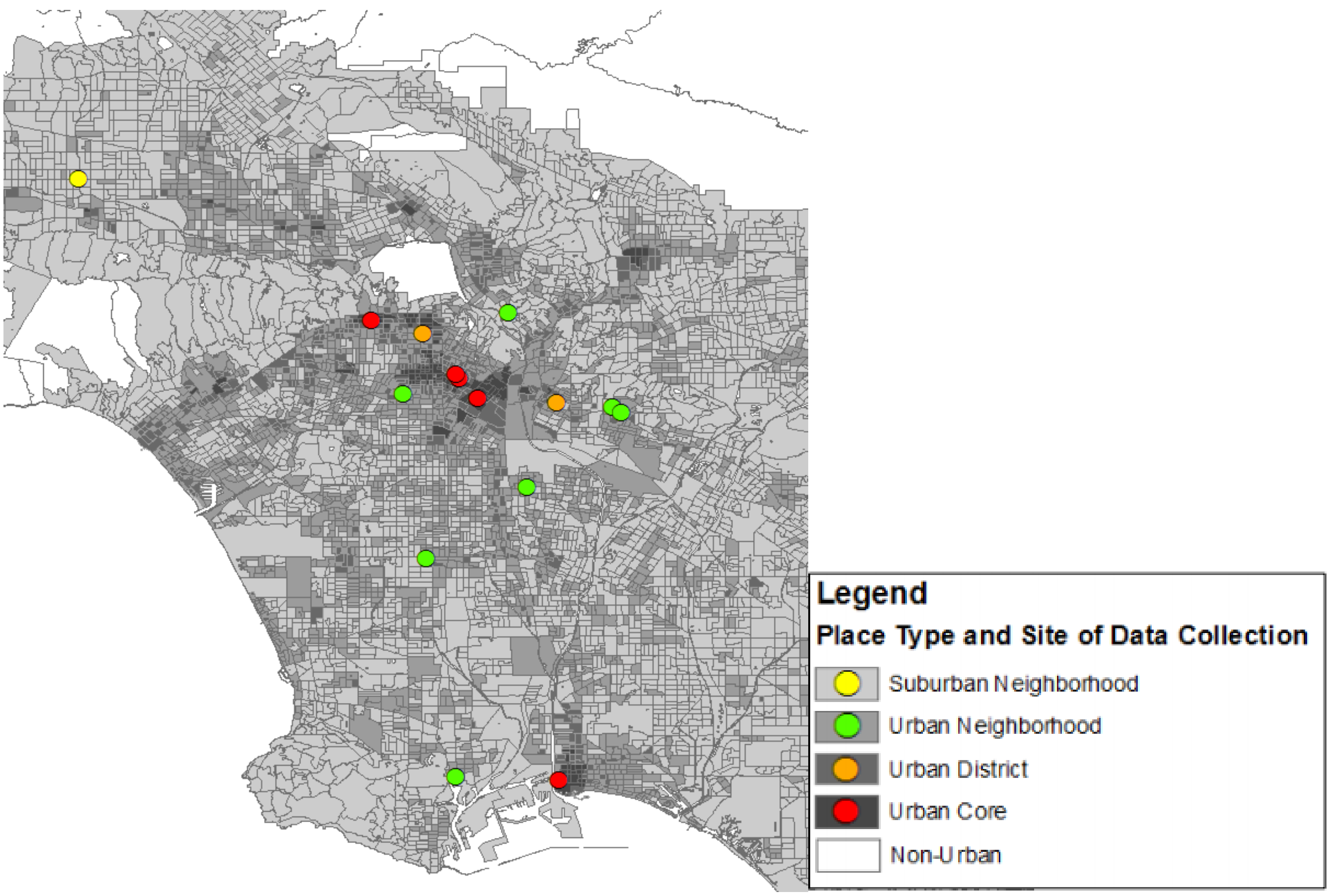


Figure 17 Bay Area Region Sites

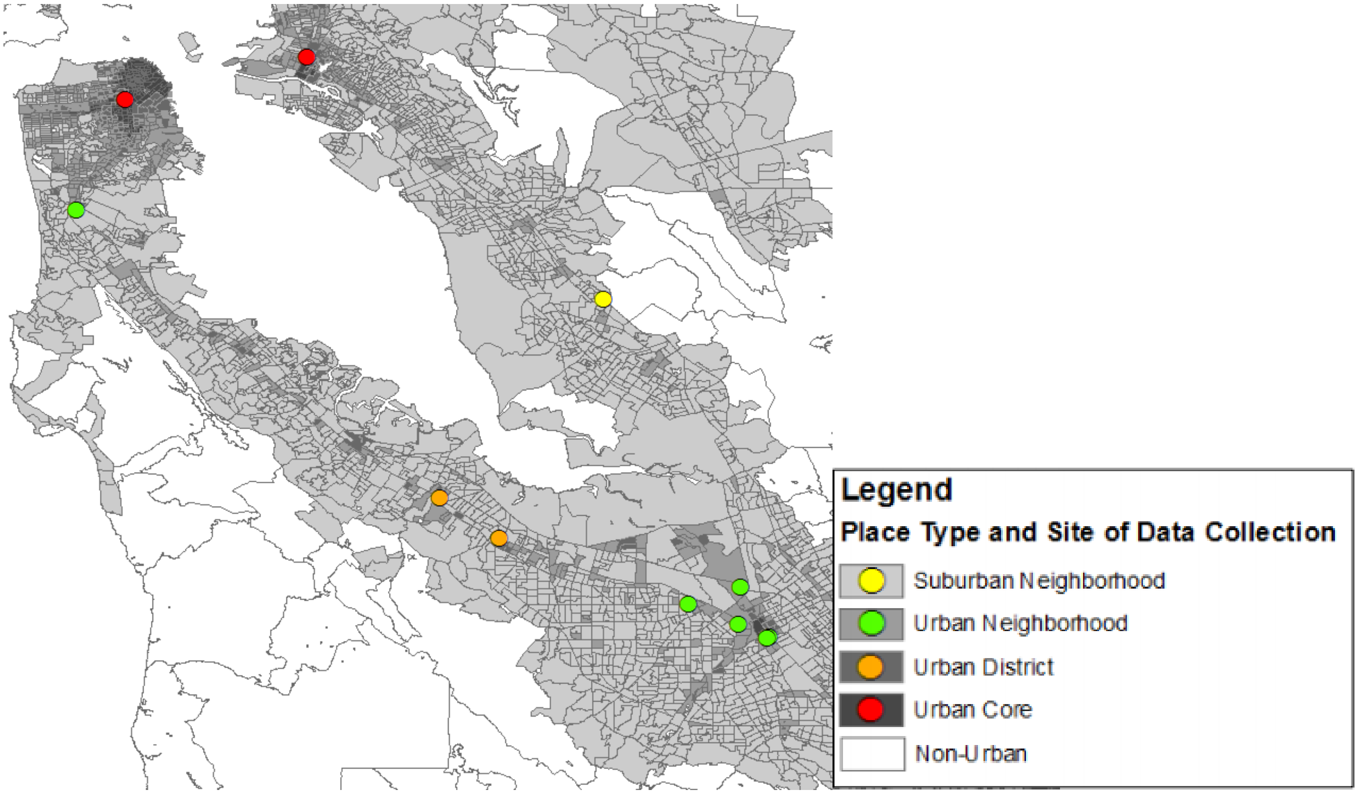


Table 25 On-site Data Collection Locations and Built Environment Information

ID	Site Name	Primary Address	Los Angeles (LA) or Bay Area (BA)	City	Place Type	Building size (DUs)	Occupancy	On-site parking
1	801 Alma	801 Alma Street	BA	Palo Alto	Urban District	50	1.00	66
2	Alta Vista Apartments	5051 East 3rd Street	LA	East Los Angeles	Urban Neighborhood	60	1.00	135
3	Athens Glen	11515 S. Budlong Ave.	LA	Los Angeles	Urban Neighborhood	51	0.90	110
4	Casa Rita Apartments	6508 Rita Avenue	LA	Huntington Park	Urban Neighborhood	103	1.00	240
5	Cathedral Gardens*	618 21st Street	BA	Oakland	Urban Core	98	1.00	100
6	Confidential Site 1	-	BA	San Francisco	Urban Core	82	1.00	83
7	Fourth Street Apartments*	1460 N 4th Street	BA	San Jose	Urban Neighborhood	100	0.98	79
8	Guadalupe*	76 Duane Street	BA	San Jose	Urban Neighborhood	23	1.00	40
9	Harbor View	326 N. King Avenue	LA	Wilmington	Urban Neighborhood	120	0.98	172
10	Kern Villa Apartments	202 North Kern Avenue	LA	Los Angeles	Urban Neighborhood	49	0.98	91
11	Lenzen Park	790 Lenzen Avenue	BA	San Jose	Urban Neighborhood	88	0.98	129
12	Mariposa Place Apartments	1050 N. Mariposa Avenue	LA	Los Angeles	Urban District	58	1.00	76
13	Mission Gateway	33155 Mission Blvd.	BA	Union City	Suburban Neighborhood	121	0.98	350
14	Parkside Apartments	400 W. 9th St.	LA	Los Angeles	Urban Core	79	0.99	73
15	Pico/Gramercy	3215 W. Pico Blvd.	LA	Los Angeles	Urban Neighborhood	71	1.00	80
16	Presidio	1450 El Camino Real	BA	Santa Clara	Urban Neighborhood	40	1.00	40
17	Puerto Del Sol	745 W. 3rd Street	LA	Long Beach	Urban Core	64	1.00	145
18	Rio Vista (Glassell Park)	3000 Verdugo Road	LA	Los Angeles	Urban Neighborhood	50	1.00	56
19	San Antonio Place	210 San Antonio Circle	BA	Mountain View	Urban Neighborhood	120	0.98	75
20	Selma Community Housing	1605 N. Cherokee Avenue	LA	Los Angeles	Urban Core	66	1.00	67
21	Sherman Village	7135 Wilbur Avenue	LA	Reseda	Suburban Neighborhood	73	1.00	114
22	Sol y Luna	2915 East First Street	LA	Los Angeles	Urban District	53	1.00	68
23	The Paseo at Californian	1901 W. 6th Street	LA	Los Angeles	Urban Core	53	1.00	55
24	Confidential Site 2	-	BA	Colma	Urban Neighborhood	119	1.00	131
25	Troy*	714 S. Almaden Ave	BA	San Jose	Urban Neighborhood	30	1.00	39
26	Villa del Lago	456 S. Lake St.	LA	Los Angeles	Urban Core	74	1.00	72

*Indicates residents received free transit pass

Table 26 On-site Data Collection Locations and Built Environment Information

ID	Site Name	Population Density (per acre)	Employment Density (per acre)	Retail Density (per acre)	Intersection Density (per mi^2)	Distance to transit (miles)
1	801 Alma	24	24	5	114	0.23
2	Alta Vista Apartments	8	26	0	73	0.22
3	Athens Glen	3	4	0	16	0.12
4	Casa Rita Apartments	42	22	9	58	0.15
5	Cathedral Gardens	31	65	1	163	0.11
6	Confidential Site 1	43	273	6	143	0.08
7	Fourth Street Apartments	7	37	1	46	0.38
8	Guadalupe	38	3	1	147	0.28
9	Harbor View	18	2	0	102	0.06
10	Kern Villa Apartments	22	3	0	91	0.14
11	Lenzen Park	19	19	1	107	0.31
12	Mariposa Place Apartments	52	3	0	119	0.06
13	Mission Gateway	4	22	0	43	0.09
14	Parkside Apartments	8	67	7	199	0.03
15	Pico/Gramercy	27	7	0	198	0.11
16	Presidio	13	6	0	218	0.06
17	Puerto Del Sol	40	16	0	233	0.11
18	Rio Vista (Glassell Park)	32	5	2	151	0.06
19	San Antonio Place	26	6	1	51	0.05
2	Selma Community Housing	13	49	4	149	0.16
21	Sherman Village	27	1	0	123	0.06
22	Sol y Luna	15	12	5	246	0.04
23	The Paseo at Californian	177	15	0	202	0.04
24	Confidential Site 2	24	3	2	113	0.09
25	Troy	38	3	1	147	0.31
26	Villa del Lago	37	8	0	505	0.15

*Indicates residents received free transit pass

Built Environment Measures

Urban context refers to the collective set of measures of the built environment, or the human-made or manipulated spaces in which people live, work, recreate, and perform other activities. As mentioned previously, mode choices, travel distances, and trip frequency are influenced by the characteristics of the urban context in which travel takes place. For this reason, we would like to test the influence of various built environment characteristics of affordable housing locations on trip generation rates. The set of built environment measures tested are shown in Table 27 below. These were identified for inclusion in our analysis because of their relationships to travel outcomes, as per the scholarly literature.

Table 27 Description of Built Environment Data

Variable Description	Units	Data Source
Population Density	Residents per acre by Census Block Group	2016 ACS (5-year) B01003 Total Population (block group); Divided by Census Block Group area (acres)
Employment Density	Jobs per acre by Census Block Group	2015 LEHD Workplace Area Characteristics (WAC) All Jobs (JT00), Total Jobs (S000), Total Number of Jobs (C000); Divided by Census Block Group area (acres)
Retail Density*	Retail jobs per acre by Census Block Group	2015 LEHD Workplace Area Characteristics (WAC) All Jobs (JT00), Total Jobs (S000), Total Number of Jobs by NAICS 44-45 “Retail” (CNS07); Divided by Census Block Group area (acres)
Intersection Density*	Intersections (three-way or more) per square mile	Smart Location Database (2014); Variable D3b: Street intersection density (weighted, auto-oriented intersections eliminated) using NAVSTREETS
Distance to transit	Miles	Google General Transit Feed Specification (GTFS) (TransitFeeds) including stops that run routes with modes denoted as bus, light-rail, streetcar, subway or metro (See **Error! Reference source not found.**; Walking distance calculated by the Google Distance Matrix API where the mode was “walking” and the departure time and date were Wednesday March 21, 2018 at 5PM.
Building size	Number of dwelling units (DUs)	Site developers
Occupancy	Occupied DUs divided by total DUs	Site developers
On-site Parking	Number of on-site parking spaces	Site developers/on-site staff

*These variables were tested in our analysis but did not make a significant contribution to explaining trip generation.

The following table describes the General Transit Feed Specification (GTFS) static transit feed specification for the study areas that were used in computing the distance to transit measure. The on-site and mail out data collection began during the end of August, 2017. To the extent possible, the feeds that were updated prior to August 25th, 2017 were collected from GTFS and used in this analysis.

Table 28 GTFS Data Available

Location	Study Area (Los Angeles - LA or San Francisco Bay area - BA)	Name	Date of GTFS
Los Angeles	LA	Los Angeles Department of Transportation (LADOT)	12/7/2015
Simi Valley	LA	Simi Valley Transit	1/29/2018
Monterey	BA	Monterey-Salinas Transit	8/3/2017
Stanford	BA	Stanford Marguerite Shuttle	8/22/2017
Ventura County	LA	Ventura County Transportation Commission	8/25/2017
Pinole	BA	WestCAT	7/29/2017
Rio Vista	BA	Rio Vista Delta Breeze	5/18/2017
Concord	BA	County Connection (CCCTA)	8/17/2017
Stockton	BA	Altamont Corridor Express (ACE)	8/24/2017
Livermore	BA	Livermore Amador Valley Transit Authority	09/16/2016
Monterey Park	LA	Spirit Bus	8/3/2017
Los Angeles	LA	Spirit	12/13/2016
Glendale	LA	City of Glendale	7/25/2017
Santa Monica	LA	City of Santa Monica	8/10/2017
El Monte	LA	El Monte Transit	1/29/2018
San Gabriel Valley	LA	San Gabriel Valley, Foothill transit	7/7/2017
Palos Verdes Valley	LA	Palos Verdes Valley Transit Authority	12/19/2016
Long Beach	LA	Long Beach Transit	8/5/2017
Palos Verdes Peninsula	LA	Palos Verdes Peninsula Transit Authority	7/1/2017
Torrance	LA	City of Torrance	8/8/2017
Los Angeles	LA	LA Metro Bus	7/19/2017
Los Angeles	LA	LA Metro Rail	8/25/2017
Los Angeles	LA	Metrolink	7/3/2017
Marin County	BA	Marin Transit	8/11/2017
Mountain View	BA	MTgo	7/21/2017
Oakland	BA	ACTransit	8/4/2017
Oakland	BA	Capitol Corridor	3/5/2018
San Francisco	BA	BART	6/15/2017
San Francisco	BA	Caltrain	7/24/2017
San Francisco	BA	Golden Gate Bridge Highway & Transportation District	6/2/2017
San Francisco	BA	Muni	8/21/2017
San Jose	BA	Victor Valley Transit Authority	8/25/2017
San Francisco	BA	SamTrans	7/27/2017

Affordable Housing Definitions

In order to better characterize expected differences in behavior that inform the defined sampling frame (or, to define the categories of affordable housing on which this study is focused), standard definitions of affordable housing in practice were identified and re-framed to develop a working definition for transportation impact analyses.

The US Department of Housing and Community Development (HUD) defines affordable housing as income-restricted housing to support low-income households, as determined by median family income for a geographic area, to prevent households from paying more than 30% of their income for gross housing costs, including utilities (US Department of Housing and Urban Development). This is also known as the 30% rule; qualifying low-income households paying above this percentage of their income towards housing are considered to be cost-burdened. Additionally, affordable housing, which is separate from government-owned public housing, usually requires some of form of public subsidy in order to be classified as such (San Francisco Planning Department, 2015). Subsidized units are below market rate (BMR) and HUD determines applicant eligibility for its assisted-housing programs by establishing annual qualifying income limits, which fall into the following three categories:

- <u>Low-Income (LI)</u>: Households whose incomes do not exceed 80% of the median family income for the area.
- <u>Very-Low Income (VLI)</u>: Households whose incomes do not exceed 50% of the median family income for the area with adjustments for smaller and larger families and for areas with unusually high or low incomes or where needed because of facility, college, or other training facility; prevailing levels of construction costs; or fair market rents.
- <u>Extremely Low-Income (ELI)</u>: Households whose incomes do not exceed 30% of median family income for the area. Extremely low-income limits are calculated based on very-low income limits and reflect 60% of very-low income limits. HUD programs use “area median incomes” calculated on the basis of local family incomes, with adjustments for household size.

In California, state income limits for affordable housing are calculated by the Department of Housing and Community Development based on HUD’s specifications for below market rates. California updates its limits annually, which are then used to 1) determine applicant eligibility and 2) calculate affordable housing costs for applicable housing assistance programs of which there are many within the state. However, applicability of the limits is subject to a particular program’s definition of income, family, family size, effective dates and other factors (California Department of Housing and Community Develpment, 2015). Because there are fifty-eight counties in California, the median income by county varies widely and income limits vary accordingly. In Los Angeles County, for instance, the 2015 area median income (AMI) for a family of four was $64,800 whereas it was $103,300 in San Francisco County. See the limits for our study areas in Table 29.

Table 29 2015 California State Income Limits and Area Median Incomes (AMI)*

Study Area	Income Category	Number of Persons in Household 1	2	3	4	5	6	7	8
Los Angeles County	Extreme	17,950	20,500	23,050	25,600	28,410	32,570	36,730	40,890
	Very Low	29,900	34,200	38,450	42,700	46,150	49,550	52,950	56,400
	Low	47,850	54,650	61,500	68,300	73,800	79,250	84,700	90,200
	AMI	45,350	51,850	58,300	**64,800**	70,000	75,150	80,350	85,550
	Moderate	54,450	62,200	70,000	77,750	83,950	90,200	96,400	102,650
San Francisco County (Bay Area)	Extreme	24,650	28,150	31,650	35,150	38,000	40,800	43,600	46,400
	Very Low	41,050	46,900	52,750	58,600	63,300	68,000	72,700	77,400
	Low	65,700	75,100	84,500	93,850	101,400	108,900	116,400	123,900
	AMI	72,100	82,400	92,700	**103,300**	111,250	119,500	127,700	135,950
	Moderate	86,500	98,900	111,250	123,600	133,500	143,400	153,250	163,150
Income Adjustments		70%	80%	90%	**BASE****	108%	116%	124%	132%

* California uses the term area median income (AMI) to refer to median family income (MFI).
** Adjustments are relative to the "base case" of a four-person household with AMI
Source: *California Department of Housing and Community Development* (California Department of Housing and Community Develpment, 2015)

In California, there are a number of subsidized housing programs in place, some of which are supply-side subsidies for developers such as low-income housing tax credits (LIHTC), while others are demand-side such as housing choice vouchers. Programs are administered at the state, county and municipal level and the affiliated housing agencies oversee their own directory of affordable housing, which means that no comprehensive affordable housing directory is available. The organization Affordable Housing Online works to maintain as complete a database as possible, though it is likely still not entirely comprehensive (See Table 30).

Some housing programs are designated for particular groups in addition to being income-restricted, such as supportive housing for the elderly (Section 202) and supportive housing for persons with disabilities (Section 811). Because there is no comprehensive statewide directory of affordable units, it is difficult to determine what percentage of housing is thus sub-categorized and how many affordable housing units are considered open to all who are eligible. Housing that caters toward specific populations—seniors, families (e.g., larger household sizes and presence of children), and diverse abilities—will likely have substantially different trip rates, vehicle miles traveled, and vehicle ownership rates due to variation of housing characteristics in addition to income.

Table 30 California Affordable Housing by Program Type

Program	Projects	Units
Project Based Section 8	1,339	98,295
Section 202 (Supportive Housing for the Elderly)	490	29,531
Section 811 (Supportive Housing for Persons with Disabilities)	190	2,756
Section 515 (USDA Rural Development)	480	24,998
RDRA	418	16,466
LIHTC (Low Income Housing Tax Credit)	2,891	227,159
Senior	1,162	87,167
Public Housing	214	10,066
Section 8 Voucher*	113	320,548
Total	4,754	372,136

Note: The total does not necessarily equal the sum of each program as some properties may participate in multiple funding programs.

* This program is not project based; instead Housing Authorities provide vouchers to individual renters. In the state of California there are 113 independent Housing Authorities that may issue these vouchers.
Source: (Affordable Housing Online, 2016)

For the purpose of this study, we define affordable housing using the categories of income thresholds as defined by HUD. Although we identified a number of housing types (e.g. family, senior, diverse abilities) with likely influence on trip rates, we limited our study to focus on income-restricted housing listed as "open to all." This may include a wide variety of household types but does not restrict the dwellings to households of a specific sub-population beyond low-income. Additionally, we limited our study to developments where all of the dwelling units are dedicated to income-restricted housing.

Additional Site Selection Criteria

The following additional criteria have been adapted or replicated from the Caltrans SGTG project Phases I and II (Handy, Shafizadeh, & Schneider, 2013; Texas A&M Transportation Institute, 2017) as characteristics to determine feasibility of survey and count data collection at various sites.

Transferrable Data

Both trip data and development characteristics should be representative of the typical types of land uses expected to be developed in the future in California. This should include development size, mix of development components, geographic location with respect to the transportation system, and area development patterns.

Site Size and Activity

Only sites large enough to generate at least 100 peak period trips should be selected. This is so that we will be able to obtain a sufficient number of interviews to provide a breakdown of mode splits for the site person trips. Apartment sites having 100 or more dwelling units (DU) should be sought. Some smaller buildings may be considered acceptable if they are adequately represented based on their urban context. In some cases, multiple buildings totaling more than these threshold values will be considered acceptable if they can be surveyed as one site and as long as the full site operates as if it were a single building. The site should be large and active enough to obtain the needed data sample sizes in the number of survey hours planned. Surveys to obtain peak hour data should be three hours per peak period. It is desirable to obtain at least 50 samples per peak period for breakouts of trip characteristics such as mode split, but 100 or more should be sought.

Site and Area Maturity

The site or targeted building or land use within the site should be at least two years old (i.e., occupied for at least two years) and have at least 80 percent occupancy.

Normal Conditions

There should be no construction or other activity at or near a study location that restricts access or volume of activity. Sites having characteristics that generate unusual conditions not typically associated with a proposed development site should generally be avoided. Examples of such conditions include:

- Higher or lower than normal customer bases or activity, such as (currently) an Apple store or the only grocery store in a downtown;
- Sites serving students and that are within a mile of major colleges or universities (5,000 or more students) or sites within ½ mile of census tracts with more than 15 percent of the population between the ages of 18 and 21.
- Sites within ½ mile of a stadium, military base, major tourist attraction, commercial airport, or other specialty high activity location.

Ability to Isolate and Survey Site

It should be possible to isolate the survey site and each land use to permit accurate complete cordon, door, and/or driveway counts and interviews covering all person trips and modes. Any trips using parking or access points that are shared with buildings or land uses not intended to be included in the survey need to be documented so they can be subtracted to yield only trips from the targeted building or land use. In most cases, shared parking or access should rule out a site for a survey. However, it may be the nature of development located in areas with higher-levels of accessibility to provide shared parking, even without bottom-floor retail. These sites should be evaluated independently to determine whether counts pertaining to the residents can be separated from surrounding commercial or office who may be sharing off-street parking.

Additionally, it should be feasible to conduct counts and interviews at a site without the possibility of double-counting or missing trips.

Limited Number of Count and Interview Locations

The site should have a limited (i.e., small number) of access points in order to limit the cost to collect counts and interviews.

Safe Count and Interview Locations

Locations to be used for survey personnel to conduct counts (pedestrians, bicyclists or vehicles) should be safe for both survey personnel and passersby. It is not necessary to arrange for elaborate safety provisions just to afford minimal safety.

No Through Trips

There should be no through trips passing through the development unless they can be isolated and accurately accounted for. Presence of through trips increases the cost of surveys and introduces the chance for errors.

Site Data Available

Data describing the site characteristics should be confirmed, either by the development property owner/manager or from field measurements.

Field Verification of Survey Suitability

Each prospective site should be checked in the field to ensure that the above conditions can be met so the site can be surveyed efficiently and accurately. A preliminary data collection plan should be developed as part of the field reconnaissance. If the site looks promising for a survey, this field visit might also include a visit with the property owner/manager to gain a better understanding about how the development functions, where all access points are located, and to answer questions that arise as the preliminary data collection plan is developed. This meeting might also be used to initiate the permission request if the site is deemed desirable for a survey.

Obtain Permissions

Permission from the site property owner/manager to collect data at each site and land use should be obtained. In some cases, it may be possible to collect all data at or from locations on public sidewalks, but it is preferred, and generally considered good practice, to request permissions as a matter of courtesy and to facilitate obtaining site-related data that normally comes from the property owner/manager (e.g., development units, occupancy).

Site Data Collection Forms

Door and driveway counts should be made manually. No video, tube or other mechanical or electronic counts should be made. Counts should cover every access point or route across external cordons around the survey sites. Counts should consist of vehicles by type (including bicycle and pedestrian), and vehicle occupancy. Two forms should be used to manually record the counts, one for when counts consist of vehicles and pedestrians and the other for when counts include pedestrians only.

Intercept surveys should be conducted on tablet software to increase the efficiency of data collection and editing. If the tablets are not working properly, a manual paper version of the form should be used.

Interviews should be used to determine the mode of travel and vehicle occupancy (if any) for all trips involving a walk across the site cordon. Those trips should include pedestrian, bicycle, transit (rail or bus), and walking to/from a vehicle parked off-site.

In nearly all cases, interviews should be conducted at every door, gate, or walkway having five or more peak period trips. Where activity is less or where there are several doors or gates serving the same part of a building or route to/from the building, interviews should be conducted at a portion of the doors/gates and that data should be used for the similar access points. In no case should a busy pedestrian access point be left without an interviewer.

Interviewers should be instructed to try to interview as many people entering or exiting the building as they can. There is no intent to interview only a proportional sample (e.g., one out of every five). Of course, not every passing pedestrian will be willing to be interviewed and some will pass by while an interviewer is busy interviewing someone else.

[redacted] Site Summaries

The following pages outline brief descriptions of each site selected for on-site data collection. Site summaries include a general description of each development and nearby amenities, along with a table of built environment measures, including those found in Table 27, as well as each site's dwelling unit size and cost breakdown, motorized vehicle and person trips, vehicle occupancies, and derived mode share splits.

Site ID: 1 (801 Alma)
Address: 801 Alma Street, Palo Alto, CA 94301
Region: Bay Area
Place type: Urban district
Data collection date: August 31, 2017

This apartment complex is located in downtown Palo Alto, just over 30 miles southeast of downtown San Francisco. The four-story building houses 50 units, ranging from one to three bedrooms. There are 60 assigned parking spots for residents in an underground lot with an additional six spaces for visitors on the back end of the complex. Two-hour free street parking is available in the nearby vicinity, and the complex also features secure bike storage on site. There are eight points of pedestrian access; half are located off Alma St. to the southwest, with access to the rest via an alleyway behind the building. The garage entrance is to the northeast off High St. Additional development amenities include a landscaped courtyard with children's play area, a computer learning center, and on-site property management. There is a node of commercial shopping to the building's immediate northwest with restaurants, clothing stores, cafes, and markets. A medical center and more cafes are to the immediate southwest, and another large commercial shopping center can be found just under a mile west of the building. The area is walkable and bikeable with dedicated greenways for bikes along adjacent streets. Additionally, the area is serviced by a variety of transit options. A Caltrain station is a less than a half mile walk northwest, and a number of bus lines service the eight bus stops within a quarter mile radius.

Site information

Building size (DUs)	50
Occupancy	1
On-site parking spaces	66
Land Use (ITE Code)	223
Population Density (per acre)	24
Employment Density (per acre)	24
Retail Density (per acre)	5
Intersection Density (per square mile)	114
Distance to transit (miles)	0.23

Trip generation (ITE Method)

AM	
Person Trips	99
Motorized vehicle trips	38
Vehicle Occupancy	2.1
PM	
Person Trips	50
Motorized vehicle trips	13
Vehicle Occupancy	2.2

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	8	$568-$689
2 BR	26	$708-$1181
3 BR	16	$819-$1364
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	79.8	58.0
Transit	1.8	0.0
Walk	15.6	39.7
Bike	2.8	2.3

Site ID: 2 (Alta Vista Apartments)
Address: 5051 East 3rd Street, East Los Angeles, CA 90022
Region: Los Angeles
Place type: Urban neighborhood
Data collection date: August 23, 2017

This three-story mixed-use building spans over a block in East Los Angeles, just under six miles from downtown. The development houses 60 two- to three-bedroom units and includes 135 spaces of underground parking on-site. 114 spaces are assigned to residents, with an additional 15 spaces for visitors and six spaces accessible for those with disabilities. In total, there are 13 points of pedestrian access into the development: two give exclusive access to a single unit, with five located along E 3rd St., three off of S. Woods Ave., four in the alleyway north of the building, and the remaining one off the building's west side. Garage entry points are on located on the west side of the building, opening to the alleyway on the north and to E 3rd St on the south. 12 of the 60 units are dedicated live-work spaces for residents who own small businesses on the ground floor. The building is located catty-corner from the Atlantic Rail Station served by the Metro Gold Line.

Site information

Building size (DUs)	60
Occupancy	1.00
On-site parking spaces	135
Land Use (ITE Code)	223
Population Density (per acre)	8
Employment Density (per acre)	26
Retail Density (per acre)	0
Intersection Density (per square mile)	73
Distance to transit (miles)	0.22

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	0	N/A
2 BR	30	$529-$920
3 BR	30	$607-$1058
4 BR	0	N/A

Trip generation (ITE Method)

AM	
Person Trips	126
Motorized vehicle trips	49
Vehicle Occupancy	1.9
PM	
Person Trips	73
Motorized vehicle trips	33
Vehicle Occupancy	1.6

Derived mode shares

Mode	Percent Share	
	AM	PM
Motorized vehicle	73.8	71.2
Transit	11.0	8.0
Walk	15.2	20.5
Bike	0.0	0.0

Site ID: 3 (Athens Glen)
Address: 11515 S. Budlong Ave., Los Angeles, CA 90044
Region: Los Angeles
Place type: Urban neighborhood
Data collection date: August 24, 2017

This gated complex is made up of four, three-story buildings with 51 two- to four-bedroom units. The development is located roughly 10 miles south of downtown Los Angeles, with single-family housing to the north and east, and a major arterial freeway to the south. There are 110 spaces of on-site parking in a surface lot. There are just two pedestrian access points to the larger complex and a gated parking entryway along Budlong Ave. to the east. Within the complex, there are grassy courtyards, a playground, and an on-site laundry facility. The area is fairly walkable, with restaurants and convenience stores lining nearby Imperial Hwy and S Vermont Ave, and Los Angeles Southwest College is located two blocks west. The complex is a half mile walk from the Vermont/Athens Metro Station serviced by the Metro Green Line.

Site information

Building size (DUs)	51
Occupancy	0.90
On-site parking spaces	110
Land Use (ITE Code)	223
Population Density (per acre)	3
Employment Density (per acre)	4
Retail Density (per acre)	0
Intersection Density (per square mile)	16
Distance to transit (miles)	0.12

Trip generation (ITE Method)

AM	
Person Trips	73
Motorized vehicle trips	36
Vehicle Occupancy	1.6
PM	
Person Trips	71
Motorized vehicle trips	33
Vehicle Occupancy	1.4

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	0	N/A
2 BR	21	$948
3 BR	18	$1090
4 BR	12	$1203

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	80.8	71.8
Transit	12.8	14.1
Walk	6.4	14.1
Bike	0.0	0.0

Site ID: 4 (Casa Rita Apartments)
Address: 6508 Rita Avenue, Huntington Park, CA 90255
Region: Los Angeles
Place type: Urban neighborhood
Data collection date: August 24, 2017

Located just over five miles southwest of downtown Los Angeles, this apartment complex is made up of two, five-story buildings with a total of 103 units. Each unit features two to three bedrooms and most households are allotted two parking spaces. 240 on-site parking spaces are available between a ground level covered lot and subterranean parking lot. There is only one pedestrian entrance point on the west side of the building along Rita Ave. Four exit-only points are located along Rita Ave and Seville Ave. Garage access is located at one point on the southeast corner of the complex, and another point on the northwest corner. A courtyard and children's play area are located between the development's two buildings. The surrounding area is fairly walkable, with a commercial center spanning three blocks to the southwest along Pacific Blvd, and the California Employment Development Department to the immediate south of the complex. Nearby amenities include restaurants, department stores, a movie theater, bank, and pharmacy.

Site information

Building size (DUs)	103
Occupancy	1.00
On-site parking spaces	240
Land Use (ITE Code)	223
Population Density (per acre)	42
Employment Density (per acre)	22
Retail Density (per acre)	9
Intersection Density (per square mile)	58
Distance to transit (miles)	0.15

Trip generation (ITE Method)

AM	
Person Trips	221
Motorized vehicle trips	55
Vehicle Occupancy	1.8
PM	
Person Trips	162
Motorized vehicle trips	40
Vehicle Occupancy	1.5

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	0	N/A
2 BR	72	$948-$1151
3 BR	31	$1045-$1325
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	44.8	37.7
Transit	5.6	14.7
Walk	49.6	45.9
Bike	0.0	1.7

Site ID: 5 (Cathedral Gardens)
Address: 618 21st Street, Oakland, CA 94612
Region: Bay Area
Place type: Urban core
Data collection date: August 29, 2017

Two buildings, one four-story and one three-story, come together to form this 100-unit apartment complex. The units include one to three bedrooms, and each includes an assigned parking space in an underground parking structure beneath the four-story building. There are eight points of pedestrian access from the street, with five points along 21st St., one on the northwest side by an adjacent landscaped plaza, and two along 22nd St. The complex is located in Oakland's urban core, just nine miles east of downtown San Francisco. The two buildings define a large central courtyard with some seating, and the development features a computer lab, fitness center, and on-site laundry. Residents can also opt in to a free transit pass program provided through Alameda-Contra Costa transit district. The complex is opposite a large central bus station and is just a quarter mile from the nearest BART station.

Site information

Building size (DUs)	100
Occupancy	1.00
On-site parking spaces	100
Land Use (ITE Code)	223
Population Density (per acre)	31
Employment Density (per acre)	65
Retail Density (per acre)	1
Intersection Density (per square mile)	163
Distance to transit (miles)	0.11

Trip generation (ITE Method)

AM	
Person Trips	157
Motorized vehicle trips	47
Vehicle Occupancy	2.2
PM	
Person Trips	108
Motorized vehicle trips	29
Vehicle Occupancy	1.9

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	32	$587-$1174
2 BR	34	$704-$1408
3 BR	34	$813-$1627
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	65.6	50.9
Transit	32.1	3.5
Walk	2.3	42.1
Bike	0.0	3.5

Site ID: 6 (Confidential Site 1)
Address: --
Region: Bay Area
Place type: Urban core
Data collection date: August 29, 2017

Less than one mile southwest of downtown San Francisco, this five-story apartment building holds 82 units. Unit sizes range from studios to three bedrooms. One parking space is reserved for each unit in a secure, covered garage. There are four points of pedestrian access on the north façade and an additional two on the building's south side. Separate entrance and exit points to parking garages are also located along the south side of the complex. There are two landscaped courtyards and a playground within the development grounds. The surrounding area supports walking, biking, and transit modes. A dedicated bike lane, separated from auto traffic with vegetation, runs along the adjacent street to the west of the building. There is an abundance of restaurants within a couple blocks to the northwest, parking to the southwest, and entertainment venues toward downtown. A BART Station serviced by a number of light rail lines is within a half mile of the development.

Site information

Building size (DUs)	82
Occupancy	1.00
On-site parking spaces	83
Land Use (ITE Code)	223
Population Density (per acre)	43
Employment Density (per acre)	273
Retail Density (per acre)	6
Intersection Density (per square mile)	143
Distance to transit (miles)	0.08

Trip generation (ITE Method)

AM	
Person Trips	49
Motorized vehicle trips	11
Vehicle Occupancy	1.2
PM	
Person Trips	59
Motorized vehicle trips	14
Vehicle Occupancy	1.3

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	4	$807
1 BR	20	$615-$738
2 BR	24	$665-$1271
3 BR	34	$707-$1295
4 BR	0	N/A

Derived mode shares

Mode	Percent Share	
	AM	PM
Motorized vehicle	26.5	30.5
Transit	34.5	32.2
Walk	33.0	21.9
Bike	6.0	15.4

Study ID: 7 (Fourth Street Apartments)
Address: 1460 N 4th Street, San Jose, CA 95112
Region: Bay Area
Place type: Urban neighborhood
Data collection date: August 31, 2017

This apartment complex features 100 units ranging from one to three bedrooms. The building consists of seven stories of residences atop two levels of secure garage parking beginning at ground level. Some residents are on a waitlist for the 79 spaces of on-site parking in the garage; residents are also all offered free Clipper Cards for the San Francisco Translink system. There are additional two-hour free on-street parking spaces in the vicinity. Three points of pedestrian access and garage entryway are to the southwest off N. 4th St. The development is just under 50 miles southeast of downtown San Francisco, and includes a landscaped courtyard with children's play area, a computer lab, free Wi-Fi, and a seventh-floor terrace fitted with local vegetation for rainwater filtering. To the southwest, there are restaurants and shopping outlets, along with a small park. An airport is just over a mile to the west, and there are five Santa Clara Valley Transportation Authority light rail line stops accessible within 0.2 miles of the development.

Site information

Building size (DUs)	100
Occupancy	0.98
On-site parking spaces	79
Land Use (ITE Code)	223
Population Density (per acre)	7
Employment Density (per acre)	37
Retail Density (per acre)	1
Intersection Density (per square mile)	46
Distance to transit (miles)	0.38

Trip generation (ITE Method)

AM	
Person Trips	121
Motorized vehicle trips	39
Vehicle Occupancy	1.9
PM	
Person Trips	82
Motorized vehicle trips	21
Vehicle Occupancy	1.5

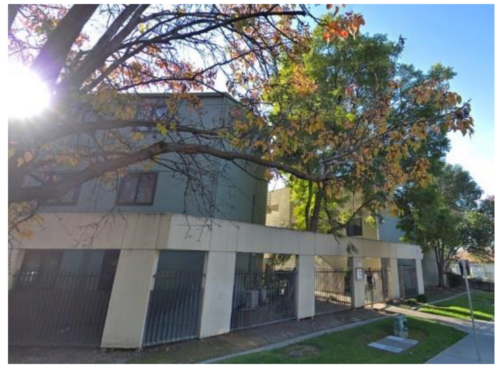
Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	39	$1,052
2 BR	31	$538-$1446
3 BR	30	$1126-$1603
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	59.5	37.8
Transit	13.9	17.8
Walk	26.6	44.4
Bike	0.0	0.0

Site ID: 8 (Guadalupe)
Address: 76 Duane Street, San Jose, CA 95110
Region: Bay Area
Place type: Urban neighborhood
Data collection date: August 29, 2017



This apartment complex is about 50 miles southeast of downtown San Francisco, but just a mile southeast of downtown San Jose. The two, three-story buildings house 23 units ranging from one to three bedrooms. Parking is included for residents in a gated surface parking lot with 40 spaces total. Additional free street parking is available in the surrounding neighborhood. The main pedestrian point of access and parking entrance are off Duane St. to the north of the complex. The development occupies a lot at the end of a cul-de-sac in a residential neighborhood. Residents can opt to participate in the complex's community garden or library programs and are eligible for free annual transit passes via the Santa Clara Valley Transportation Authority's Eco Pass Program. The San Jose Trolley line services a stop just over a quarter mile walk from the development.

Site information

Building size (DUs)	23
Occupancy	1.00
On-site parking spaces	40
Land Use (ITE Code)	223
Population Density (per acre)	38
Employment Density (per acre)	3
Retail Density (per acre)	1
Intersection Density (per square mile)	147
Distance to transit (miles)	0.28

Trip generation (ITE Method)

AM	
Person Trips	48
Motorized vehicle trips	15
Vehicle Occupancy	1.7
PM	
Person Trips	32
Motorized vehicle trips	14
Vehicle Occupancy	1.4

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	6	$1066-$1290
2 BR	11	1271-$1540
3 BR	6	$1467-$1777
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	52.1	59.4
Transit	47.9	40.6
Walk	0.0	0.0
Bike	0.0	0.0

Study ID: 9 (Harbor View)
Address: 326 N. King Avenue, Wilmington, CA 90744
Region: Los Angeles
Place type: Urban neighborhood
Data collection date: October 11, 2017

This apartment complex is made up of four, three story buildings that house 120 units. Units range from one to four bedrooms in size, and 172 spaces of on-site parking are available between two gated parking lots on the east and west ends of the development. Harbor View issues an additional 40 spaces on on-street parking surrounding the vicinity. There is one point of pedestrian access from the street to the south of the complex off W C St. The main driveway is to the north off W D St., with parking exit driveways to N Wilmington Blvd. and Hawaiian Ave. The development offers a common courtyard with children's play area, computer room, and after-school program room. The complex is 19 miles south of downtown Los Angeles; there are three food markets within a mile of the development, a park one block away, and a large shopping center a couple of miles southwest.

Site information

Building size (DUs)	120
Occupancy	0.98
On-site parking spaces	172
Land Use (ITE Code)	223
Population Density (per acre)	18
Employment Density (per acre)	2
Retail Density (per acre)	0
Intersection Density (per square mile)	102
Distance to transit (miles)	0.06

Trip generation (ITE Method)

AM	
Person Trips	253
Motorized vehicle trips	54
Vehicle Occupancy	1.8
PM	
Person Trips	249
Motorized vehicle trips	67
Vehicle Occupancy	1.8

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	11	$947
2 BR	33	$1136
3 BR	60	$1307
4 BR	16	$1499

Derived mode shares

Mode	Percent Share	
	AM	**PM**
Motorized vehicle	38.7	49.0
Transit	5.6	16.4
Walk	44.6	32.8
Bike	11.1	1.8

Site ID: 10 (Kern Villa Apartments)
Address: 202 North Kern Avenue, Los Angeles, CA 90022
Region: Los Angeles
Place type: Urban neighborhood
Data collection date: August 23, 2017

This complex is made up of eight two-story buildings located in East Los Angeles, just under six miles east of downtown. The development's 49 units are two to three bedrooms, and each residence is assigned at least one of 91 available parking spaces between two surface parking lots. Three points of pedestrian access are along N Kern Ave. to the west of the building. Access to parking lots, which are found on the north and south sides of the complex, are also off N Kern Ave. The complex is fully gated and includes a central courtyard with a children's play area. There are some restaurant and retail shopping options in the nearby blocks, and a large park is to the immediate east of the development. The complex is a half mile north of the East Los Angeles Civic Center, which features a Metro Gold Line station.

Site information

Building size (DUs)	49
Occupancy	0.98
On-site parking spaces	91
Land Use (ITE Code)	221
Population Density (per acre)	22
Employment Density (per acre)	3
Retail Density (per acre)	0
Intersection Density (per square mile)	91
Distance to transit (miles)	0.14

Trip generation (ITE Method)

AM	
Person Trips	89
Motorized vehicle trips	27
Vehicle Occupancy	1.3
PM	
Person Trips	59
Motorized vehicle trips	20
Vehicle Occupancy	1.9

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	0	N/A
2 BR	13	$227-$786
3 BR	36	$1875
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	40.4	62.7
Transit	35.7	5.3
Walk	11.9	32.0
Bike	11.9	0.0

Site ID: 11 (Lenzen Park)
Address: 790 Lenzen Avenue, San Jose, CA 95126
Region: Bay Area
Place type: Urban neighborhood
Data collection date: August 30, 2017

This apartment complex houses 88 units, ranging from studios to two bedrooms, in two stories of residences atop a ground level secured parking structure. Additional overflow parking is available behind the garage, creating 129 on-site spots total. There is one pedestrian point of access off Lenzen Ave. to the building's northwest, and an additional entrance from the overflow parking area. Garage access is also off Lenzen Ave., while entry into the overflow surface lot is behind the complex on N. Morrison Ave. The location is roughly 50 miles southeast of downtown San Francisco, but just one mile west of downtown San Jose. A common courtyard area with a pool, on-site laundry facilities, a gym, computer lab, and 'tot lot' children's play area are included in the complex. A small park is located to the building's immediate northeast. There is a supermarket and commercial shopping node roughly one mile to the northeast, and there are two bike shares within a half mile.

Site information

Building size (DUs)	88
Occupancy	0.98
On-site parking spaces	129
Land Use (ITE Code)	223
Population Density (per acre)	19
Employment Density (per acre)	19
Retail Density (per acre)	1
Intersection Density (per square mile)	107
Distance to transit (miles)	0.31

Trip generation (ITE Method)

AM	
Person Trips	49
Motorized vehicle trips	29
Vehicle Occupancy	1.3
PM	
Person Trips	45
Motorized vehicle trips	21
Vehicle Occupancy	1.2

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	38	$101-$1222
1 BR	38	$1109-$1339
2 BR	12	$1285-$1552
3 BR	0	N/A
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	77.6	55.6
Transit	3.2	4.9
Walk	16.0	29.6
Bike	3.2	9.9

Site ID: 12 (Mariposa Place Apartments)
Address: 1050 N. Mariposa Avenue, Los Angeles, CA 90029
Region: Los Angeles
Place type: Urban district
Data collection date: August 22, 2017

This four-story apartment building is located on a corner lot just over five miles northwest of downtown Los Angeles. The building houses 58 units, each ranging from one to four bedrooms. 76 spaces of parking are included in an underground lot. There is limited pedestrian access from the street, with the main entrance on the building's north side off Santa Monica Blvd., and an additional entrance near the northwest corner of the building off N Mariposa Ave. The access point for the garage is also on N Mariposa Ave. on the southwest side of the building. The development features a ground-floor laundromat, a drop-in station for Los Angeles Police Department, and office space with separate entry points. There's a specialty market and restaurants along Santa Monica Blvd., and shopping and entertainment off Sunset and Hollywood Blvd. can be found a couple blocks to the north. The Los Angeles Metro Red Line services a stop on Vermont Ave two blocks east of the building.

Site information

Building size (DUs)	58
Occupancy	1.00
On-site parking spaces	76
Land Use (ITE Code)	223
Population Density (per acre)	52
Employment Density (per acre)	3
Retail Density (per acre)	0
Intersection Density (per square mile)	119
Distance to transit (miles)	0.06

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	13	$546-$789
2 BR	19	$651-$944
3 BR	21	$750-$1068
4 BR	5	$830-$1207

Trip generation (ITE Method)

AM	
Person Trips	113
Motorized vehicle trips	43
Vehicle Occupancy	1.1
PM	
Person Trips	65
Motorized vehicle trips	25
Vehicle Occupancy	1.1

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	42.2	43.1
Transit	22.1	13.6
Walk	35.4	40.7
Bike	0.0	2.7

Site ID: 13 (Mission Gateway)
Address: 33155 Mission Blvd., Union City, CA 94587
Region: Bay Area
Place type: Suburban neighborhood
Data collection date: August 30, 2017

This apartment complex features three to four stories of residences, secure parking, and ground floor retail. Located just under 30 miles southeast of downtown San Francisco, the three-building development holds 121 units ranging from one to four bedrooms. Each building contains its subterranean parking garage, and there is an additional surface lot which shares parking space for on-site retail; 350 spaces of parking are available on-site in total. There is one pedestrian point of access along Whipple Rd. to the south of the complex, and the remaining five are along Mission Blvd. to the northeast. There is one parking entry point on each of the three adjacent roads. In addition to the first-floor retail space, which includes a coffee shop and car rental service, the complex features a landscaped courtyard, art room, computer lab, pool, and children's play area. The development is located along a major arterial and is close to a park to the immediate northeast. There is a gas station and specialty supermarket within a block of the complex, and an industry and commercial headquarters center roughly two miles to the southwest.

Site information

Building size (DUs)	121
Occupancy	0.98
On-site parking spaces	350
Land Use (ITE Code)	223
Population Density (per acre)	4
Employment Density (per acre)	22
Retail Density (per acre)	0
Intersection Density (per square mile)	43
Distance to transit (miles)	0.09

Trip Generation (ITE Method)

AM	
Person Trips	284
Motorized vehicle trips	160
Vehicle Occupancy	1.47
PM	
Person Trips	165
Motorized vehicle trips	89
Vehicle Occupancy	1.5

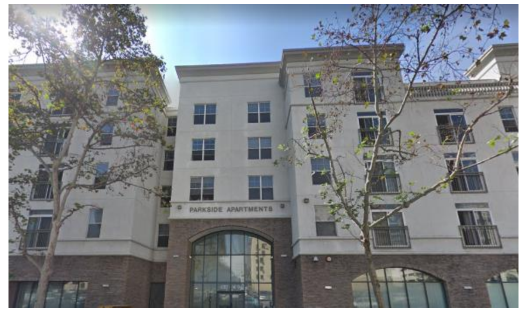
Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	14	$685-$1174
2 BR	59	$821-$1408
3 BR	38	$949-$1627
4 BR	10	$1058-$1815

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	82.7	78.2
Transit	0	1.6
Walk	11.5	17.1
Bike	5.8	3.1

Site ID: 14 (Parkside Apartments)
Address: 400 W. 9th St., Los Angeles, CA 90015
Region: Los Angeles
Place type: Urban core
Data collection date: October 12, 2017



This apartment complex in downtown Los Angeles is a five-story building with 79 units, each ranging from one to four bedrooms. There are 73 parking spaces available on site, with 65 reserved for residents, and eight points of pedestrian access from the street. The main entrance is off W. 9th St. Another entryway is at the northeast corner of the building, and three more are along S. Olive St. The remaining three doors are to the northwest along S. Grand Ave. Garage entrance is from S. Olive St. on a one-way driveway, with an exit driveway to S. Grand Ave. The Blue and Expo rail lines are available at stops within a quarter mile, and the Red and Purple lines are less than a mile away. The development backs up to a bank to the southwest, with shopping and restaurants in all the surrounding blocks. There are multiple grocery stores surrounding the area, the closest just a walk one block northwest. The complex is one mile from the LA Conventional Center, and a hospital is just under a mile away to the southwest.

Site information

Building size (DUs)	79
Occupancy	0.99
On-site parking spaces	73
Land Use (ITE Code)	223
Population Density (per acre)	8
Employment Density (per acre)	67
Retail Density (per acre)	7
Intersection Density (per square mile)	199
Distance to transit (miles)	0.03

Trip generation (ITE Method)

AM	
Person Trips	129
Motorized vehicle trips	23
Vehicle Occupancy	1.78
PM	
Person Trips	96
Motorized vehicle trips	19
Vehicle Occupancy	1.5

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	26	$545-$952
2 BR	11	$651-$1140
3 BR	16	$750-$1262
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	31.8	30.2
Transit	63.1	20.6
Walk	5.1	44.6
Bike	0.0	4.6

Site ID: 15 (Pico/Gramercy)
Address: 3215 W. Pico Blvd., Los Angeles, CA 90019
Region: Los Angeles
Place type: Urban neighborhood
Data collection date: October 12, 2017

This four-story apartment complex houses 71 units, ranging from one to three bedrooms, four miles west of downtown Los Angeles. Parking is available in an underground lot, with 70 spots reserved for residents and an additional 10 spaces for visitors. There are seven points of pedestrian access from the street level. Four, including the main entrance, are to the west off S Gramercy Pl. One is to the south off W. Pico Blvd, and two others to the east off St. Andrews Pl. Garage access is near the pedestrian entrance off S Gramercy Pl. A community center is built into the main building, which gives residents access to club amenities and a courtyard with green space. Children who reside in the apartments have access to free educational services, including tutoring and after school programs. A healthcare center is located across the street, and there are restaurants along the stretch of road to the south of the building, along with a dollar store, auto center, and convenience stores just one block southeast. A grocery store and pharmacy are within a half mile southeast of the complex. The Purple Metro line services a stop roughly one mile from the development.

Site information

Building size (DUs)	71
Occupancy	1.00
On-site parking spaces	80
Land Use (ITE Code)	223
Population Density (per acre)	27
Employment Density (per acre)	7
Retail Density (per acre)	0
Intersection Density (per square mile)	198
Distance to transit (miles)	0.11

Trip generation (ITE Method)

AM	
Person Trips	72
Motorized vehicle trips	37
Vehicle Occupancy	1.3
PM	
Person Trips	46
Motorized vehicle trips	17
Vehicle Occupancy	1.5

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	19	$566-$820
2 BR	19	$676-$980
3 BR	33	$1131
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	66.7	54.3
Transit	--	--
Walk	--	--
Bike	--	--

Site ID: 16 (Presidio)
Address: 1450 El Camino Real, Santa Clara, CA 95050
Region: Bay Area
Place type: Urban neighborhood
Data collection date: August 31, 2017

This three-story apartment building features 40 units of studio and one-bedroom dwellings four miles northwest of downtown San Jose. One parking space per unit is included for residents in a surface lot on the building's south side. There are four points of pedestrian street access: the main entrance is on the southeast corner, with three others located off each of the three adjacent streets. Driveway access to the surface lot is provided off either side of the complex via Jefferson St. or Madison St. A community room, on-site management, and on-site property maintenance are housed within the complex. There are two parks nearby, one across the street to the northwest, and another two blocks southeast. Other nearby amenities include restaurants across to the northeast, and a market, clothing store, pharmacy, bank, and other services just over a half mile west.

Site information

Building size (DUs)	40
Occupancy	1.00
On-site parking spaces	40
Land Use (ITE Code)	223
Population Density (per acre)	13
Employment Density (per acre)	6
Retail Density (per acre)	0
Intersection Density (per square mile)	218
Distance to transit (miles)	0.06

Trip generation (ITE Method)

AM	
Person Trips	27
Motorized vehicle trips	14
Vehicle Occupancy	1.21
PM	
Person Trips	30
Motorized vehicle trips	15
Vehicle Occupancy	1.3

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	20	$804-$1013
1 BR	20	$1069-$1293
2 BR	0	N/A
3 BR	0	N/A
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	63.0	63.3
Transit	24.7	7.3
Walk	12.3	14.7
Bike	0	14.7

Site ID: 17 (Puerto Del Sol)
Address: 745 W. 3rd Street, Long Beach, CA 90802
Region: Los Angeles
Place type: Urban core
Data collection date: October 11, 2017

This apartment complex is 20 miles south of downtown Los Angeles, but just over half a mile west of downtown Long Beach. The development is made up of three, four-story buildings and houses 64 units ranging from two to four bedrooms. There are 145 spaces of on-site parking included for residents in a secure parking garage. There are 16 points of pedestrian street access: five off Maine Ave. to the east, six along W 3rd St. to the south, and five off Golden Ave. to the west. Access to the parking garage is provided off Maine Ave. A community center with on-site services including tutoring, summer programs for children, computer training, fitness and art classes, credit counseling, and financial management courses is included in the development. An elementary school and children's health clinic are just across the street to the south, a park is to the immediate west, and the Governor George Deukmejian Courthouse is to the southeast. There are a number of retail stores, restaurants, a light rail station, bank, and pharmacy in nearby downtown Long Beach.

Site information

Building size (DUs)	64
Occupancy	1.00
On-site parking spaces	145
Land Use (ITE Code)	223
Population Density (per acre)	40
Employment Density (per acre)	16
Retail Density (per acre)	0
Intersection Density (per square mile)	233
Distance to transit (miles)	0.11

Trip generation (ITE Method)

AM	
Person Trips	89
Motorized vehicle trips	33
Vehicle Occupancy	1.48
PM	
Person Trips	87
Motorized vehicle trips	22
Vehicle Occupancy	1.3

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	0	N/A
2 BR	38	$676-$822
3 BR	15	$786-$954
4 BR	11	$868-$1056

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	55.1	33.3
Transit	1.2	0.0
Walk	43.7	66.7
Bike	0.0	0.0

Site ID: 18 (Rio Vista / Glassell Park)
Address: 3000 Verdugo Road, Los Angeles, CA 90065
Region: Los Angeles
Place type: Urban neighborhood
Data collection date: August 23, 2017

This 50-unit apartment building is just over five miles north of downtown Los Angeles. It features two levels of subterranean parking, four stories of two- to three-bedroom residences, and a fifth-floor veranda. The complex includes 56 parking spaces, with 53 reserved for residents and three for visitors. Two pedestrian entrance points are on the west side of the building along Verdugo Rd., with a parking garage entrance in-between them. The development features a central landscaped courtyard, a computer lab, on-site property management, and a rooftop edible community garden. The surrounding area supports walking and biking, with a food market within two blocks, and a park, retail stores, schools, and restaurants in the surrounding blocks along Cypress Ave and N San Fernando Rd to the west.

Site information

Building size (DUs)	50
Occupancy	1.00
On-site parking spaces	56
Land Use (ITE Code)	223
Population Density (per acre)	32
Employment Density (per acre)	5
Retail Density (per acre)	2
Intersection Density (per square mile)	151
Distance to transit (miles)	0.06

Trip generation (ITE Method)

AM	
Person Trips	113
Motorized vehicle trips	25
Vehicle Occupancy	1.7
PM	
Person Trips	92
Motorized vehicle trips	19
Vehicle Occupancy	2.1

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	0	N/A
2 BR	35	$552-$1120
3 BR	15	$637-$1600
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	38.1	42.4
Transit	0.0	13.7
Walk	61.9	43.9
Bike	0.0	0.0

Site ID: 19 (San Antonio Place)
Address: 210 San Antonio Circle, Mountain View, CA 94040
Region: Bay Area
Place type: Urban neighborhood
Data collection date: August 31, 2017

This three-story building forms an apartment complex with a total of 120 units, some of which are reserved for special needs residents. 75 parking spaces are included in an underground parking garage. There are six points of pedestrian access from the street, with the main entrance located at the building's north corner, and four others along San Antonio Cir to the west. The remaining access point is opposite the main entrance on the building's south side. On-site laundry is included. The development, located roughly 35 miles southeast of downtown San Francisco, also features a common area with a grassy courtyard and children's play area. A Caltrain station is located to the immediate southeast, and a large shopping center with multiple grocery options is available a half mile to the south, with a bank, health clinic, and restaurants along the way. The building is located in a fairly residential area, with single family suburban neighborhoods to the northwest and west of the development. The majority of the units in this development are reserved for special needs. This information was not disclosed to the study team until data collection was in process.

Site information

Building size (DUs)	120
Occupancy	0.98
On-site parking spaces	75
Land Use (ITE Code)	223
Population Density (per acre)	26
Employment Density (per acre)	6
Retail Density (per acre)	1
Intersection Density (per square mile)	51
Distance to transit (miles)	0.05

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	118	$272-$899
1 BR	1	--
2 BR	1	--
3 BR	0	N/A
4 BR	0	N/A

--: cost unknown

Trip generation (ITE Method)

AM	
Person Trips	38
Motorized vehicle trips	12
Vehicle Occupancy	1.1
PM	
Person Trips	44
Motorized vehicle trips	13
Vehicle Occupancy	1.4

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	34.2	40.9
Transit	30.7	26.5
Walk	35.1	24.5
Bike	0.0	8.2

Site ID: 20 (Selma Community Housing)
Address: 1605 N. Cherokee Avenue, Los Angeles, CA 90028
Region: Los Angeles
Place type: Urban core
Data collection date: August 22, 2017

This development is located in downtown Hollywood, roughly eight miles northwest of downtown Los Angeles. It features a 66 unit, six-story building located on a corner lot with ample street access. Units range from one to three bedrooms. 67 parking spaces are provided for residents in a garage which facilitates direct access to residential units. The main pedestrian access point is on the building's southwest corner, with two additional gated points of access to the west of the building along N Cherokee Ave. The entrance point for the subterranean parking garage is just east of the main entry along Selma Ave. This is a transit-oriented development located just a block away from a number of restaurants, retail stores, and entertainment venues along Hollywood Blvd. The Metro Red Line services a stop less than a quarter mile away for easy downtown access.

Site information

Building size (DUs)	66
Occupancy	1.00
On-site parking spaces	67
Land Use (ITE Code)	223
Population Density (per acre)	13
Employment Density (per acre)	49
Retail Density (per acre)	4
Intersection Density (per square mile)	149
Distance to transit (miles)	0.16

Trip generation (ITE Method)

AM	
Person Trips	99
Motorized vehicle trips	32
Vehicle Occupancy	1.9
PM	
Person Trips	67
Motorized vehicle trips	21
Vehicle Occupancy	1.8

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	8	$732-$977
2 BR	35	$536-$1173
3 BR	23	$677-$1600
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	61.6	56.7
Transit	4.5	4.8
Walk	33.9	33.7
Bike	0.0	4.8

Site ID: 21 (Sherman Village)
Address: 7135 Wilbur Avenue, Reseda, CA 91335
Region: Los Angeles
Place type: Suburban neighborhood
Data collection date: August 24, 2017

This three-story building is 28 miles northwest of downtown Los Angeles. It features 73 units, each ranging from one to three bedrooms. The building spans an entire block on a corner lot, with the main façade facing east. Parking is included for tenants, with a total of 114 parking spaces in an underground parking structure on the premise. Free street parking is also available along the Wilbur Ave. to the east side of the complex. There are five points of pedestrian access along Wilbur Ave. and one point along Sherman Way. Access to either of the parking garages can be found on both adjacent streets. The complex includes a clubhouse and business center, as well as some shaded outdoor common areas. There is a children's playground, seating area, and some additional street parking on the southeast corner of the complex. The building is surrounded by a number of single-family homes, with a strip mall containing some fast food restaurant options, home and auto repair stores, and local markets to the south along Sherman Way.

Site information

Building size (DUs)	73
Occupancy	1.00
On-site parking spaces	114
Land Use (ITE Code)	223
Population Density (per acre)	27
Employment Density (per acre)	1
Retail Density (per acre)	0
Intersection Density (per square mile)	123
Distance to transit (miles)	0.06
Jobs accessible by transit	22501
Jobs accessible by walking	8018

Trip generation (ITE Method)

AM	
Person Trips	99
Motorized vehicle trips	38
Vehicle Occupancy	1.9
PM	
Person Trips	94
Motorized vehicle trips	31
Vehicle Occupancy	1.5

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	20	$447-$753
2 BR	28	$534-$842
3 BR	25	$624-$932
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	73.7	48.9
Transit	11.9	0.0
Walk	14.3	51.1
Bike	0.0	0.0

Site ID: 22 (Sol Y Luna)
Address: 2915 East First Street, Los Angeles, CA 90033
Region: Los Angeles
Place type: Urban District
Data collection date: August 23, 2017

This four-story apartment building is three miles east of downtown Los Angeles and houses 53 one- to three-bedroom units. There are 68 spaces of on-site parking available for residents, and three-bedroom units are allotted two parking spaces. Parking is secured in garages beneath the building's residences, with office space integrated into the floor level parking area. The building is located on a corner lot, with three pedestrian access points along E 1st. St, one pedestrian access point on Evergreen St., and access to either parking garage along either street. The development includes two community courtyard spaces and on-site laundry facilities. The area is both walkable and bikeable, with a park located two blocks south, and a number of restaurants, convenience stores, and a medical clinic four blocks north along E Cesar E Chavez Ave. Soto Station with Metro Gold Line service is less than a half mile northwest of the development.

Site information

Building size (DUs)	53
Occupancy	1.00
On-site parking spaces	68
Land Use (ITE Code)	223
Population Density (per acre)	15
Employment Density (per acre)	12
Retail Density (per acre)	5
Intersection Density (per square mile)	246
Distance to transit (miles)	0.04

Trip generation (ITE Method)

AM	
Person Trips	106
Motorized vehicle trips	25
Vehicle Occupancy	2.1
PM	
Person Trips	118
Motorized vehicle trips	26
Vehicle Occupancy	2.0

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	16	$451-$753
2 BR	15	$541-$843
3 BR	22	$620-$934
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	49.1	44.1
Transit	4.1	5.1
Walk	46.8	50.8
Bike	0.0	0.0

Site ID: 23 (The Paseo at Californian)
Address: 1901 W. 6th Street, Los Angeles, CA 90057
Region: Los Angeles
Place type: Urban Core
Data collection date: August 22, 2017

Just two miles northeast of downtown Los Angeles, this six-story building features 53 one- to three- bedroom residential units. 55 parking spaces for residents are included in a two-level underground parking garage. Additional free street parking is available along adjacent W 6th St., although parking is prohibited on S. Bonnie Brae. Secure bike parking and storage is also available at the development. The main pedestrian entrance is on the south corner of the building, with two other points of access on the southwest façade (W 6th St.) and northwest façade along into an alleyway. Parking garage entrance and exit points are also located along the ally, while bike storage is next to the W 6th St. pedestrian access point. Given the proximity of downtown, there are many nearby amenities, including a park, restaurants, retail stores, and a medical center within two blocks. Stops for the Red and Purple Metro lines are just a few blocks southwest.

Site information

Building size (DUs)	53
Occupancy	1.00
On-site parking spaces	55
Land Use (ITE Code)	223
Population Density (per acre)	177
Employment Density (per acre)	15
Retail Density (per acre)	0
Intersection Density (per square mile)	202
Distance to transit (miles)	0.04

Trip generation (ITE Method)

AM	
Person Trips	61
Motorized vehicle trips	20
Vehicle Occupancy	1.9
PM	
Person Trips	57
Motorized vehicle trips	13
Vehicle Occupancy	1.9

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	26	$545-$952
2 BR	11	$651-$1140
3 BR	16	$750-$1262
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	62.3	43.9
Transit	10.5	16.8
Walk	25.1	37.4
Bike	2.1	1.9

Site ID: 24 (Confidential Site 2)
Address: --
Region: Bay Area
Place type: Urban neighborhood
Data collection date: August 30, 2017

This apartment complex's 119 units are housed in a five-story building eight miles southwest of downtown San Francisco. Units are one to three bedrooms, and at least one parking space of 131 available on-site are included for residents. There are four points of pedestrian access and one vehicle point of access to the building, all on its southern façade. The complex includes a landscaped community courtyard, on-site laundry, and child care facility with outdoor play space housed in its ground floor. A BART station is nearby to the northwest, and a metro center serviced by a number of bus lines is located to the south. A grocery store and commercial shopping center are available just under two miles to the southwest, and a medical center can be found a mile southwest.

Site information

Building size (DUs)	119
Occupancy	1.00
On-site parking spaces	131
Land Use (ITE Code)	223
Population Density (per acre)	24
Employment Density (per acre)	3
Retail Density (per acre)	2
Intersection Density (per square mile)	113
Distance to transit (miles)	0.09

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	28	$428-$1114
2 BR	44	$509-$1332
3 BR	47	$583-$1534
4 BR	0	N/A

Trip generation (ITE Method)

AM	
Person Trips	187
Motorized vehicle trips	57
Vehicle Occupancy	2.0
PM	
Person Trips	144
Motorized vehicle trips	41
Vehicle Occupancy	1.8

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	59.9	52.1
Transit	36.8	34.0
Walk	3.3	13.9
Bike	0.0	0.0

Site ID: 25 (Troy)
Address: 714 S. Almaden Ave, San Jose, CA 95110
Region: Bay Area
Place type: Urban neighborhood
Data collection date: August 29, 2017

This apartment complex is made up by three, two-story buildings located roughly 50 miles southeast of downtown San Francisco, but just a mile southeast of downtown San Jose. The development contains 30 one- to two-bedroom units. There are 39 available parking spaces, including nine visitor spaces, in a secure ground-level lot; an additional 50-60 free parking spaces are available in the immediate vicinity along the residential street curbs. There are seven points of pedestrian street access and one additional pedestrian walkway into the complex: six are to the southeast along Almaden Ave., while the seventh entrance and walkway are on Duane St. along with the surface lot entrance. The San Jose Convention Center and the City's Civic Center are to the north of the development along with a number of restaurants, entertainment venues, supermarkets, and other commercial stores. Residents are eligible for free annual transit passes through the Santa Clara Valley Transportation Authority's Eco Pass Program.

Site information

Building size (DUs)	30
Occupancy	1.00
On-site parking spaces	39
Land Use (ITE Code)	221
Population Density (per acre)	38
Employment Density (per acre)	3
Retail Density (per acre)	1
Intersection Density (per square mile)	147
Distance to transit (miles)	0.31

Trip generation (ITE Method)

AM	
Person Trips	86
Motorized vehicle trips	17
Vehicle Occupancy	2.1
PM	
Person Trips	89
Motorized vehicle trips	21
Vehicle Occupancy	2.2

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	3	$1151-$1390
2 BR	27	$1283-$1552
3 BR	0	N/A
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	40.7	51.7
Transit	11.9	4.0
Walk	47.4	40.3
Bike	0.0	4.0

Site ID: 26 (Villas del Lago)
Address: 456 S. Lake St., Los Angeles, CA 90057
Region: Los Angeles
Place type: Urban core
Data collection date: August 22, 2017

This five-story, 74-unit development features four levels of residences atop a group level podium that houses 72 spaces of secure parking for residents. Units range from one to three bedrooms. Four pedestrian and one parking garage access points are to the west of the building along S Lake St. The development features an internal courtyard, children's play area, and recreation room. The apartment building is just under three miles northwest of downtown Los Angeles. A small commercial center with restaurants, retail stores, and a medical center are located in the same block as the development, and MacArthur Park is just two blocks to the southwest. A Metro station serviced by the Red and Purple lines is a less than a half mile away.

Site information

Building size (DUs)	74
Occupancy	1.00
On-site parking spaces	72
Land Use (ITE Code)	223
Population Density (per acre)	37
Employment Density (per acre)	8
Retail Density (per acre)	0
Intersection Density (per square mile)	505
Distance to transit (miles)	0.15

Trip generation (ITE Method)

AM	
Person Trips	99
Motorized vehicle trips	38
Vehicle Occupancy	1.9
PM	
Person Trips	94
Motorized vehicle trips	31
Vehicle Occupancy	1.5

Dwelling unit size and cost breakdown

Size	Number of units	Cost
Studio	0	N/A
1 BR	16	$463-$820
2 BR	34	$553-$980
3 BR	24	$637-$1366
4 BR	0	N/A

Derived mode shares

Mode	**Percent Share**	
	AM	**PM**
Motorized vehicle	74.2	68.3
Transit	9.5	14.4
Walk	12.2	17.3
Bike	4.1	0.0

[redacted] Cordon count protocols & instruments

For this project, it was imperative that data collected were usable for typical analyses used for transportation impact analyses (TIAs) and environmental impact reports (EIRs). These analyses typically focus on peak hours of weekday morning and afternoon commute travel periods, which often have the highest amount of traffic across the transportation system as a whole. Normally, these analyses are conducted for the street peak hour during weekday morning (7-10am) and evening (4-7pm) street peak hours because the peak total demand usually occurs during those hours. While transportation system impacts at times other than weekday commute periods are an important topic for future research, this project covered weekday street peak periods.

To obtain representative weekday street peak hour data, on-site data collection was based around the following periods:

- Time of day. SGTG Phase I and II collected data during slightly different time periods during the AM peak hour (7:00AM to 10:00AM versus 6:30AM to 9:30AM, respectively). Both studies collected during the same time periods during the PM peak hour (4:00PM to 7:00PM).[10] This study collected data during both the AM and PM peak periods of the Phase I study (7:00AM to 10:00AM and 4:00PM to 7:00PM).

- Day of the week. Data should be collected on typical weekdays - Tuesday, Wednesday, and Thursday. Traffic patterns on Mondays and Fridays are not always the same as the midweek days and therefore should be excluded.

- Season of the year. Site trip generation for apartments should be at typical levels during fair weather months in the spring and fall (non-holiday weeks during March-May). This study collected data during the late summer and early fall.

- Weather. Data should only be collected on rain-free days. No data collection days should have abnormally high or low temperatures.

On-site Data Collection Preparation

Data were collected at 11 sites in the Los Angeles region August 22-24th, 2017. Data were collected at 11 sites in the Bay Area region August 29-31st, 2017. An additional four Los Angeles sites were identified and data were collected October 11-12th, 2017. Data collection dates for each site can be found in Appendix C.

[10] These differences in time period are not unusual of TIA studies. Data reported in ITE's *Handbook* represent a single hour within the time period of data collection.

Once a date for data collection was confirmed for each site, we coordinated with the on-site property manager to confirm building access. We also sent each property manager notices in English and Spanish to post in high-traffic areas in advance of the data collection. The notices were intended to inform residents when data collectors would present, what they would be doing, and how to visually identify them to dispel any anxiety about their presence (Figure 18 below).

We used Google Maps as well as photos taken during the June 2017 site visits to create a property "one-sheet" for each site. The one-sheet included a list of all access and egress points and a list of staffing assignments (see

Figure 19 below).

For the sake of consistency across Caltrans projects, we opted to contract with Teall Management, Inc., who managed the hiring of local staff for the Caltrans Smart Growth Trip Generation Phase II project. The firm worked with local staffing agencies in the San Francisco and Los Angeles regions to hire staff for data collection. In each region, the PSU team along led a short training with staff the day prior to starting data collection in order to explain the project and familiarize them with the tools being used. All staff were trained to conduct counts as well as to administer intercept surveys. However, bilingual staff were prioritized as interviewers.

On-site Data Collection Summary

On-site data collection consisted of cordon counts and an intercept survey (for more on the intercept survey protocols, see Appendix E. At each site on-site data collection staff were stationed at access and egress points as previously identified and were given a clipboard with a count sheet if they were assigned to count persons and vehicles, or they were given a tablet to use to administer the intercept survey. A site manager oversaw the staff at each site and collected all materials from staff at the end of each shift. Staff were also given fluorescent safety vests to wear along with a pin that identified them as part of a "Transportation Study."
Overall, on-site data collection efforts were successful. However, there were some issues that arose that are worth noting:

- Off-Site Vehicle Trips: In order to truly capture vehicle mode share, we would ideally be counting all the vehicles that parked *adjacent* to the site or vehicles that picked up/dropped off passengers as vehicle trips. The difficulty stems from the fact that staff counting vehicles entering/exiting via driveways were counting vehicle trips, but staff stationed at doorways were counting person trips. If a person arrived to a site by vehicle but parked off-site and walked up to the door, that person was counted as a person trip but their vehicle trip was not captured. The same is true for situations where people were getting picked up or dropped off, either by a friend or relative, or by a transportation network company (e.g., Uber or Lyft).

  The intercept survey did help to capture some of this information since respondents were asked to identify their mode of travel, but the intercept survey only represents a sample. The count data, on the other hand, provide a complete census. Ideally, we would have a way to accurately capture all vehicle trips as such in the count data.

  On the 2nd day of data collection in the San Francisco Area, we tried to devise a system to capture this data. We instructed counters to draw a box on their count sheet for a vehicle parked adjacent to the building or a pick-up/drop-off. The numerator was supposed to represent the number of people who got in or out of the vehicle, and the denominator was supposed to represent the number of people who stayed in the vehicle.

  This was also supposed to help us identify whether it was a parked vehicle or a vehicle that stopped to drop off or pick up passengers. (For example, for a parked vehicle we would write "2/0" indicating that 2 people got out of the car and 0 people remained after they exited. For a vehicle that dropped off passengers, we would write "2/1" meaning 2 people got out and 1 person remained in the vehicle.) This method did enable us to capture more information for some of the sites, but we determined that the data quality varied too much between sites to be able to use it. As a result, opted to limit our analysis to the person and vehicle trip information that was collected originally.

- Individual Site Issues:

  San Antonio Place: This site did not match our selection criteria as we had intended. The property manager did not inform us until we were on site for data collection that a majority of the units were reserved for special needs populations. As a result, we observed a higher rate of paratransit trips at this location than at other sites.

  Mission Gateway: This site had a Starbucks on the ground floor and while there was no internal access to the Starbucks from the residences, the Starbucks did generate a fair amount of its own vehicle trips. There were a few designated parking spots in front of the store for customers to use, which they accessed via a driveway from the adjacent street. During data collection, we observed that most Starbucks patrons entered and exited via the same driveway. However, there were some instances where patrons drove through the development to exit via a different driveway. Because the staff person assigned to count the driveway that was not adjacent to Starbucks was not in a position to differentiate between residential traffic and Starbucks traffic a system was devised to parse out those trips. The staff person adjacent to the Starbucks made note of any vehicles that entered via one driveway but exited via the other and reported that information to the staff person counting at the other driveway.

  Harbor View: This site is part of a multi-phase development and on the date of data collection, property management staff were interviewing residential applicants for the next phase of the development, which was slated to open soon. Interviews had been scheduled from 9:00 am – 3:00 pm and interviewees entered through the front gate. Although we could mostly separate out residents from interviewees, this did present an issue with data collection since it was an aberration from a "typical" day at the development.

Throughout the data collection process, staff members were instructed to make notes about changes that might need to be made during the data cleaning process. Once on-site data collection was complete the notes from each site were compiled into one list and were used to clean data as needed. (For instance, some intercept survey results were amended if an interviewer accidentally recorded 22 people traveling together when the correct number was actually 2.)

Figure 18 On-site data collection notice

Dear Residents,

We have been invited to participate in a research study about housing and transportation in California. Dr. Kelly J. Clifton and her team from Portland State University are overseeing the study. The project is funded by Caltrans.

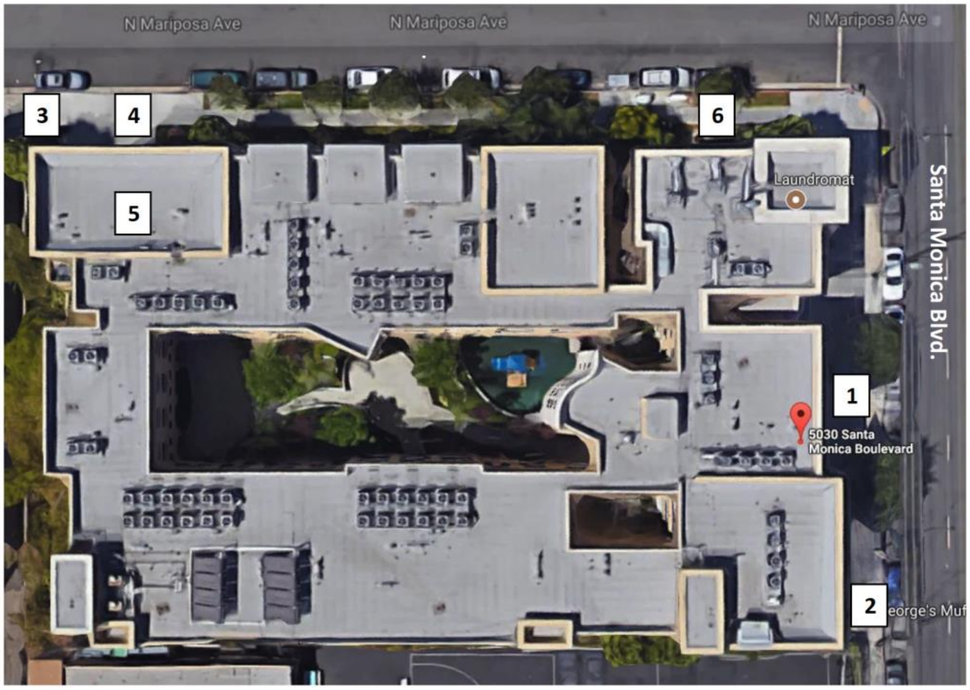
Members of Dr. Clifton's research team and a few additional temporary staff members will be at **Cathedral Gardens** to collect data. There will be approximately 4-7 staff members on-site from **7-10AM and 4-7PM on Tuesday, August 29**. Staff members will be counting people and cars as they enter and exit the building. They may ask you if you would be willing to answer a few short questions about your use of transportation. All staff will be wearing reflective vests and a button that says "Transportation Study."

In addition, you will soon be receiving a paper survey related to this research. The survey is short and should only take a few minutes to complete. A stamped envelope will be given to you to return the survey. We welcome your involvement; however, your participation is voluntary.

The information collected by the researchers will only be used for research purposes. Your identity and responses are confidential. If you have any questions or concerns, please contact us at INSERT CONTACT INFO. You may also contact Dr. Clifton and her team directly at [redacted] or [redacted].

Thank you!
Management

Figure 19 Site summary sheet example



Mariposa Place
5030 W. Santa Monica Blvd.
Los Angeles, CA 90029

Collection Date:
Tues. Aug. 22

Key:
1. Main Entrance (Ped)
2. Exit Only (Ped)
3. Exit Only (Ped)
4. Driveway
5. Garage
6. Entrance/Exit (Ped)

Mariposa Place

Staff Assignments:	Staff Name:	Tablet #:
Person counter at #1 and #2		
Surveyor at #1		
Person/vehicle counter at #3 and #4		
Surveyor at #5		
Person counter at #6		

Notes for Staff: **Property Contact:** **Internal Notes:**

Guidelines for Counters

1. The count data are the most important part of this study. While it is not difficult, it is important that you pay attention and mark the correct information on the sheet.
2. You are going to be assigned to count people or cars (noting how many people are in them) or both at a number of driveways or doorways. We want to know the total number of people coming and going from the site.
3. Do not count people that do not leave the property (e.g. people going outside to smoke or let their dog relieve themselves). Dog walkers who leave the property should be counted. Many people may be coming in one door and out the next but not really leaving the property. These people should not be counted.
4. When you count cars or trucks, note how many people are in each car or truck. On your sheet, mark a hash mark under the column that corresponds with the number of people in the car (1, 2, 3, or 4+). If there are 4 or more in the car, write the number of people in the car and put a circle around instead of using a harsh mark (e.g.⑤, ⑥). Do the same for delivery trucks or service vehicles except for 2+ people.
5. People should be counted every time they arrive to and depart from the apartment premises. It is okay to count them multiple times if they made multiple trips.
6. Similarly, it is okay if no one leaves or arrives at the property. There will be slow periods and if no one arrives or departs in a 15-min. time period, it is okay.
7. Every fifteen minutes, change the rows where you are recording your information. Every hour, change the count sheet. Please write your name on top of each sheet, with the date and time. Also, use the sheet to record anything unusual or questions you want to ask.
8. In the morning, parents may be waiting outside the apartment with their kids for the school bus. Only people who leave the premises should be counted. However, if parents walk their kids to school, everyone is counted as making that trip. This is relevant for both the surveyors and the counters. The parents can be surveyed at both ends of the trip and/or if you see the parents returning (and you surveyed them earlier), you can fill it out yourself.
9. Please let us know immediately if you encounter a situation where you are unsure what to do. In addition, any advice about improvements or problems are appreciated.
10. Please return your vest, button, data sheet, clipboard and tablet at the end of each shift.

Figure 20 Cordon Counts – Walkways

Building: ___________________Counter Name: ______________________Cell: _______________ Date: ___________ Start Time: ____:00 AM / PM

Minutes after hour	Direction	**Door Location:**		**Door Location:**		**Door Location:**		**Door Location:**		**Door Location:**	
		Walk	Bike	Walk	Bike	Walk	Bike	Walk	Bike	Walk	Bike
:00-:15	In										
	Out										
:15-:30	In										
	Out										
:30-:45	In										
	Out										
:45-:00	In										
	Out										

Figure 21 Cordon Counts – Driveways and Walkways

Building: ____________________Counter Name: _______________________Cell: ________________ Date: ____________ Start Time: ____:00 AM / PM

Minutes after hour	Direc-tion	**Driveway Location:**						**Driveway Location:**						**Door:**		**Door:**		**Door:**	
		Vehicles						**Vehicles**						**People**		**People**		**People**	
		Personal				Delivery		Personal				Delivery		Walk	Bike	Walk	Bike	Walk	Bike
		1	2	3	4+	1	2+	1	2	3	4+	1	2+						
:00-:15	In																		
	Out																		
:15-:30	In																		
	Out																		
:30-:45	In																		
	Out																		
:45-:00	In																		
	Out																		

[redacted] Intercept survey protocols and instruments

Data collection protocols for administration of the intercept survey follow those outlined in Appendix D. Additional guidelines and materials given to intercept survey staff can be found below.

Guidelines for Interviewers

1. Be friendly but persistent. Emphasize that we are only asking 5 questions about this trip. You can walk with them, if they are in a hurry. Once you are familiar with the survey, you can just ask the questions to those in a hurry without reading from the tablet and enter responses after they leave.
2. Be yourself but pay close attention to the question wording, as it influences the respondents' answers.
3. We are collecting information about a trip – a one-way journey from one destination to another.
4. If it is obvious that they are coming and/or going, you do not have to ask that question. Just enter the response and start with the questions about their mode of transportation.
5. We are interested in information about THIS trip only. Not people's general travel patterns.
6. If there is a group of people, **only survey one of them** if they are all traveling together.
7. Even if people did the survey earlier, they can do it again. We are interested in getting information about each trip that they make.
8. Some visitors to the site (non-residents of the apartments) may come from home. Check "Home" as their activity. If the visitor to the site is working there (e.g. landscaper, mail carrier, cable person), they may have come from their previous work location. In that case, mark "Work".
9. Trip distance is one-way only, not round trip.
10. A lot of the survey information can be collected based on observation - arriving/departing & number of people on the trip. If these things are obvious, you can just ask the relevant information – mode, distance and activity. Further, you can fill out the survey with information from observations (ONLY if you can discern the mode and number of people) and if the respondent refuses, enter refused on the rest of the survey.
11. Do not "practice" the survey during your shift. You will have time to practice during training each morning and afternoon.
12. Keep notes of any mistakes on a separate sheet of paper. Mark down the time of the survey and tablet used. We can correct them when we clean the data.
13. Please let us know immediately if there is something not working correctly on the tablet or if you encounter a situation where you are unsure what to do. In addition, any advice about improvements or problems is appreciated.
14. Please return your vest, button, data sheet, clipboard and tablet at the end of each shift.

Using Tablet and Notes About the Survey Application

1. Flip open tablet cover and slide dominant hand through hand strap on the back. Palm should be facing towards the tablet so that fingers can grip the side of the tablet. (Please do not remove the tablet from the cover.)

2. Press the round button on the top left-hand side of the tablet to turn the screen on/off.

3. DroidSurvey is the survey app. Tap to open app. The survey introduction and the questions are included in English and Spanish. Answers are only included in English.

4. The interviewer should hold the tablet close and face the interviewee during the survey. Only the interviewer should view the questions and answers.

5. Any trial surveys done as warm ups before the actual data collection period begins can just be left on the devices and filtered out prior to analysis based on completion time. Interviewers should enter data for a few trial surveys and resolve any questions with supervisor before actual data collection begins.

6. Items enclosed in parenthesis are notes for the surveyor and do not need to be read aloud to interviewee.

Tablet Survey Questions

1. After pressing "START" you navigate to the time/date screen. Press "SET" to automatically set date/time and then press "NEXT."

2. **Confirm whether interviewee is arriving or departing.**

3. **Collect transportation mode:** The software displays selections for the transportation mode question as "Pick 1" so that interviewees can indicate their PRIMARY mode for the trip. A follow-up question will ask them if they used or will use other modes. If they respond yes, the list of transportation modes will appear again and you can select multiple answers. If there is any question about a mode during an interview, please select "OTHER" and type in the answer.

4. **Collect number of people:** The question about the number of people traveling together specifically refers to the people **making the trip together.** (This does not include meeting someone somewhere.) If the interviewee is traveling alone "0" should be entered in response to that question.

5. **Collect distance traveled:** Ask the interviewee approximately how far they have traveled from their most recent destination or how far they will travel if they are leaving. Based on their answer, select either "BLOCKS" or "MILES." If they can't estimate the distance then select "DON'T KNOW." If you selected "BLOCKS" or "MILES" you will then be prompted to enter a value for the number of blocks or miles. You do not need to read this aloud but just mark down the number they indicated. (You can enter up to one decimal place, e.g. 2.5 miles.)

6. **Collect information about activities**: There is not limit on the number of activities that can be selected. If you have a question about what category an activity falls into, select "OTHER" and type in the response.

7. A "REFUSAL" button is available on each screen except for screens with numeric entry. If the interviewee refuses to answer a question that requires numeric entry, just press the "NEXT" button and move to the next question.

8. Note that the "BACK" button is enabled so that a response can be edited if the wrong button was pressed initially or the interviewee changes their answer.

9. When the "FINISH" button is pressed at the end the response is saved and you will automatically return to the top of the survey to start a new entry. If you need to access the Admin menu, press and hold the "START" button for several seconds.

10. The power button should be pressed quickly to turn off the device's screen and save battery charge between interviews (press quickly again to turn device back on and continue). Do not press and hold the power button or it will bring up options for Powering Off or Rebooting the device or toggling the Airplane Mode (just tap elsewhere on the screen to escape out of these options). If the power button is long pressed and Power Off or Reboot is accidentally selected, no data will be lost.

Figure 22 Intercept Survey Form[11]

Intercept Survey Form: As persons ARRIVE or DEPART, intercept as they approach or leave a specific entrance.
Name: __________________ Cell: ____________________ Building: ________________________
Door:___________________ Date: ___________________
Hello! Would you be willing to answer five questions about your transportation today? This is for a research project for the California Department of Transportation. *¡Hola! ¿Podría contestar cinco preguntas sobre su transporte de ahora? Es para un estudio del Departamento de Transporte de California.*
Time: ___________AM / PM

1. Are you arriving or departing? (Optional if it is obvious to you.) *¿Está usted llegando o saliendo? (Opcional si es que es evidente.)*
    a. Arriving ________
    b. Departing _______
    c. Refuse________

2. What is the primary mode of transportation that you used to get here or will use to get there? *¿Cuál es el principal medio de transporte utilizó para llegar aquí? ¿Cuál es el principal medio de transporte que utilizará para llegar a su destino?*

[11] This is the third and final iteration of the intercept survey. Versions 1 and 2 were used for data collection at 11 sites in Los Angeles. Version 1 was used for data collection on August 22,2017 and half of August 23rd, 2017. Version 2 was used for the remainder of August 23rd and August 24th, 2017. The sole difference between the first and second versions was an adjustment to collect information regarding group size for arriving parties. Between the second and final version, language in the survey introduction was simplified, the question “What activities are you returning from” was changed to “What activities were you doing at your last destination, and “coming from or going home” was added as an activity choice.

a. Drive personal vehicle (includes motorcycle) __
b. Passenger in personal vehicle ________
c. Taxi ________
d. Rideshare paid (e.g., Uber, Lyft) ________
e. Paratransit (e.g., services for seniors or people with disabilities) ________
f. Subway / light rail / commuter train ________
g. Bus ________
h. Walk (includes wheelchair) ________
i. Bike ________
j. Skateboard ________
k. Refuse to answer________
l. Other (please specify) _____________

3. Did you or will you use any other modes of transportation on this trip? *¿Usted utilizó otros medios de transporte en este viaje? ¿Usted va utilizar otros medios de transporte en este viaje?*
   a. Yes __________
   b. No ___________
   c. Refuse ________

4. What other modes did you or will you use on this trip? (Choose all that apply.) *¿Cuáles otros medios de transporte utilizó en este viaje? ¿Cuáles otros medios de transporte utilizará en este viaje? (Elija todos los que correspondan.)*

   a. Drive personal vehicle (includes motorcycle) __
   b. Passenger in personal vehicle ________
   c. Taxi ________
   d. Rideshare paid (e.g., Uber, Lyft) ________
   e. Paratransit (e.g., services for seniors or people with disabilities) ________
   f. Subway / light rail / commuter train ________
   g. Bus ________
   h. Walk (includes wheelchair) ________
   i. Bike ________
   j. Skateboard ________
   k. Refuse to answer________
   l. Other (please specify) __________________

5. How many people traveled with you or will travel with you on this trip including yourself? *¿Cuántas personas incluyéndose usted viajaron en este viaje?¿Cuántas personas incluyéndose usted viajarán en este viaje?*
   a. ____________ people

6. Approximately how far did you travel to get here from your last destination or will you travel to get to your first destination? *Aproximadamente, ¿Qué distancia viajó antes de llegar desde su último destino? Aproximadamente, ¿Qué distancia viajará para llegar a su primer destino?*

a. ___________ Blocks
b. ___________ Miles
c. Don’t know _______
d. Refuse _________

7. What activities were you doing at your last destination or what activities are you leaving to do at your first destination? (Choose all that apply.) / *¿Qué actividad estaba realizando en su último destino? ¿Qué actividades va a realizar en el lugar al que se dirige? (Elija todos los que correspondan.)*

   a. Work ________
   b. School ________
   c. Shopping ________
   d. Visiting with friends or family / recreation / entertainment ________
   e. Going to eat ________
   f. Church / community meeting / volunteering ________
   g. Running errands (includes appointments, personal business) ________
   h. Coming from home / going home ________
   i. Refuse to answer ________
   j. Other (please specify) ____________________

Thank you! / *Muchas gracias!*

[redacted] Calculating non-motorized vehicle mode shares

The intercept survey is used to provide additional information to support the calculation of non-motorized vehicle modes and their trip rates. The cordon counts reflect the entire population of site visitors; however, the intercept survey is administered to only a sample of them. Intercept survey respondents were asked their travel mode and group size, which allows a calculation of the sample person trips by mode and mode shares from the survey data. We apply the mode shares from the sample to these count data (total vehicle trips, total person trips, and vehicle occupancy) to calculate the non-motorized vehicle trips and rates.

The mode share responses from the intercept survey over each of the three-hour data collection periods are multiplied by the person counts from the ITE-defined peak hours[12] to arrive at trip rates for the various non-motorized vehicle modes for each peak. The motorized vehicle trip rates are calculated directly from the cordon counts. This process is described below.
We define the following variables from the observed during the cordon counts for the AM or PM ITE-defined peak hour, *c*:

> A_c: Person trips by motorized vehicle (Σ(vehicle trip*vehicle occupants)),
>
> P_c: Person trips by all modes observed during the cordon counts, and

NA_c: Person trips by non-motorized vehicle modes, calculated from the following equation (or directly from observed data):

Equation 5: $NA_c = P_c - A_c$

Based on the intercept survey responses, *s*, we can also define the following:

> T_s: person trips by public transit (Σ (transit mode response*group size)) represented in the survey;
>
> W_s: person trips by walking (Σ (walking mode response*group size)) represented in the survey;
>
> B_s: Person trips by biking (Σ (biking mode response*group size)) represented in the survey; and
>
> NA_s: Person trips by non-motorized vehicle modes represented in the survey, calculated from:

[12] The ITE-defined peak hour is based upon the maximum sum of 4 consecutive 15-minute periods during the 7:00AM to 10:00AM peak period and 4:00PM to 7:00PM pear period.

Equation 6: $NA_s = T_s + W_s + B_s$

$\%T_s$: Transit mode share of the person trips by non-motorized vehicle modes represented in the survey, calculated from:

Equation 7: $\%T_s = \frac{T_s}{NA_s}$

$\%W_s$: Walk mode share of the person trips by non-motorized vehicle modes represented in the survey, calculated from:

Equation 8: $\%W_s = \frac{W_s}{NA_s}$

$\%B_s$: Bike mode share of the person trips by non-motorized vehicle modes represented in the survey, calculated from:

Equation 9: $\%B_s = \frac{B_s}{NA_s}$

To estimate the non-motorized vehicle person trips by mode for the ITE-defined peak hour, *c*, we multiply the observed person trips by non-motorized vehicle modes (NA_c) for the ITE-defined peak hour, *c*, by the various mode shares calculated from the sample. The following result:

T_c: Person trips by transit, calculated from:

Equation 5: $T_c = NA_c * \%T_s$

W_c: Person trips by walking, calculated from:

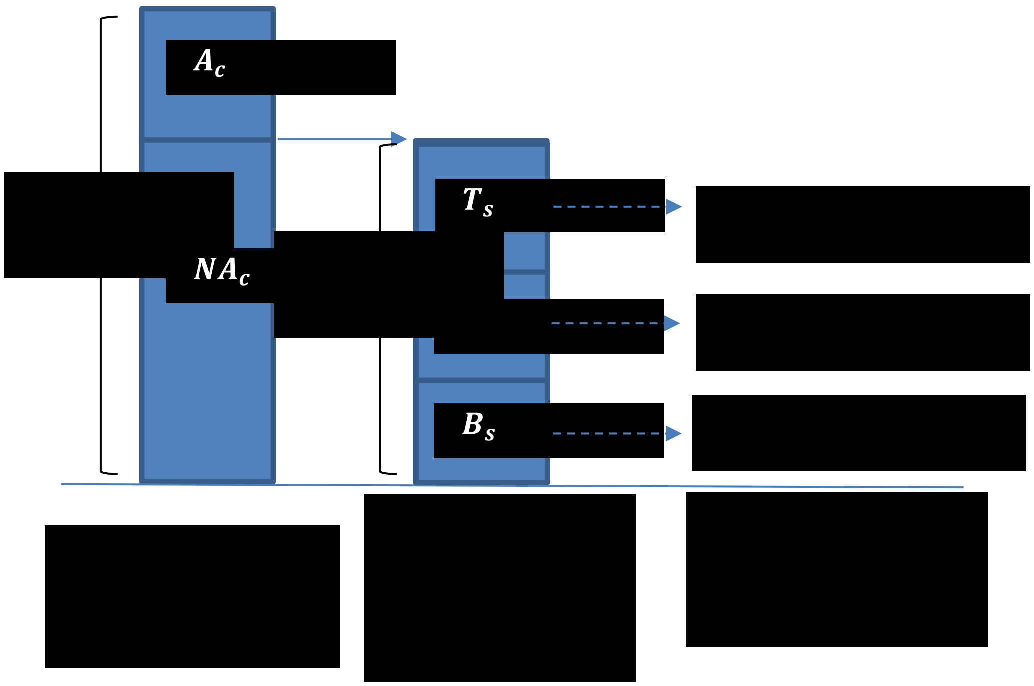
Equation 6: $W_c = NA_c * \%W_s$

B_c: Person trips by bicycle, calculated from:

Equation 7: $B_c = NA_c * \%B_s$

By dividing each of the estimated person trips by mode calculated from Equations 10, 11, and 12 by the total person trips observed, P_c , we can calculate the various shares of person trips for the non-motorized vehicle modes.

Figure 23 Calculation of non-motorized vehicle person trips for the ITE-defined peak hour



[redacted] Mail-out household Transportation Survey

The mail-out survey included 83 sites in addition to the 26 on-site locations for a total of 109 sites. For the mail-out survey we again limited our sample to sites that were 100% affordable and "open to all." Although we did not need access to the building for the mail-out survey, we did need a complete list of unit-level addresses and/or the contact information for a property manager who would be willing to help us distribute the survey to residents. For that reason, we primarily mailed sites that were included in the portfolios of the developers with whom we had already established a relationship. (For example, we mailed a number of sites included in one developer's portfolio even though we only collected on-site data at one of their sites). The survey was designed to gather information on household characteristics (e.g., income, size), resources (e.g., transportation options available), work and school travel behaviors, vehicle ownership, and vehicle miles traveled.

Once developers agreed to participate in the study they connected the PSU team with property managers at the majority of the sites. During the site visits in June 2017, property managers overwhelmingly indicated that they felt that residents would be more likely to respond to the mail-out survey if it were distributed by the property manager as opposed to delivered directly to residential mailboxes. During those initial conversations property managers also shared the most common languages spoken by residents, and based on that information we opted to translate the survey into seven languages: Arabic, Farsi, Korean, Mandarin, Russian, Spanish, and Vietnamese.

The mail-out survey was distributed in three waves. We coordinated the distribution of the survey with property managers at many of the sites. In those instances, the property manager received a packet of materials containing a survey, a letter of consent, and a self-addressed pre-paid envelope for each household, as well as a notice to post in high-traffic areas to help promote the survey (Figure 26 through Figure 29). In many cases, the property manager received the copies of the survey in multiple languages depending on the information they provided. However, even in the instances where surveys were sent in multiple languages, each household received only one self-addressed, pre-paid return envelope to prevent the same household from being sampled twice. Property managers distributed the survey to their residents but residents were not required to return them to their property manager. They were instructed to use the self-addressed, stamped envelope to return their survey directly to PSU.

In the situations where a property manager was either unavailable or did not have the capacity to distribute the survey to residents, those households received a packet of materials via direct mail. Households who received a survey via direct mail received two copies, one in English and one in either Spanish or Mandarin. Wherever possible, property managers at direct mail sites were asked to post notices about the survey to help increase awareness of it.

The first wave of materials was distributed in November 2017 to 56 sites (approximately 4,100 households). The second wave of surveys was distributed to 51 sites (approximately 3,500 households) in January 2018. In the first two waves, both modes of survey distribution were utilized (via property managers and via direct mail). A third wave was distributed in attempt to improve the overall response rate. In the third wave, survey materials were re-distributed to 33 sites from the first two waves, including 24 of the on-site locations, as well as two additional sites that had not been previously surveyed. All households were mailed directly in the third wave in order to streamline distribution. An incentive was outlined in the survey materials. Households that returned the survey were entered into a drawing to win one of twenty (20) $25 Visa gift cards.

We received a total of 360 responses across the three waves out of 7,836 households mailed for a response rate of 4.6%. We received responses from residents at 82 of the 109 developments that were included in the sample. On average, 4.4 surveys were returned from each site, with a maximum response rate of 10%. After a discussion with Caltrans staff, it was agreed that even though the survey response was lower than hoped no additional attempts would be made to increase the response rate after the third wave. The distribution and response rates are summarized in Table 31.

Table 31 Mail-out Survey Response Rates by Place Types

Land Use		Wave 1	Wave 2	Wave 3a	Wave 3b*	TOTAL	Response Rate
Urban Core	Sent	410	644	-	450	1054	7.9%
	Received	39	28	-	16	83	
Urban District	Sent	143	258	-	277	401	4.2%
	Received	3	7	-	7	17	
Urban Neighborhood	Sent	1427	1053	96	1036	2576	4.9%
	Received	65	54	4	4	127	
Suburban Neighborhood	Sent	2260	1451	94	607	3805	3.5%
	Received	91	34	2	6	133	
TOTAL	Sent	4240	3406	190	2370*	7836	4.6%
	Received	198	123	6	33	360	

*The 33 sites from wave 3b had already been sent surveys in wave 1 or 2; surveys were re-sent to these sites to increase response rates.

The spatial distribution of these sites in the Los Angeles and Bay Area regions are seen in Figure 24 and Figure 25, respectively.

Figure 24 Mail-out Survey Sites in Los Angeles Region

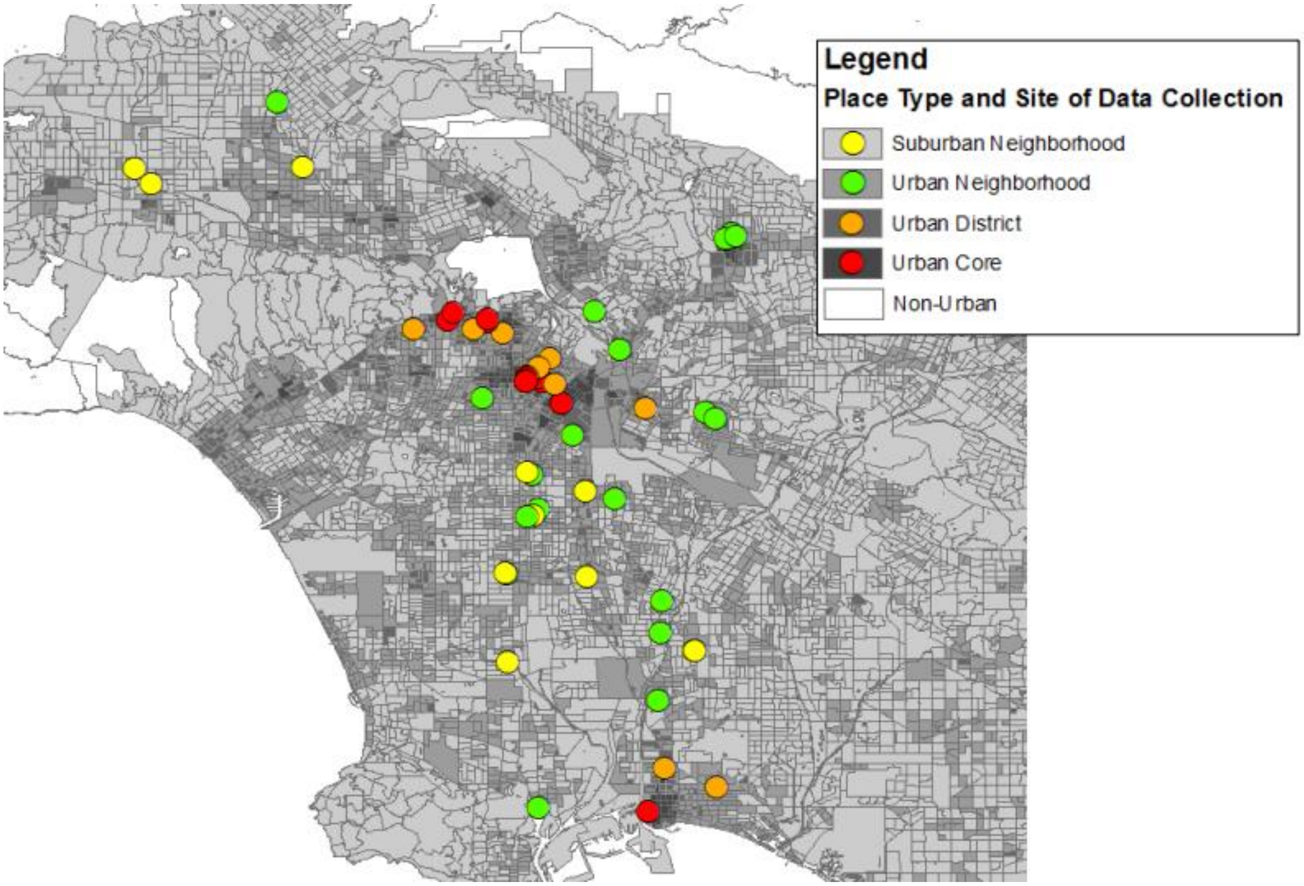


Figure 25 Mail-out Survey Sites in Bay Area Region

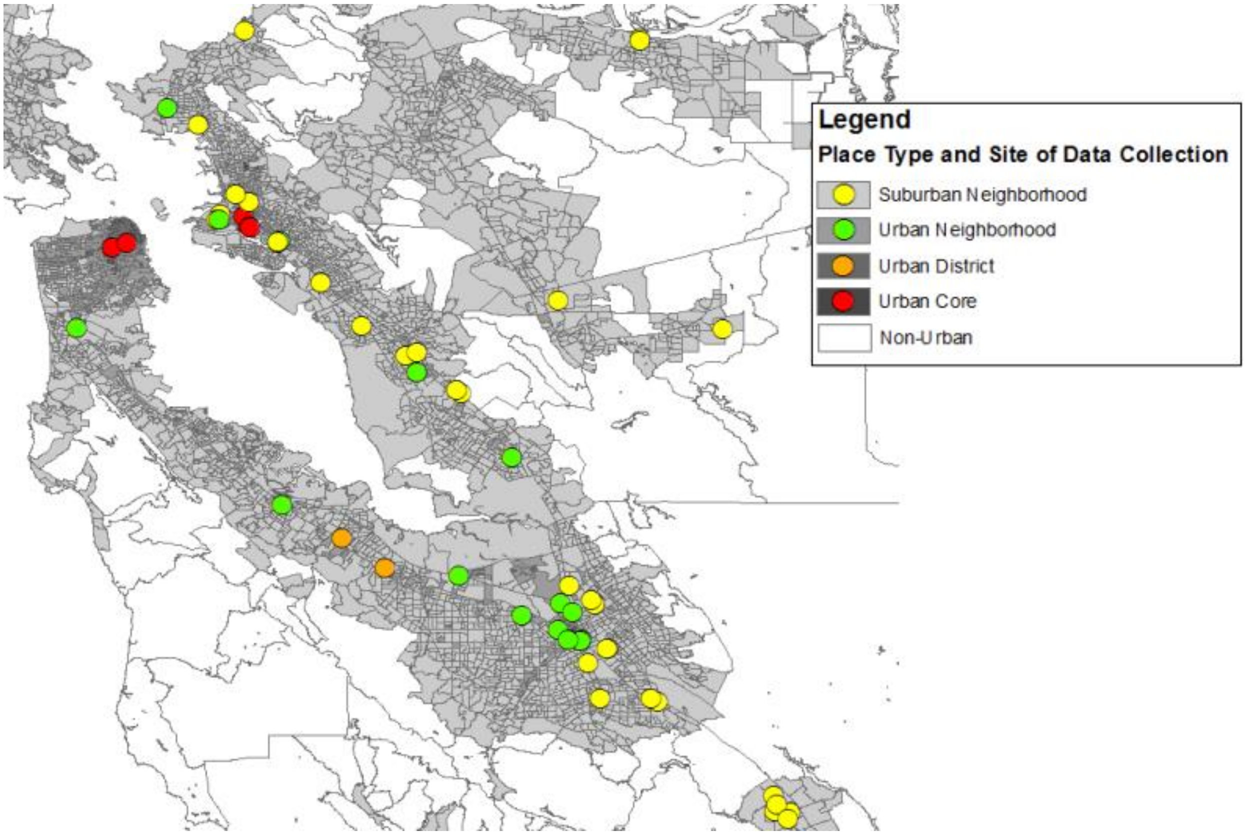


Figure 26 Mail-out survey data collection notice

Dear Residents,

We have been invited to participate in a research study about housing and transportation in California. Dr. Kelly J. Clifton and her team from Portland State

Dear Residents,

We have been invited to participate in a study about housing and transportation in California. Dr. Kelly J. Clifton and her team from Portland State University are overseeing the study. The project is funded by Caltrans.

You will soon be receiving a survey that is part of this study. The survey is short and should only take a few minutes to complete. A stamped envelope will be given to you to return the survey.

We welcome your involvement; however, your participation is voluntary. **Everyone who completes the survey and returns it is eligible for a drawing for a chance to win a $25 gift card.**

The information collected in this survey will only be used for research purposes. **Your identity and responses are confidential.** If you have any questions or concerns, please contact Dr. Clifton and her team at [redacted] or [redacted]

Thank you!
Management

Figure 27 Mail-out survey data collection reminder

Portland State University

It's not too late!

You recently received a short survey from our research team asking you a few questions. **We would still love to hear from you if you have not yet completed it! Your input is important to us.**

Everyone who completes the survey and returns it is eligible for a drawing for a chance to win a $25 gift card. We ask that you please complete it and put in the mail by January 19 to be eligible to win. You can return it in the pre-paid envelope included with the survey. No additional postage needed!

Thanks, and Happy New Year!

Kelly J. Clifton, Ph.D.
Portland State University
Dept. of Civil and Environmental Engineering
[redacted]

Figure 28 Mail-out survey instructions and consent form

Portland State UNIVERSITY

Housing and Transportation Study Consent Statement

You are invited to participate in a research study about housing and transportation. This research is being conducted by Dr. Kelly J. Clifton and her research team from Portland State University. We are interested in learning more about the transportation choices that you and your household make.

We ask that one adult from your household (18 years of age or older) complete this brief survey, which should take approximately 5 minutes, and return it using the postage-paid envelope provided. Your involvement in the study is completely voluntary and the information you provide will be used for research purposes only. Your answers will be confidential and no identifying information about you or your household will be disclosed.

If you need additional space to answer any of the questions, please use a separate sheet of paper and return it along with your survey. See the reverse side for an example of Question 9.

Everyone who completes the survey and returns it is eligible for a drawing for a chance to win one of 10 $25 gift cards. To enter this drawing, you must put your name and contact information on the form below. This information will not be associated with your survey information. **Please return the survey within two weeks.**

If you have any questions about the Housing and Transportation Study or if you would like to request this survey in another language, please feel free to call us at [redacted] or email us at [redacted] If you have questions regarding your legal rights as a research subject, please contact the PSU Office of Research and Integrity at [redacted]

Your input is valuable and will help make our study a success. Thank you!

Sincerely,

Dr. Kelly J. Clifton
Department of Civil and Environmental Engineering
Maseeh College of Engineering and Computer Science
[redacted]

Please enter my name in the drawing to win a $25 gift card.

Name: ____

Contact Information: ____

Please tear off the bottom portion of this sheet and return it along with your completed survey in the envelope provided.

Figure 29 Mail-out survey (English)

Portland State UNIVERSITY

Housing and Transportation Study

1. In the table below, fill out information regarding yourself:

	How often do you use the following:	For what kinds of trips do you use it for:
Transit pass	____ Every day or almost every day ____ A few times per week ____ A few times per month ____ Less than once a month ____ Never	____ Running errands *(e.g grocery shopping)* ____ Picking up or dropping off others ____ Commuting to work or school ____ Social activities *(e.g, visiting friends)* ____ Other: ____________
Carshare *(e.g., Zipcar)*	____ Every day or almost every day ____ A few times per week ____ A few times per month ____ Less than once a month ____ Never	____ Running errands *(e.g grocery shopping)* ____ Picking up or dropping off others ____ Commuting to work or school ____ Social activities *(e.g, visiting friends)* ____ Other: ____________
Bikeshare *(e.g., Ford GoBike)*	____ Every day or almost every day ____ A few times per week ____ A few times per month ____ Less than once a month ____ Never	____ Running errands *(e.g grocery shopping)* ____ Picking up or dropping off others ____ Commuting to work or school ____ Social activities *(e.g, visiting friends)* ____ Other: ____________
Rideshare *(e.g., Uber)*	____ Every day or almost every day ____ A few times per week ____ A few times per month ____ Less than once a month ____ Never	____ Running errands *(e.g grocery shopping)* ____ Picking up or dropping off others ____ Commuting to work or school ____ Social activities *(e.g, visiting friends)* ____ Other: ____________

2. In the table below, fill out the information for each vehicle belonging to you or someone in your apartment:

	Make (*e.g.,* Ford)	Model (*e.g.,* Focus)	Year	Daily Mileage (Estimate)
Vehicle 1				
Vehicle 2				
Vehicle 3				
Vehicle 4				

3. What is the zip code of your work and/or school location? *(If applicable.)* Work ________ School _________

4. How many working bicycles for adults are owned by the people in your household? ________

5. How many bedrooms are in your apartment?

____ Studio ____ 1 bedroom ____ 2 bedrooms ____ 3 or more bedrooms

6. How many parking spaces are assigned to your apartment in the building where you live? *Please indicate the total number even if you do not use them. Enter 0 if you do not have any.* Number of spaces: ______

Do you pay for parking? ____Yes ____No If yes, how much do you pay total? We pay: $______

7. What is the total monthly household rent for your apartment?

____ $0 - 499 ____ $1,000 - 1,499 ____ $2,000 - 2,499 ____ $3,000 - 3,499 ____ Prefer not to say
____ $500 - 999 ____ $1,500 - 1,999 ____ $2,500 - 2,999 ____ $3,500 or more ____ Don't know

8. To which income category does your household belong? *Please identify which category represents your total household income (total incomes for all persons living in the apartment) for the last year.*

____$0 - 9,999 ____$25,000 - 34,999 ____$50,000 - 74,999 ____$100,000 or more ____Don't know
____$10,000 - 24,999 ____$35,000 - 49,999 ____$75,000 - 99,999 ____Prefer not to say

9. Please use the table below to fill out information about <u>each person</u> who lives with you in your apartment:

	Age:	How many days a week does each person:	How many miles from home is:	How does each person *usually* get to work:	How does each person *usually* get to school:	Mark if each person has a:
Yourself	___ Under 16 ___ 16 to 65 ___ Over 65	Work: _____ Not applicable ___ Go to school: ______ Not applicable ___	Work: _____ miles School: _____ miles	___ Drive ___ Get a ride ___ Walk ___ Bike ___ Transit ___ Rideshare service	___ Drive ___ Get a ride ___ Walk ___ Bike ___ Transit ___ Rideshare service	___ Monthly transit pass ___ Carshare membership *(e.g., ZipCar)* ___ Bikeshare membership *(e.g., Ford GoBike)* ___ Rideshare membership *(e.g., Uber)*
Person 2	___ Under 16 ___ 16 to 65 ___ Over 65	Work: _____ Not applicable ___ Go to school: ______ Not applicable ___	Work: _____ miles School: _____ miles	___ Drive ___ Get a ride ___ Walk ___ Bike ___ Transit ___ Rideshare service	___ Drive ___ Get a ride ___ Walk ___ Bike ___ Transit ___ Rideshare service	___ Monthly transit pass ___ Carshare membership *(e.g., ZipCar)* ___ Bikeshare membership *(e.g., Ford GoBike)* ___ Rideshare membership *(e.g., Uber)*
Person 3	___ Under 16 ___ 16 to 65 ___ Over 65	Work: _____ Not applicable ___ Go to school: ______ Not applicable ___	Work: _____ miles School: _____ miles	___ Drive ___ Get a ride ___ Walk ___ Bike ___ Transit ___ Rideshare service	___ Drive ___ Get a ride ___ Walk ___ Bike ___ Transit ___ Rideshare service	___ Monthly transit pass ___ Carshare membership *(e.g., ZipCar)* ___ Bikeshare membership *(e.g., Ford GoBike)* ___ Rideshare membership *(e.g., Uber)*
Person 4	___ Under 16 ___ 16 to 65 ___ Over 65	Work: _____ Not applicable ___ Go to school: ______ Not applicable ___	Work: _____ miles School: _____ miles	___ Drive ___ Get a ride ___ Walk ___ Bike ___ Transit ___ Rideshare service	___ Drive ___ Get a ride ___ Walk ___ Bike ___ Transit ___ Rideshare service	___ Monthly transit pass ___ Carshare membership *(e.g., ZipCar)* ___ Bikeshare membership *(e.g., Ford GoBike)* ___ Rideshare membership *(e.g., Uber)*
Person 5	___ Under 16 ___ 16 to 65 ___ Over 65	Work: _____ Not applicable ___ Go to school: ______ Not applicable ___	Work: _____ miles School: _____ miles	___ Drive ___ Get a ride ___ Walk ___ Bike ___ Transit ___ Rideshare service	___ Drive ___ Get a ride ___ Walk ___ Bike ___ Transit ___ Rideshare service	___ Monthly transit pass ___ Carshare membership *(e.g., ZipCar)* ___ Bikeshare membership *(e.g., Ford GoBike)* ___ Rideshare membership *(e.g., Uber)*
Person 6	___ Under 16 ___ 16 to 65 ___ Over 65	Work: _____ Not applicable ___ Go to school: ______ Not applicable ___	Work: _____ miles School: _____ miles	___ Drive ___ Get a ride ___ Walk ___ Bike ___ Transit ___ Rideshare service	___ Drive ___ Get a ride ___ Walk ___ Bike ___ Transit ___ Rideshare service	___ Monthly transit pass ___ Carshare membership *(e.g., ZipCar)* ___ Bikeshare membership *(e.g., Ford GoBike)* ___ Rideshare membership *(e.g., Uber)*

Thank you! Please return the completed survey in the stamped envelope provided.

[redacted] Vehicle ownership model validation

Here we present the validation of the two vehicle ownership models: one developed in Section 4 using data from the California Household Travel survey and the other developed in Section 5 from the mail-our survey from this study. Data collected from a more recent National Household Travel Survey (NHTS 2017) (Federal Highway Administration, 2017), summarized in Table 32, were used to validate both the HTS models and the current models estimated using our mail-out survey responses.

Model validation

The current NHTS contains information about the travel behavior of US residents and was collected between April 2016 and May 2017. From the total 26,095 households in California from the NHTS, only the households that had income levels below the Average Median Income (AMI) as defined by the (California Department of Housing and Community Develpment, 2015) and were not classified as Refused or Unknown were selected to validate both models.

Table 32 Description of the Validation Dataset (NHTS 2017 subsample)

Dependent Variables	Descriptions	Mean	Std. Dev.
Household Vehicles	Count of personal vehicles owned by household	1.4	0.9
Vehicle Miles Traveled	Daily vehicle miles traveled	30.6	51.1
Independent Variables	**Descriptions**	**Proportion[1]**	
Region			
Los Angeles	Respondent lives in Los Angeles Area (Los Angeles County)	86%	
Bay Area	Respondent lives in Bay Area (Alameda, Contra Costa, San Francisco, San Mateo and Santa Clara Counties)	14%	
Household Size	Size of respondent's household	2.02	
Household Size Squared	Size of respondent's household, squared	5.66	
Household Income			
Low Income		37%	
Very Low Income		23%	
Extreme Low Income		40%	
Place Type			
Urban Core		7%	
Urban District		12%	
Urban Neighborhood		32%	
Suburban Neighborhood		49%	

Notes:
[1] Total valid households: 1119

The comparison of models with different model forms is complex. Simple measures such as pseudo R^2 measures should not be used to compare the performance to models using different forms. Instead, the performance of each model was tested using validation of the external dataset and compared along three main metrics: bias (mean error)[13], precision (standard deviation of the predictions)[14], and accuracy (root mean square error)[15] (Walther and Moore 2005), similar to how the count data were validated in Section 3.1. Two additional diagnostic approaches were used to compare model performance: exploring the distribution of predicted to observed values and exploring the over- and under-estimation of predictions compared with observed values. These two approaches allow for more disaggregate exploration of bias and accuracy. The following two subsections describe the findings from the analysis and validation of household vehicle ownership and vehicle miles traveled, respectively.

Because of the differences in the sample strategy between the mail-out survey and the 2012 CHTS, we use a third dataset to compare the performance of these two models. A sample of 1,119 households from California in the NHTS 2017 had valid data for the dependent and independent variables of Model 1 and were used to estimate vehicle ownership. The bias, precision, and accuracy of the models can be found in Table 33.

Table 33 Validation Metrics of Vehicle Ownership Models

	Model 1	Model 2
Source:	Mail Out	CHTS
Model Form:	Ordered Probit	Negative Binomial
Bias	0.29	-0.02
Precision	0.49	0.50
Accuracy	0.76	0.64

Note:
Source of method: (Walther and Moore 2005).

The bias can be interpreted as the average deviation from the observed value. Model 1 overestimate vehicle ownership (0.29) while Model 2 slightly underestimate vehicle ownership (-0.02), suggesting Model 2 had lower bias.

Precision can be described as the spread of error for the predicted values. The results suggest that both models are very similar, with 95% of the predictions falling within about one vehicle of the observed vehicles owned for Model 1 and Model 2 (two standard deviations of 0.49 or 0.50, respectively). This may be a result of the small variance of the observations, but both models perform well here.

[13] Calculated as $BIAS = \frac{\sum_{i=1}^{n}(Y-\hat{Y})}{n}$, where Y and $\hat{Y}$are observed and predicted values, respectively, for observations $i \in \{1, n\ observations\}$.

[14] Calculated as $PRECISION = sd(\hat{Y})$, where $\hat{Y}$are predicted values and $sd()$ is the standard deviation.

[15] Calculated as $ACCURACY = \sqrt{\frac{\sum_{i=1}^{n}(Y-\hat{Y})^2}{n}}$, where Y and $\hat{Y}$are observed and predicted values, respectively, for observations $i \in \{1, n\ observations\}$.

The accuracy measure considers the squared error in prediction, normalizing it with the size of the sample makes it sensitive to outliers. Comparing the performance of the validation sample, which indicate whether there are large outliers in Model 1 or Model 2, the results suggest relatively similar performances in terms of accuracy with slightly higher sensitivities in Model 1 (the model developed with a smaller sample size).

Table 34 and Table 35 explore the distribution of prediction accuracy of Models 1 and 2 using the NHTS (2017) sample. In generally, Model 1 underestimates vehicle ownership in the NHTS sample more frequently than using Model 2 (see Table 35)—39% versus 19%, respectively.

Table 34 Predicted and Observed Vehicle Ownership from Models (1) Mail-Out Survey Analysis and (2) CHTS Analysis using a Subset of NHTS 2017

		Predicted Vehicles Owned			
		0 cars	1 car	2 or more cars	Total Sample
Model 1					
Observed	0 vehicles	106	79	8	193
	1 vehicle	138	309	39	486
	2 or more	20	275	145	440
	Total	264	663	192	1119
Model 2[1]					
Observed	0 vehicles	23	165	5	193
	1 vehicle	8	420	58	486
	2 or more	0	208	232	440
	Total	31	793	295	1119

Notes:
Source: Model 1 – Mail out survey; Model 2 – CHTS 2010. Validation Sample: NHTS 2017
[1] As the outcome of the negative binomial model is not an integer, the results were rounded to next whole number to fit the categories listed.

Table 35 Estimation of Vehicle Ownership from Models (1) Mail-Out Survey Analysis and (2) CHTS Analysis using a Subset of NHTS 2017

	Model 1		Model 2[1]	
Overestimated	126	11%	228	20%
Accurate	560	50%	675	60%
Underestimated	433	39%	216	19%
Total	1119	100%	1119	100%

Notes:
Source: Model 1 – Mail out survey; Model 2 – CHTS 2010. Validation Sample: NHTS 2017
[1] As the outcome of the negative binomial model is not an integer, the results were rounded to next whole number to fit the categories listed.

Appendix I Technical Notes

Outlier Testing for Caltrans Affordable Housing Trip Generation Study

Due to the small sample size, we explored the influence of individual sites on model results. Using the outlier test for 'student residuals' (Neter, Wasserman, and Kutner 1989), two developments were identified as being outliers on the dependent variable—Mission Gateway observation of AM motorized vehicle trips and Troy's observation of PM person trips—but both observations were only slightly above the 3.0 value threshold used. The Mahalanobis test (Tabachnick and Fidel 1989) was used to explore multivariate outliers on the suite of independent variables (e.g., developments that *looked* different based on the suite of X-variables used), but no developments were found to be significant outliers. Cook's distance was used to identify potential influential cases (Bollen and Jackman 1985), but no observations were found to be 'influential' (with values greater than 2.5). To test for potential multicollinearity among independent variables, the variance inflation factor was used on all models with no issues found (Neter, Wasserman, and Kutner 1989).

Following, special attention was given to the Harbor View, Mission Gateway and San Antonio Place developments as they both were identified as having unique circumstances. The regression analysis was repeated with and without each of the observations (first without Harbor View, then without Mission Gateway, and so on). Removing Harbor View or San Antonio Place observations had little if any consequences to the performance of the model including the significance, direction, and size of the model coefficients. Mission Gateway did impact the effect size and occasionally the significance of the some of the variables in the AM peak hour models; however, after reviewing the context of the site and the data collection processes it was determined this observation was appropriate for analysis and be left in the regression.

Variable Significance for Caltrans Affordable Housing Trip Generation Study

While it can be useful to explore coefficient significance and effect size as well as model performance, this information does not provide us with a sense of which variables are most important in each model. To explore this, we calculated the contribution of each independent variable in explaining the variation of trip generation rates for each model (see Table 36)[16]. A higher level of variation explained indicates the variable matters more for the given model.

The results indicate that the parking ratio is the most important variable for predicting motorized vehicle trips in the AM or PM peak hour. The average number of bedrooms for each development, as well as employment density, were major contributors in all four regressions as well. Dwelling units was only significant in the PM motorized vehicle trip rate models, but since we've regressed the trip rate upon these variables, this finding (and its corresponding

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[16] To approximate the contribution of variation explained, the regression was estimated one additional time for each independent variable leaving that variable out. Following, the adjusted R^2 (explanation of variance, controlling for sample size) of the new model without the given variable was compared with the adjusted R^2 for the model including all variables. This process was repeated for each model and independent variable to derive the estimates in Table 36.

contribution in explaining variation) only suggests that the PM motorized vehicle trips per dwelling units seems to have a non-linear relationship with the number of dwelling units.

Table 36 Contribution to Explanation of Variance Explained (Amount Change in Adjusted R^2 Values) from the Four Models Presented in Table 7

Peak Hour:	AM		PM	
Trip Rate Model:	Motorized Vehicle	Person	Motorized Vehicle	Person
Structural Characteristics				
Dwelling Units	*n.s.*	*n.s.*	0.07	*n.s.*
Average Bedrooms	0.14	0.36	0.07	0.16
Parking Ratio (Spaces to Total Units)	0.25	*n.s.*	0.17	*n.s.*
Built Environment & Location				
Population Density	*n.s.*	*n.s.*	*n.s.*	*n.s.*
Employment Density	0.12	0.13	0.09	0.05
Distance from Nearest Transit Station (Miles)	*n.s.*	*n.s.*	*n.s.*	*n.s.*
Bay Area (Dummy)	0.11	0.08	0.05	*n.s.*

Notes:
Values indicate the change (increase) in the explanation of variance (adjusted R^2) before and after each variable is introduced *ceteris paribus*.
n.s.: Not significant

Pooled Data and Models for Caltrans and Los Angeles' Affordable Housing Trip Generation Studies

Next, we explore the use of these data as a pooled AM and PM motorized vehicle trip rate models, expanding the data provided in Table 7. The original models noted are the same models provided in Table 7 previously. First, the descriptive statistics are provided in Table 37; the original sample summary statistics were provided in

Table 5 and Table 6 the LA sample was summarized Table 8.

Table 37 Summary Statistics of Pooled Data (N=35) from Caltrans and Los Angeles' Affordable Housing Trip Generation Observations and Location Characteristics

	Median	Mean	Minimum	Maximum
Trips per Occupied Dwelling Unit				
AM Peak Hour (between 7:00-10:00AM)[a]				
Motorized vehicle trip rate	0.48	0.50	0.10	1.35
PM Peak Hour (between 4:00-7:00AM)[a]				
Motorized vehicle trip rate	0.38	0.37	0.11	0.78
Structural Characteristics				
Dwelling Units	60.0	65.9	20	121
Average Bedrooms[b]	2.20	2.07	0.03	2.82
Parking Ratio (Spaces to Total Units)	1.28	1.36	0.35	2.89
Built Environment & Location				
Population Density	26.3	32.9	3	177
Employment Density	7.5	25.4	1	273
Distance from Nearest Transit Station (Miles)	0.11	0.13	0.01	0.38
Bay Area (Dummy)	0	0.31	0	1

Note:
Sources: (Fehr & Peers, 2017), Caltrans Affordable Housing and Trip Generation Rates and Strategies
[a] Peak hour defined as peak period of the adjacent street, as per ITE.
[b] Studios were counted as zero bedrooms.

A pooled data model was estimated using the original model form including both the original study data as well as LA's data. The AM and PM peak hour motorized vehicle trip rates models are provided in Table 38 (AM) and

Table 39 (PM) below. For the AM Peak hour models, the results indicate no change in the significance of any variables, and there was only one minor change in effect size related to parking supply. Overall, the difference between the pooled model and original model suggests the pooled model has slightly more variation in trip rates—indicated by the slight reduction in adjusted R^2 despite the increase in sample size. It is likely that the LA observations (N=9) represent a smaller range in urban contexts, thus capturing a wider variety of trip rates for those observations.

Table 38 OLS Regression of AM Peak Hour[a] Motorized vehicle trips Using Caltrans' Data Alone and Pooled Caltrans and Los Angeles' Data

		Table 7 Model				Pooled Model			
		Coef	Elasticity	p-value		Coef	Elasticity	p-value	
1	Total Units	-0.001	-0.14	0.48		-0.001	-0.13	0.33	
2	Average Bedrooms[b]	0.19	0.75	0.01	**	0.19	0.80	0.00	***
3	Population Density (50 residents per acre)	-0.02	-0.86	0.74		0.005	0.33	0.87	
4	Employment Density (10s of jobs per acre)	-0.02	-1.03	0.01	**	-0.02	-1.01	0.01	**
5	Distance from Nearest Transit Station (Miles)	-0.36	-0.09	0.33		-0.16	-0.04	0.63	
6	Parking Ratio (Spaces to Total Units)	0.23	0.63	0.00	***	0.20	0.54	0.00	***
7	Bay Area (Dummy)	0.23	0.19	0.02	**	0.23	0.14	0.01	**
0	Constant	-0.12		0.48		-0.13		0.38	
	Observations				26				35
	R^2				0.75				0.66
	Adjusted R^2				0.66				0.57

Note:
[a] Peak hour defined as peak period of the adjacent street, as per ITE.
[b] Studios were counted as zero bedrooms.
"***": p-value < 0.01; "**": p-value < 0.05; "*": p-value < 0.1; ".": p-value <0.2

When comparing PM peak hour models, the results indicate only minor changes in effect size. In the pooled model, three of the four variables that were significant in the original model gained additional (although minor) significance. There was also an improvement in the significance of the Bay Area dummy. Although we discussed this in the last subsection, this finding indicates issues in site selection leading to a positive difference in trip rates here is only increased when including additional LA sites. Overall, the results indicate a small reduction in overall explanation of variance (adjusted R^2) despite the added sample.

Table 39 OLS Regression of PM Peak Hour[a] Motorized vehicle trips Using Caltrans' Data Alone and Pooled Caltrans and Los Angeles' Data

		Table 7 Model				Pooled Model			
		Coef	Elasticity	p-value		Coef	Elasticity	p-value	
1	Total Units	-0.002	-0.37	0.07	*	-0.002	-0.35	0.06	*
2	Average Bedrooms[b]	0.11	0.56	0.07	*	0.12	0.68	0.02	**
3	Population Density (50 residents per acre)	-0.05	-3.82	0.31		-0.02	-1.76	0.53	
4	Employment Density (10s of jobs per acre)	-0.01	-0.68	0.05	*	-0.01	-0.68	0.04	**
5	Distance from Nearest Transit Station (Miles)	-0.32	-0.11	0.32		-0.17	-0.06	0.53	
6	Parking Ratio (Spaces to Total Units)	0.15	0.52	0.01	**	0.14	0.50	0.01	**
7	Bay Area (Dummy)	0.13	0.14	0.10	.	0.16	0.13	0.03	**
0	Constant	0.15		0.32		0.05		0.67	
	Observations				26				35
	R^2				0.65				0.57
	Adjusted R^2				0.52				0.46

Note:
[a] Peak hour defined as peak period of the adjacent street, as per ITE.
[b] Studios were counted as zero bedrooms.
"***": p-value < 0.01; "**": p-value < 0.05; "*": p-value < 0.1; ".": p-value <0.2