Transportation Intensity Study

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FINAL REPORT

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Pitkin County
Colorado

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LIST OF ABBREVIATIONS AND DEFINITIONS

ACS – American Community Survey

ADT – Average Daily Traffic

CGAC – Community Growth Advisory Committee

DVMT – Daily Vehicle Miles Traveled

Employee Trips – Trips associated with either O&M or construction workers tied to a residential land use, including NHB trips

HBO – Home-Based Other, representing resident trips not related to work

HBW – Home-Based Work, representing residents related to work

HOA – Homeowner's Association

ITE – Institute of Transportation Engineers

KSF – 1,000 Square Feet

LEHD – Longitudinal Employer-Household Dynamics

LODES – LEHD Origin-Destination Employer-Household Dynamics

NAICS – North American Industry Classification

NHB – Non-Home-Based, representing construction and operational/management employee trips related to residential land uses

O&M – Operations and Management

Resident Trips – Trips generated by residents of the Unincorporated Pitkin County, including HBW and HBO trips

Residential Trips – Trips associated with residential land uses in UPC

UPC – Unincorporated Pitkin County

VMT – Vehicle Miles Traveled

EXECUTIVE SUMMARY

This Transportation Intensity Study was developed to understand how residential land use, particularly large homes, contributes to daily trip-making and vehicle miles traveled (VMT) in Unincorporated Pitkin County, Colorado. The County sought a data-driven approach to quantify how home size influences transportation demand. The analysis focuses on single-family homes, stratified by size, with particular emphasis on those over 5,750 square feet, a threshold previously identified by the County as associated with greater transportation impacts.

The results show a reasonable relationship between home size and transportation intensity, but not in the way traditional models might suggest. Pitkin County Resident trip production – trips made by residents of single family homes -- remain relatively stable across home sizes, with households generating between 8 and 8.6 resident trips per day on average. However, employee trips—those made by landscapers, property managers, cleaners, and contractors—rise significantly with home size. The largest homes in the dataset generate nearly five employee trips per day during periods of peak occupancy, compared to just half a trip for the smallest homes. These employee-related trips also tend to be longer, and, while they are expected to decrease during periods of low occupancy, it is estimated they persist at a higher rate than resident trips in large homes year-round.

This employee-related travel is a major contributor to countywide trips and VMT. Homes greater than 5,750 square feet represent 19.51 percent of all daily residential trips despite comprising just 14.36 percent of the housing stock in the Unincorporated County. Compared to the total daily trips produced in the Unincorporated Pitkin County (encompassing all land uses), residential land uses contribute 57.01 percent of all trips (excluding trips that pass through Unincorporated Pitkin County). Based on the available assessor's parcel data, residential land uses contribute roughly 20% of all parcels in the UPC, while large residential properties contribute only 3% of all parcels[1].

The study also reveals that trip purpose matters. Home-based work (resident commuting) accounts for only about 10 percent of total trips, while non-home-based employee trips and home-based other trips make up the majority. This reinforces the idea that large homes, especially those with high service needs exhibit atypical trip patterns compared to typical residences, generating more trips from employees/contractors than from the residents themselves. The impact of large homes on transportation infrastructure is more closely tied to their operations and labor intensity than to the number of full-time residents when considering the seasonal nature of many of the residents.

While this study has estimated the proportion of transportation intensity in the Unincorporated County attributable to residential land uses and efficiency-based metrics, there are some limitations related to the unique land use and behavioral characteristics of Pitkin County exhibits. Opportunities for future analysis include addressing these data limitations by conducting traffic counts in regions of the county with homogeneous housing profiles and limited access as well as conducting a household survey similar to those prepared for incorporated areas in Pitkin County.

1 It should be noted, the total number of parcels that residential parcels are compared to includes both vacant parcels as well as parcels designated with land uses that would not be expected to contribute transportation intensity, i.e. those designated for agriculture or natural resource collection currently in periods of no production. Thus, residential parcels may represent a higher proportion of occupied, in-use parcels.

INTRODUCTION

This study is intended to understand and quantify the transportation intensity associated with residential land uses in Unincorporated Pitkin County, Colorado. Transportation intensity is defined within this analysis as the portion of vehicle trips in Unincorporated Pitkin County associated with a given land use. A key assumption underlying the data analysis is that the transportation patterns related to residential land uses in the county, specifically related to large homes over 5,750 square feet, is a significant contributor to the growth of transportation intensity of the county. As the volume of large single-family residential development increases along with its associated activity, be it employment generated for construction and maintenance or additional residential vehicle trips on the roads, transportation presumably intensifies.

To better understand and quantify this relationship, the goals of this study are to

1. Define the existing transportation intensity by:
    a. The portion of vehicle trips and vehicle miles traveled (VMT) in Unincorporated Pitkin County that are related to residential uses, including home operating, maintenance, home service, and construction/development
    b. The portion of vehicle trips and vehicle miles traveled (VMT) in Unincorporated Pitkin County that are related to homes above 5,750 square feet
2. Identify metrics or proxies that can best quantify residential transportation intensity
3. Establish a quantitative baseline for transportation intensity, including trip-based efficiency metrics for Unincorporated Pitkin County

BACKGROUND

This study has been undertaken to quantify the qualitative assumptions and related recommendations put forth by the Pitkin County Community Growth Advisory Committee (CGAC). Per CGAC Final Report (2023) recommendations, "large houses generate substantial traffic growth, adding to traffic congestion and detracting from rural character". This underlying assumption has been studied and assessed using a variety of sources. The following discussion describes previous investigations into home size as it relates to trip generation and transportation intensity.

Community Growth Advisory Committee VMT Comparison

The *VMT Comparison Methodology* report conducted in 2021 for Pitkin County informs the assumption that large houses generate substantial traffic growth. The report summarizes existing quantitative and qualitative conditions within the County. Per conversations with County staff, large homes are defined as a managed property that is greater than or equal to 5,750[2] square feet. Per the 2020 Census, Pitkin County had 14,016 housing units. County staff estimates that of those units, 583 are "large homes" located in the Unincorporated County. These homes are assumed to produce more trips than smaller homes due to their unique occupancy patterns, travel behavior, and employment generated through their maintenance and upkeep.

Based on conversations and interviews with property managers and Homeowner's Associations (HOAs), it was estimated that workers conduct one maintenance trip daily to and from properties managed by a property management company. Property managers report that there are two distinct seasons with different management activities throughout the year:

- Peak Season, during which the homeowner is actively living in the home for between 2 and 3 months of the year.
    - Employees make 25 to 30 weekly trips to and from a given property while actively occupied.
- Off-Peak Season, during which the home is empty or at greatly reduced capacity for between 9 and 10 months of the year.
    - Employees make 5 to 10 weekly maintenance trips to and from a given property during periods of vacancy.

For HOA-managed properties, each property is estimated to utilize an average of two workers that independently make one trip to and from the property 5 days a week, 52 weeks per year.

These interviews estimate a baseline of 1,040 maintenance trips associated with HOA properties annually, or an average of 2.85 trips per day. For properties managed by property managers, it is estimated that there are 650 maintenance trips annually, or 1.78 trips per day.

Institute of Transportation Engineers

The Institute of Transportation Engineers (ITE) publishes trip-generation rates for specific land uses that are periodically updated as new data becomes available, based on case studies and observed transportation behavior. Generally, single-family detached housing (land use code 210) is estimated to produce, on average, roughly 9.43 trips per day per unit[3], described in **Figure 1**. While ITE publishes

2 https://pitkincounty.com/DocumentCenter/View/31288/VMT-Comparison-Methodology, accessed March 3, 2025

3 Institute of Transportation Engineers (ITE), *Trip Generation Manual*, 11th Edition (2021)

generation rates based on the number of units or number of residents, there is no documentation supplied estimating trip generation based on physical unit size. Due to this limitation and the unique behavior associated with residential land uses in Pitkin County, novel analysis is required to generate a trip generation rate for both employees associated with a residential property and its residents.

Figure 1 – ITE Trip Generation Summary for Single-Family Detached Housing

Single-Family Detached Housing
(210)

Vehicle Trip Ends vs: Dwelling Units
On a: Weekday

Setting/Location: General Urban/Suburban
Number of Studies: 174
Avg. Num. of Dwelling Units: 246
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
9.43	4.45 - 22.61	2.13

Unique Land Use Profiles and Special Markets

Special markets in transportation modeling refer to typically isolated and unique land uses that require tailored approaches due to their distinctive travel patterns and demands. Accurately assessing the inclusion and behavior of these markets is essential when aggregating transportation impacts on a regional scale. Special markets include a variety of use cases, for example, universities with high concentrations of students and staff with specific travel needs, airports which generate significant traffic from passengers and employees, or shopping malls. Special markets and unique land use profiles extend to subregions as well-- such as highly specific large-scale developments, large resorts and amusement parks, which can act as isolated sub-cities with unique trip generation within the broader municipality.

The unique behavior associated with large vacation homes in UPC acts as a special market segment dispersed on the regional scale. Inconsistent seasonal occupancy leads to fluctuating travel patterns, not only representing distinct patterns for home-based trips conducted by residents but also attracting disproportionately higher employment trips related to operations and management as compared to typical residential land uses. These factors further differentiate the residential land uses in UPC from the standard ITE considerations and necessitate further study to fully account for the unique impacts.

Aspen Residential Employment Generation Study

The City of Aspen conducted a comprehensive analysis of employment generation associated with residential properties, as documented in the 2015 *Aspen Residential Employment Generation Study*[4]. This study drew data from the 2014 Aspen Homeowner Survey, local economic analysis, and interviews with construction and property management professionals. Given Aspen's location within Pitkin County and its close ties to residential areas in the unincorporated county, the findings offer valuable insights into employment patterns and homeowner behavior across the broader Pitkin County region. This study has

4 *Aspen Residential Employment Generation Study*, City of Aspen, March 4 2015

three sections discussed below: Employment Generation Estimates in Aspen, the Aspen Homeowner Survey, and the Multi-Community Dataset.

Employment Generation Estimates in Aspen

Employment associated with residential units was estimated as the sum of construction employment (measured as employee-years of labor attributed to unit square footage averaged over an assumed 40-year career) and the ongoing operations and management labor associated with unit characteristics (such as type of property and floor area). Construction employment was found to grow at a linear rate of 0.110 employees per 1,000 square feet and 0.096 employees for single-family/duplex units and condominiums/townhouse units, respectively. Operations and maintenance employment was shown to grow at an exponential rate as floor area increases in single family/duplex units and at a linear rate in condominiums and townhome units, which tend to have a lower maximum floor area. Table 1 summarizes construction, operations, and maintenance employment, and total employment for different unit types at 500 square foot increments between 500 and 7,000 square feet. Past 7,000 square feet, the analysis found that O&M employment grew by 0.128 employees at 500-square-foot increments, while construction followed the same linear rate.

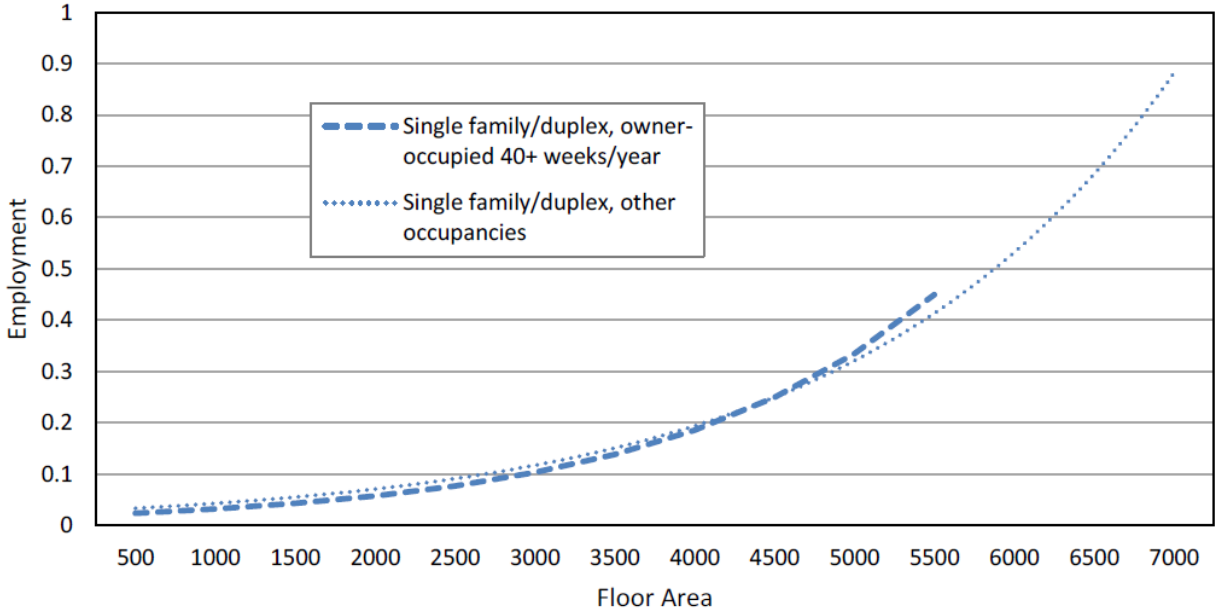
Table 1 – Estimated Employment Generation Associated with Free-Market Residential Units, by Unit Type

Floor Area	Initial Construction Employment		Operations and Maintenance Employment		Total Employment	
	Single Family/ Duplex	Condominium/ Townhome	Single Family/ Duplex	Condominium/ Townhome	Single Family/ Duplex	Condominium/ Townhome
500	0.055	0.048	0.034	0.085	0.089	0.133
1,000	0.110	0.096	0.043	0.126	0.153	0.222
1,500	0.165	0.144	0.055	0.167	0.22	0.311
2,000	0.220	0.192	0.070	0.208	0.29	0.4
2,500	0.276	0.239	0.090	0.249	0.366	0.488
3,000	0.331	0.287	0.115	0.290	0.446	0.577
3,500	0.386	0.335	0.146	0.331	0.532	0.666
4,000	0.441	0.383	0.187	n/a	0.628	n/a
4,500	0.496	0.431	0.239	n/a	0.735	n/a
5,000	0.551	0.479	0.306	n/a	0.857	n/a
5,500	0.606	0.527	0.391	n/a	0.997	n/a
6,000	0.661	0.575	0.499	n/a	1.16	n/a
6,500	0.716	0.623	0.638	n/a	1.354	n/a
7,000	0.772	0.671	0.816	n/a	1.588	n/a

Different types of occupancies were considered as well, both properties that are primarily occupied for most of the year by their owner and other occupancy types, including rental properties and vacation homes, on the basis that different occupancy types will represent different maintenance needs. While

construction is a constant linear rate, the curve representing the growth rates for O&M employment generation for single-family homes by owner use pattern is displayed in **Figure 2**.

Figure 2 – Modeled Relationship between Operations/Maintenance Employment and Floor Area: Single Family/Duplex Units, by Occupancy Type



Aspen Homeowner Survey

These generation rates represent the average of the datasets analyzed, while significant outliers do exist. Looking specifically at single-family/duplex units in Aspen, the 2014 Homeowner Survey cited in the *Employee Generation* Study found that most homeowners (87%) utilized some form of hired labor for O&M, ranging from a supplement to primarily owner-conducted self-maintenance to full property management. Of the respondents:

- 87% hire O&M Labor to some extent
- 78% conduct O&M themselves, using hired labor as a supplement
- 27% contract a property management company for O&M
- 21% belong to a Homeowner Association, handling some degree of O&M
- 8% maintain an on-site caretaker for the property

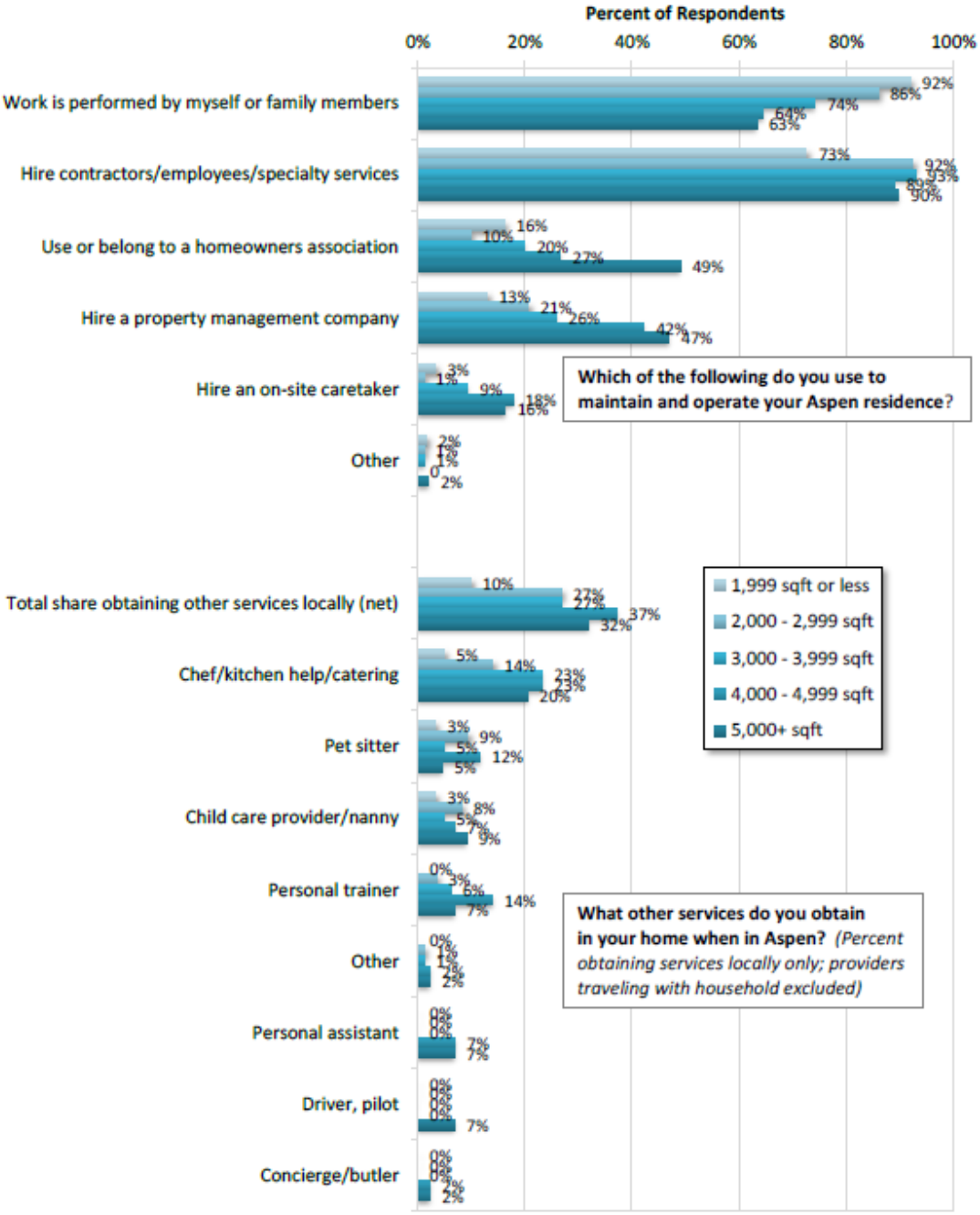
Additionally, 27% of homeowners hire additional services, including:

- 18% contracting a chef, kitchen, or catering staff
- 7% contract pet sitters
- 6% contracting nannies or child chare

These rates are stratified across different ranges of home sizes. Self-maintenance and owner-performed O&M is significantly higher at the lowest size range analyzed (under 2,000 square feet) at 92% than the highest size range (5,000 square feet and higher) at 63%. The opposite trend occurs when comparing the utilization of hired labor, as larger homes have higher utilization rates. The least intensive hired labor

categories see higher utilization in the mid-range of floor area (3,000 to 4,000 square feet), while utilization increases with large homes directly correlating to the cost and intensity of O&M, such as on-site caretakers. Figure 3 illustrates the relationship between floor area and the utilization of different categories of O&M.

Figure 3 – Providers Used for Home Operations and Upkeep, and Use of Additional Services Obtained In the Home: Single Family/Duplex Units, by Floor Area (Free-Market Units Only)



These trends were validated through interviews and surveys with both General Contractors representing the construction industry in Aspen as well as property management providers representing the O&M industry. Conversations with interviewees lent support to the analysis and subsequent estimation

methodology. Interviews with construction contractors were limited, providing a small sample of three projects confirming a range of labor intensity for project square footage in line with the estimation rates utilized, while five Property Management firms supplied a quantitative sampling of anonymized units which they supplied contracting services to. Randomly sampling three single-family/duplex properties, one with "high" employment/service needs, one with "average" needs, and one with "low" needs affirmed the results of this analysis and the broader Aspen Homeowner Survey. The median square foot size for a high needs unit was 8,000 square feet, 5,500 square feet for an average needs unit, and 3,200 square feet for a low need unit, ranging from 1,300 hours of labor annually on the high end to 175 hours of labor on the low end. Interviews with these firms reported that size, on-property amenities, the number of occupants, and time spent occupied were the most significant factors in determining the amount of labor a property typically contracts for, citing size as a significant trend.

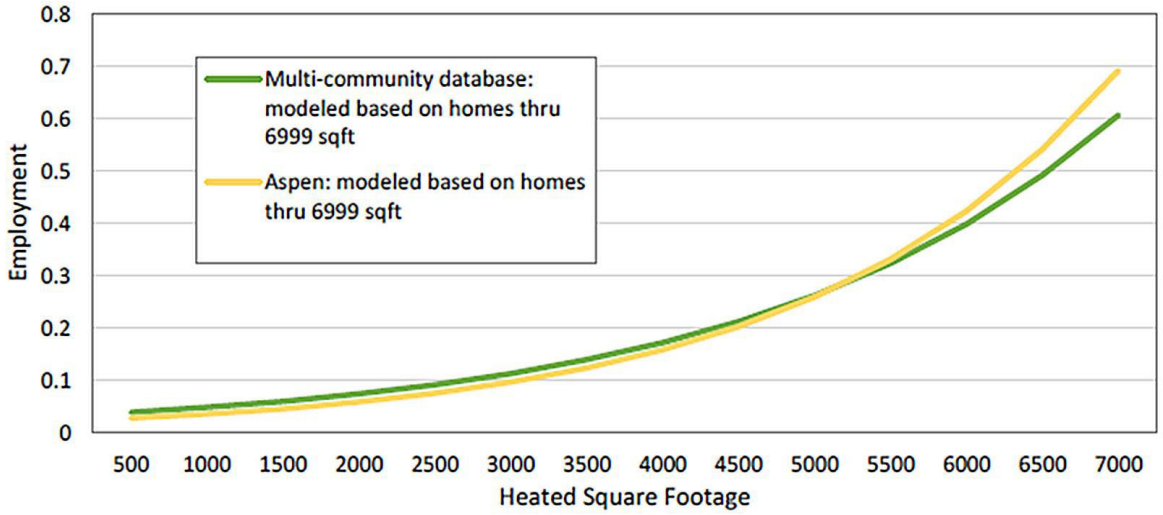
Multi-Community Dataset

In lieu of an extensive homeowner survey in Unincorporated Pitkin County, the analysis provided assumes that communities with representative characteristics of the unincorporated area within the broader county, immediate vicinity, and other representative areas will exemplify the trends within the unincorporated area today. The *Residential Employee Generation Study* cites several other surveys and studies conducted regarding employment generation across a variety of similar communities over 15 years, which has been aggregated in a Multi-Community Database. These studies include:

- Aspen, CO
- Snowmass Village, CO
- Breckenridge/Upper Blue River Valley, CO
- Unincorporated Gunnison County, CO (Pitkin's southern border)
- Unincorporated Eagle County, CO (Pitkin's northern border)
- San Miguel County, CO
- Teton County, WY
- Blaine County, ID

Comparing the results of employment generation for O&M for single family/duplex units across the aggregated multi-community database to the employment generation formulas and estimation methodology determined in the *Aspen Residential Employment Generation Study*, the analyses find nearly identical generation rates across the datasets, despite representing a blend of incorporated and unincorporated areas compared to a solely incorporated area. **Figure 4** illustrates the exponential curves generated from either dataset modeling the relationship between O&M and heated square footage in single family/duplex units. The curves demonstrate a direct correspondence between 500 and 6,000 square feet, observing diverging trends as square footage increases to higher sizes.

Figure 4 – Modeled Relationship between O&M Employment and Heated Square Footage, Single Family/Duplex Units: Aspen vs. Multi-Community Database



The shared characteristics between Aspen, the Multi-Community Dataset, and Unincorporated Pitkin County, the proximity between the modeled areas and Unincorporated Pitkin County, and the resulting trend correlating unit square footage to higher employment bolster assumptions made on behalf of CGAC tying large homes to higher rates of employment. The purpose of this analysis is to build upon the research previously conducted to quantify the trip-generation and thus transportation intensity attributed to unit size ranges in Unincorporated Pitkin County based on differences in employment generation, homeowner behavior, and travel patterns.

Pitkin County Transportation Impact Fee Study

The *Pitkin Transportation Impact Fee Study*[5] (2020) generated a unique trip generation rate specifically for "large" homes in Pitkin County. Utilizing traffic counts and property improvement reports provided by the County Assessor, seven cornered-off study areas in the County containing residential parcels were identified, relying on one focal road for access. Using the counts selected, all traffic to and from residences were captured, heated square footage of homes were summarized for the selected area, and average daily trips per improved residential property were generated for the peak season of traffic in the County, from June through August. With a sample size of 589 improved units across the 7 study areas, estimated daily trip generated rates were provided for homes with different average square footage at each site, producing a range of trip rates. Table 2 summarizes the trip generation rate range for the 7 selected areas.

5 *Transportation Impact Fee Study,* Pitkin County and RPI Consulting, July 31 2020

Table 2 – Average Daily Traffic (ADT) per Improved Residential Property for Unincorporated Study Areas compared to Thousands of Square Feet (KSF) per Property

Counter Location	Study Area	Average KSF per Property	# Improved Residential Properties	Peak Season ADT	ADT per Residential Property
Gateway Road at Snowmass Creek Road	Gateway of Snowmass Mesa Subdivision	2.7	71	464	6.5
Laurel Drive at Highway 82	Mountain Valley	3.3	121	902	7.5
Snowmass Creek Road above Watson Divide	Snowmass Creek	4.1	81	702	8.7
Glen Eagles at Maroon Creek Road	Aspen Highlands	5.0	22	245	11.1
Snowmass Creek Road above end pavement	Snowmass Creek	5.4	15	187	12.5
Red Mountain Road at Hunter Creek Bridge	Red Mountain	6.9	229	3671	16.0
Midnight Mine at Castle Creek	Midnight Mine Road	9.1	6	117	19.5

Applicability to Transportation Intensity in UPC

The sources discussed above identify behavior patterns consistent with the CGAC Final Report and act as a point of comparison with the following analysis regarding the Unincorporated County. Data collected to estimate employee generation rates in Aspen and in the Multi-Community dataset indicate that employment correlates positively with residential unit size and that incorporated areas with a similar profile to Unincorporated Pitkin County may behave similarly. Historical traffic counts in the Unincorporated County provided for the *Transportation Impact Fee Study* indicates that ADT correlates positively with residential unit size. The following analysis is oriented towards confirming and quantifying these trends within the Unincorporated County.

METHODOLOGY AND ANALYSIS

To assess and quantify transportation intensity in the Unincorporated Pitkin County by both home size and trip purposes, several steps were taken to build a simplified model that estimates trip production (the number of trips originating from a specific area), trip attraction (the number of trips ending in a specific area), and daily VMT for residential single-family homes based on unit size. The following discussion describes the sources utilized and the approach to analysis.

Sources

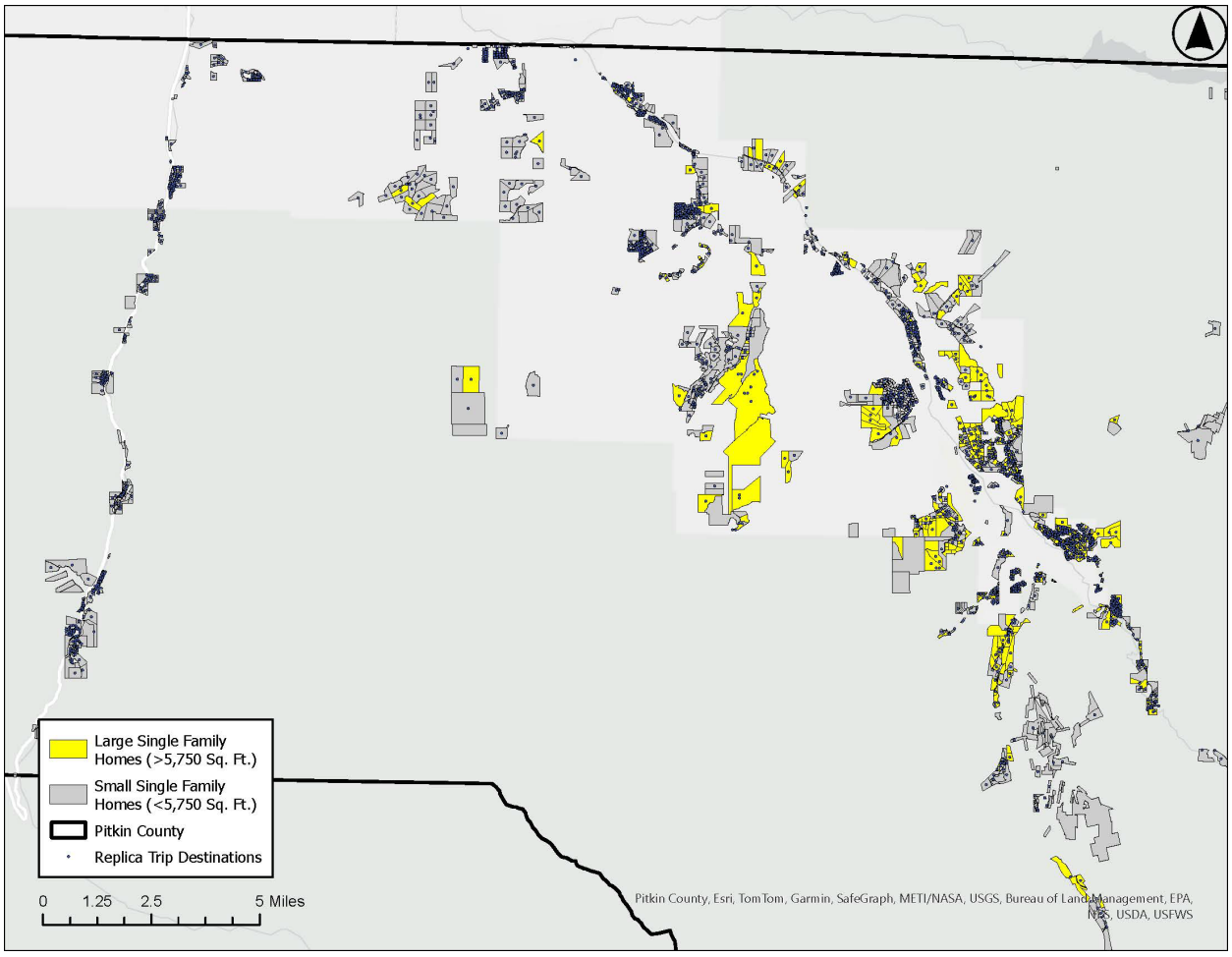
Data sources include:

- Census Data
    - Longitudinal Employer-Household Dynamics (LEHD) datasets, including the most recently available Origin-Destination Employment Statistics (LODES) 2022 dataset enumerated by 2020 census blocks.
    - TIGER Line/Shapefile Geographies for Pitkin County and the State of Colorado.
    - The most recent American Community Survey (ACS) datasets (2023) supplied 1-year and 5-year estimates regarding housing and employment information in Pitkin County.
- Replica
    - Replica is a transportation analytics platform built on large-scale mobile-based datasets and calibrated to ACS and LEHD Census data.
    - Fall and Spring 2023 datasets were utilized for analysis, modeling the most recently available full year.
- Pitkin County Assessor's Parcel Data (2024)
    - Pitkin County Assessor's data was employed, elucidating land use, unit size, unit values, and location for Unincorporated and Incorporated Pitkin County.
    - Large and Small Single Family Residential Parcels intersecting the Unincorporated County are visualized in
    - Figure 5.
- COVID-19 Contractor Survey (2021)
    - A survey conducted in 2021 among contracted workers traveling to job sites in Pitkin County was evaluated, providing travel mode, car/vanpooling rates, number of employees visiting specific addresses, and number of visits to specific addresses.
- Historical Traffic Count Data
    - Pitkin County's previously completed traffic counts across the County offered historical insight into road volumes in select locations.
- Colorado State Demography Office
    - Housing Characteristics (2023) summaries offered population, housing, and occupancy estimates for the most recently available year in the Unincorporated County and relevant nearby jurisdictions.
- US Bureau of Economic Analysis

- Employment by Industry Statistical datasets supplied annual employment by industry, including full-time, part-time, and full-time equivalent employment for Pitkin County.

- Previous Studies
  - *Aspen Residential Employment Generation Study* (2015)
  - *Pitkin County VMT Comparison Methodology* Report
  - *Pitkin County Transportation Impact Fee Study* (2020)
  - *Pitkin County VMT Analysis for 2019, and 2023* (2024)

Figure 5 – Large and Small Single Family Residential Parcels intersecting the Unincorporated Pitkin County



Approach for Resident Trip Generation (Replica)

Using Replica data and the assessor's dataset, the synthesized County population and all trips origin and destination points within the Unincorporated County were spatially analyzed to assess trips generated by residential properties attributable to residents of Pitkin County. Resident trip takers were identified using latitude and longitude values for home locations supplied in Replica's dataset, which also provided household and individual income, car access, work industry, and more. Any resident whose home location fell within a residential parcel labeled as a single-family home in the Unincorporated County was tagged as a resident. The trip table generated by Replica ties each unique trip to a person ID. All trips associated with residents of the Unincorporated County were summarized and sorted in matrices comparing the average

daily trips of residents by household income, unit size, car access, trip purpose (working commutes, home return trips, etc.), trips internal to the County, and regional departure[6]. The same matrices were used to generate resident trip generation rates and to estimate the average length of a single resident trip based on house size. The average trip length within the house's size range is applied to this trip rate to determine the total residential VMT associated with residents in the Unincorporated County when estimating VMT production at the unit-level. When aggregating attributable VMT for residents at the UPC-level, VMT was derived directly from the Replica trip table rather than estimated as a result of trip generation and average trip lengths.

The *Pitkin County VMT Analysis for 2023* identified seasonal factors used to estimate seasonal changes in county-wide transportation trends[7] calculate annualized daily VMT. The analysis produced an annualized VMT estimate using a distinct modeling framework that normalized for seasonality. However, this study emphasizes a peak occupancy by trip purpose, adding a level of complexity not addressable through Replica data alone. Since the two analyses rely on different datasets, serve distinct purposes, and were aggregated using separate methodologies, a direct comparison is not feasible.

Approach for Resident Work-Based Trips (LEHD)

Replica is calibrated to large-scale national datasets and produces accurate, high level results modeling travel behavior nation-wide. However, Pitkin County exhibits specific land uses, trip purposes, and occupancy patterns that are underrepresented in nation-wide datasets such as seasonal occupancy, residential maintenance-based employment, and decreased employment rates in larger homes that may be used as vacation properties. To accurately assess and isolate the portion of daily resident trips with the purpose of work, the average employment rate for different home sizes was assessed. Both the LEHD "OnTheMap" spatial analysis tool and the LODES raw origin-destination data for employment in Pitkin County were analyzed to assess the portion of transportation intensity attributed to Pitkin County residents' work-based tours. LEHD supplies the home Census block of employed people in the Unincorporated County. Centroids were generated for parcels within the assessor's dataset labeled as single-family residences. These centroids were spatially joined to the census-block geographies and sorted by unit living space at intervals of 2,750 square feet, beginning with all residencies below 3,000 square feet through residencies greater than 11,250 square feet to assess the average employment per unit at different size ranges. The total employment for each size range was divided by the sum of each unit's square footage within that size range, generating an employment rate per square foot. This unique generation rate reflects the portion of the total daily trip rate (and subsequently VMT) for a unit attributable to the resident's work-based tour.

6 It should be noted that trips tied to a resident's person ID may include trips made by ride-share services, personal drivers, or chauffeurs. Assuming that the trips is made with the primary purpose of transporting the resident, the trip is attributable to the resident rather than to non-home-based employment. Any additional trip made by the employee as a result is assumed to be captured by the NHB trip category.

7 *FINAL Vehicle Miles Traveled (VMT) Analysis for 2023*, Kimley-Horn, December 23, 2024

Approach for Employment Generation at Residential Properties

A draft study analyzing economic intensity in the Unincorporated County supplied an exponential equation to estimate a unit's employment generation rate based on its size[8]. This equation was analyzed and converted to a trip-generation rate. The economic and industry profile of Pitkin County was analyzed to gather the North American Industry Classification (NAICS) codes related to construction and operations, and management. Selecting trip-takers employed under any of these NAICS codes, a trip table representing any trip intersecting Pitkin County was generated using Replica. Each industry was analyzed to generate the average daily trips in commuting, work-based tour and the total vehicle miles traveled related to the commuting tour. Construction-related trips and operations and management trips were analyzed separately. Of the three types of construction represented in the dataset, mileage and trips produced were averaged to represent the final trip rate and vehicle miles traveled for construction employment generation. For operations and management industries, the weighted average of the County's employment profile was taken for both trip rates and lengths. To determine the resulting employment generation's proportion of construction and operational employment, it was assumed that the results at 1,000 square foot (87% operational and 13% construction) reported by the source study would apply at any size range.

Due to the large home sizes in Pitkin County, the exponential equation used to estimate employment generation exceeds the expected value of employment for large homes past a certain limit. To not exceed the employment estimates reported by the previously discussed interviews with property managers, the exponential equation is used for properties up to 9,250 square feet in size. For each additional 1,000 square feet past 9,250, a linear rate of 0.1 employees is applied. Thus, the trip rates generated using Replica are applied to the resulting construction and operational employment generated at a given unit's size to estimate the total employment-based trips generated by residential properties in the Unincorporated County. The weighted average trip length is subsequently applied to the resulting trip rate to determine the total employee-based VMT.

COVID-19 Contractor Survey Analysis

As an additional point of comparison for construction employment generation in the Unincorporated County, the COVID-19 Contractor Survey was analyzed in relation to residential parcels. Taking the raw survey data, responses were processed to standardize data formatting and to filter out erroneous entries. Each valid address and entry information was geocoded using a locator created with Census TIGER line geography for the Colorado road network, producing a spatial representation of contractor worksites. Each entry was spatially joined to the assessor's parcel data and analyzed at different size ranges to assess the volume of contractor and construction generated during the sample period. Significant points of departure were analyzed and compared to the base assumption for the size range encompassing large homes with significant impacts (greater than 5,750 square feet), as well as the average construction days, employees, and trips associated with parcels within these size ranges. These rates were then converted to trips and employment generated per square foot within each range. The resulting trends were used as a point of comparison against alternative construction estimation methods (i.e. economic intensity generation formula).

8 *Peer Community Comparison Matrix*, Economic & Planning Systems, Inc., February 3, 2025

Model Structure

The approaches above describe a model to define transportation intensity, by the share attributable to residential land uses, the purpose of transportation, and by the share attributable to large homes. For each size range, transportation intensity can be defined as the sum of total daily resident home-based trips and total daily employee non-home-based trips (NHB). Resident trips can be divided into two purposes: home-based work (HBW) trips and home-based other (HBO) trips. HBO trips are the result of the total daily resident work-based trips subtracted from the total daily resident trips. The average trip lengths by industry and trip purpose described above can be applied to the trip rates to estimate household vehicle miles traveled (VMT). These three trip purposes can be aggregated to the Unincorporated County level and divided estimating the daily trips and VMT for each category based on single-family units above 5,750 square feet and those below 5,750 square feet to quantify transportation intensity generated by residential land uses in the Unincorporated County.

RESULTS

Average Daily Resident Trips and Trip Lengths

To estimate transportation intensity in the Unincorporated County contributed by different characteristics of units, average daily trips generated by both residents and employees were analyzed. The results of the Replica analysis tracking average daily trips and the corresponding average trip lengths attributable to residents of the Unincorporated County are summarized in **Table 3**. The average daily trips generally positively correlate with a unit size, while average trip lengths present a U-shaped trend, increasing with the smallest and largest homes while decreasing in homes closer to 5,750 square feet.

Table 3 – Average Daily Resident Trips aggregated by Unit Floor Area

Category	<3,000 Sq. Ft.	3,000-5,750 Sq. Ft.	5,750 to 8,500 Sq. Ft.	8,500 to 11,250 Sq. Ft.	>11,250 Sq. Ft.
Average Trips	8.04	8.35	8.63	8.62	8.58
Average Trip Length (mi)	18.95	15.39	14.43	17.08	20.01
Average HBW Trip Length (mi)	15.20	14.35	13.94	13.37	16.32

Average Daily Resident Work-Based Trips

The proportion of the average daily resident trips found above attributable to residents' work-based tours were estimated utilizing spatial LEHD employment data within the Unincorporated County. The results of the LEHD analysis tracking average employment within a unit's size range, the maximum employment estimated for the range, and employment per unit square foot are summarized in **Table 4**. Employment sharply declines in units greater than 5,750 square feet, indicating that the many larger units have fewer than 1 permanently employed occupant. This trend accurately reflects economic data available for Pitkin County indicating that 68% of personal income is derived from non-labor sources, such as investments, interest, dividends, or retirement accounts[9].

Table 4 – Employment per Unit Square Foot, Maximum Employment, and Average Employment

Category	<3,000 Sq. Ft.	3,000-5,750 Sq. Ft.	5,750 to 8,500 Sq. Ft.	8,500 to 11,250 Sq. Ft.	>11,250 Sq. Ft.
Employment rate per Sq. Ft.	0.00076	0.00021	0.00007	0.00002	0.00001
Maximum Employment in Size Range	2.27	1.21	0.55	0.21	0.10
Employment for Average Size in Range	1.14	0.85	0.44	0.19	0.12

9 Headwater Economics' Economic Profile System, Pitkin County, accessed September, 2024

Employee Generation Formula

The modified employment generation formula for Unincorporated Pitkin County estimating both 40-year construction careers and ongoing O&M employment generated per 1,000 square feet of constructed residential property is shown in **Table 5**, and the curve representing that equation at different unit sizes is displayed in **Figure 6**. The weighted average O&M and construction trip tours generated from Replica are 2.69 and 2.10, respectively. The corresponding average trip lengths are 21.20 miles and 25.30 miles. The full industry breakdown is shown in **Table 6.**

Table 5 – Employee Generation Formula for Unincorporated Pitkin County (Peer Research)

Jurisdiction	Employee Generation Formula	Employee Careers Generation from 1,000 Sq. Ft. New Residential
Unincorporated Pitkin County	EXP(-4.64138+(0.000328* New Sq. Ft.)+2.00514 (Increases linearly by 0.1 per 1,000 new Residential Sq. Ft. after 9,250)	0.11(0.014 construction + 0.096 O&M)

Figure 6 – Employee Generation Formula Curve for Unincorporated Pitkin County

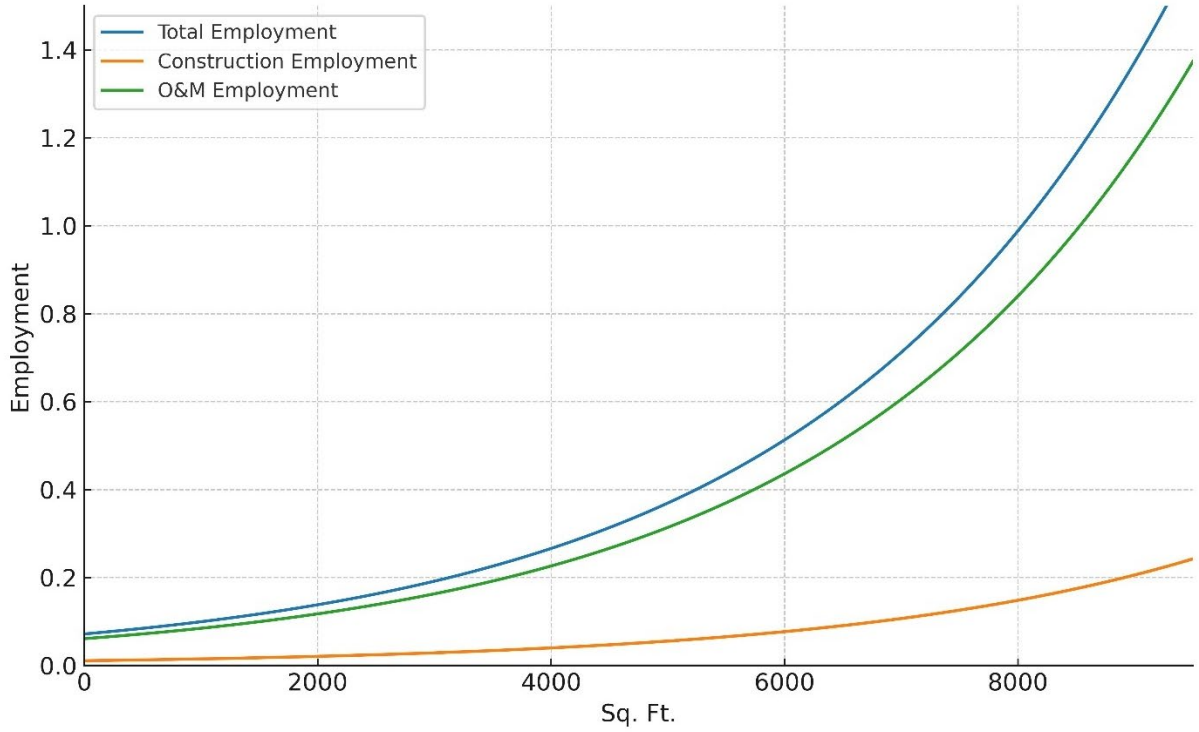


Table 6 – Weighted Average Industry Average Trip Tours and Lengths

Industry	Average Trips Taken	Average Trip Lengths	Percent of O&M
Real Estate and Rental and Leasing	2.84	17.45	8%
Residential Property Managers	3.51	17.49	31%
Administrative, Support, Waste Management Services	2.26	20.55	27%
Caterers	2.67	24.47	3%
Other Services (except Public Administration)	2.42	29.36	27%
Pet Care (except Veterinary) Services	3.43	17.52	1%
Construction	2.10	25.30	--*
O&M Average:	2.69	21.20	--*
Construction Average:	2.10	25.30	--*
*Construction, O&M Average, and Construction Averages do not represent a proportion of total O&M			

COVID-19 Construction Survey Validation

The results of the spatial analysis after processing the COVID-19 contractor survey were used both as a validation measure of the upward trend in construction employment generation with unit size, as well as an indication of the size limit when employment associated with residential properties reaches its greatest disparity. To assess this, the number of average worker trips per day were analyzed for unit sizes at intervals of 1,000 square feet, starting at 1,000 square feet. The number of average worker trips for units smaller and larger than the square foot value were compared side by side to assess the trend in worker trips to a property and identify at what size limit contractor trips are at their highest for larger homes as compared to smaller homes. The results are displayed in **Figure 7**. The positive correlation with increasing unit size seen in the employment generation formula is similarly seen in the contractor survey. The point where worker trips are at their greatest for homes larger than the unit's size in relation to homes smaller than its size, is at 8,000 square feet. This indicates that while large managed homes are defined as homes larger than 5,750 square feet, there may be a higher disparity between smaller and larger home transportation intensity impacts when analyzing a higher limit such as 8,000 square feet The total number of workers present on-site per day divided by unit size ranges are presented in **Figure 8**, excluding any outliers with little to no survey results that may skew the dataset. The line displayed in **Figure 8** does not represent a fit for the data but rather a trend, limited by the availability of survey responses.

Figure 7 – Average Worker Trips per Day Greater and Lesser than Unit Size

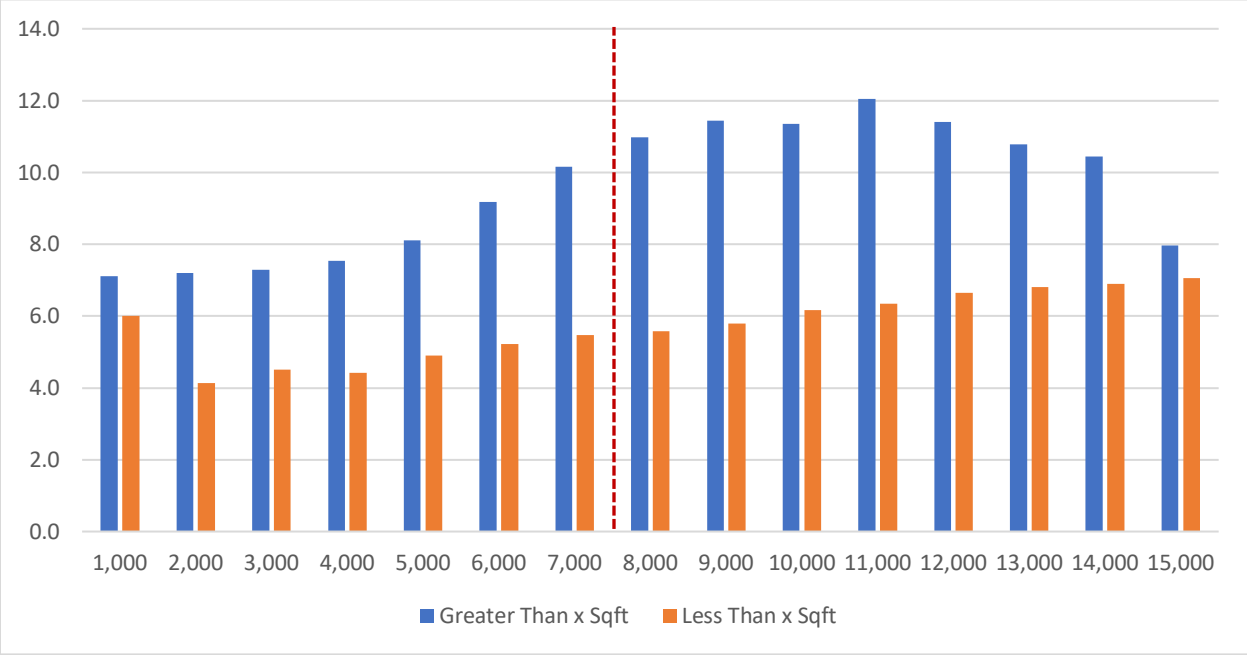
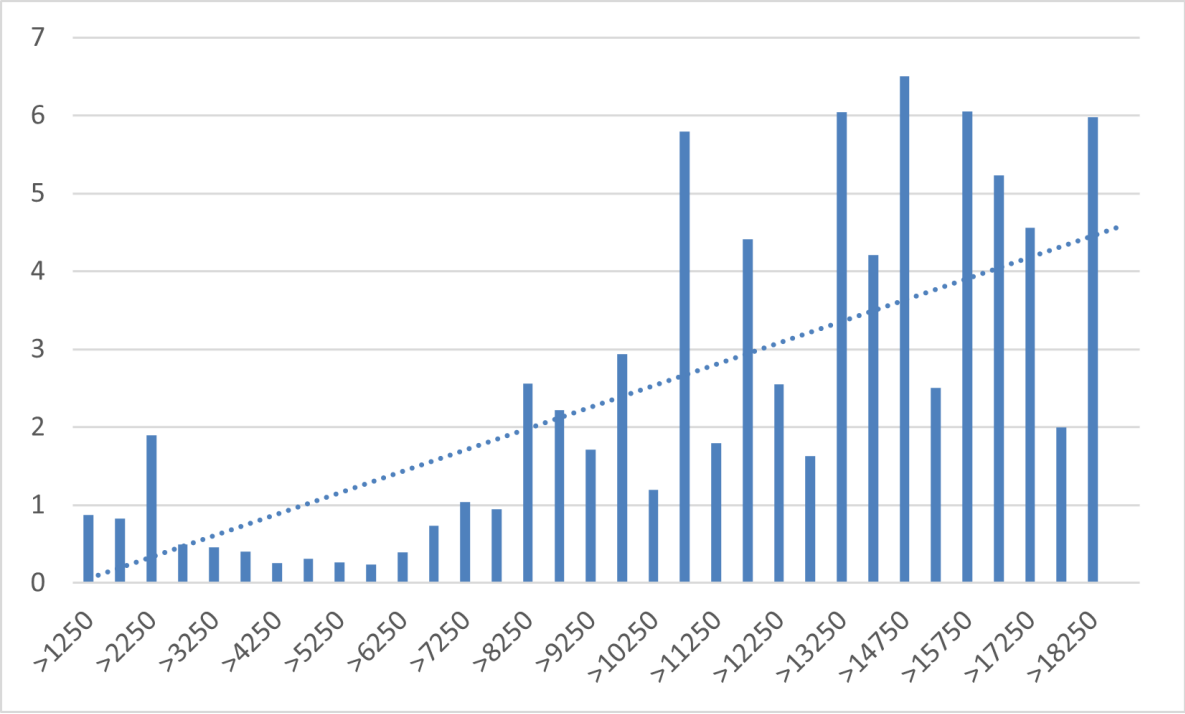


Figure 8 – Average Workers on-site per Day by Unit Size (Sq. Ft.)



FINDINGS

Transportation Intensity

The results of the analyses described above provide a model for transportation intensity in the Unincorporated Pitkin County used to achieve the guiding study goals. To quantify residential transportation intensity, the trips produced by large and small homes were aggregated to the Unincorporated County-level and compared as a residential total against the total daily trips produced by all land uses.

Goal 1: Define the existing transportation intensity by:

a. The portion of vehicle trips and VMT in Unincorporated Pitkin County that are related to residential uses, including home operating, maintenance, home service, and construction/development

Findings are presented representing peak occupancy conditions for large homes across the Unincorporated County. The total daily residential trips encapsulate all vehicle trips related to residential land uses in Unincorporated Pitkin County, including home operations, maintenance, construction and resident trips. This value was compared to the total daily trips produced in the Unincorporated County regardless of land use. The results are summarized in Table 7. Residential land uses account for 57.01% of the Unincorporated County's total daily trips excluding trips passing through Unincorporated Pitkin County.

Table 7 – Daily Residential Trips compared to Total Daily Trips (Unincorporated Pitkin County)

Daily Residential Trips	Total Daily Trips	Percent of Total Daily Trips
24,988	43,834	57.01%

b. The portion of vehicle trips and VMT in Unincorporated Pitkin County that are related to homes above 5,750 square feet

To accurately assess transportation intensity for homes larger than 5,750 square feet, we compared both the total number of residential trips and the share of residential VMT generated by large and small homes to their respective share of the overall housing market. This allowed us to evaluate both the collective impact of large homes and the per-unit impact of individual large homes. The direct results for the proportion of trips attributed to large homes compared to small homes are shown in Figure 9. Comparing home size ranges to their market share, large homes represent an outsized impact on transportation intensity. The total residential trips and residential VMT at the Unincorporated County level compared to both categories are shown in Table 8 .

Figure 9 – Transportation Intensity as Residential Trip Contribution compared to Market Share

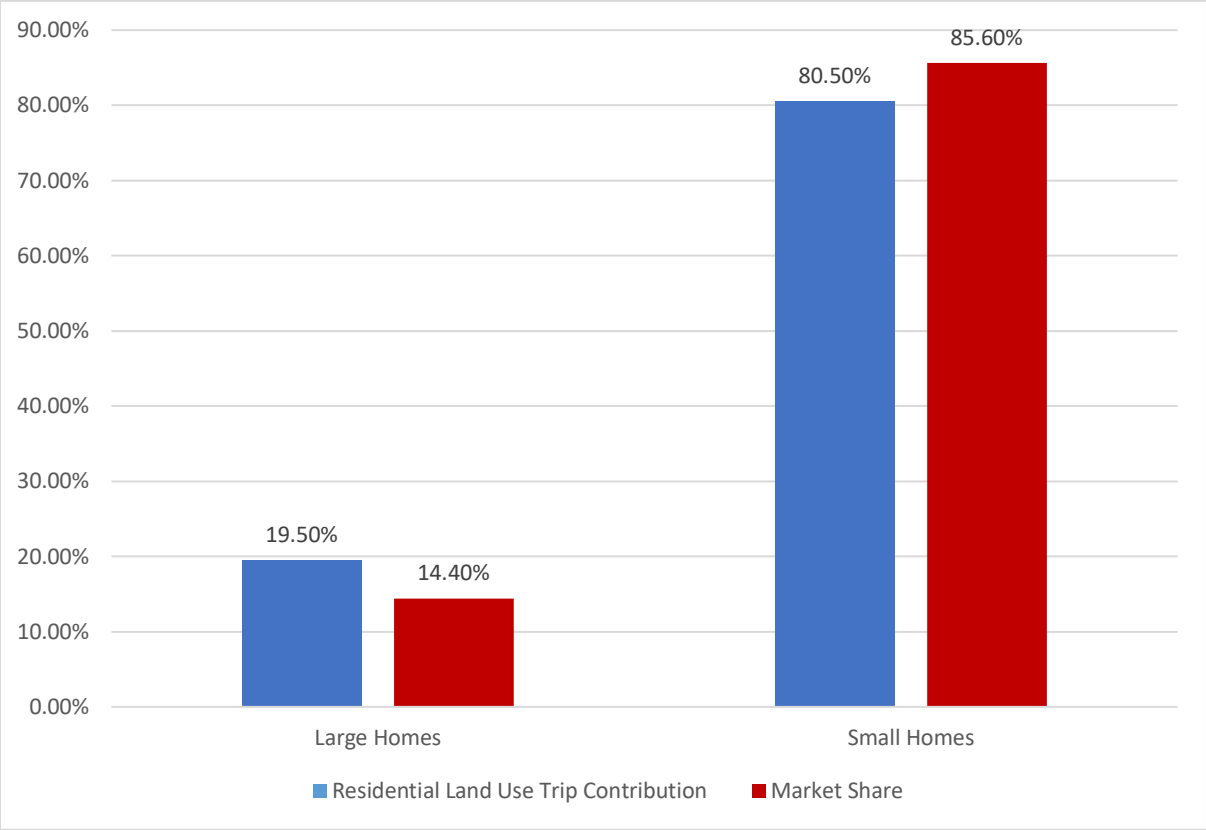


Table 8 – Total Daily Residential Trips and VMT in the Unincorporated County contributed by Large and Small Homes at Peak Occupancy

Category	Total Residential Trips	Percent of Total Residential Trips	Total Residential VMT	Percent of Total Residential VMT	Market Share
Unincorporated County	24,988	--	141,076	--	--
Large Homes	4,875	19.51%	41,333	29.30%	14.36%
Small Homes	20,113	80.49%	99,743	70.70%	85.64%

The share of trips contributed by specific trip purpose (Home-Based Other, Home-Based Work, and Non-Home-Based employment) is shown in **Figure 10**. The values shown are quantified in **Table 9**.

Figure 10 – Transportation Intensity as share of Residential Trips contributed by Trip Purpose

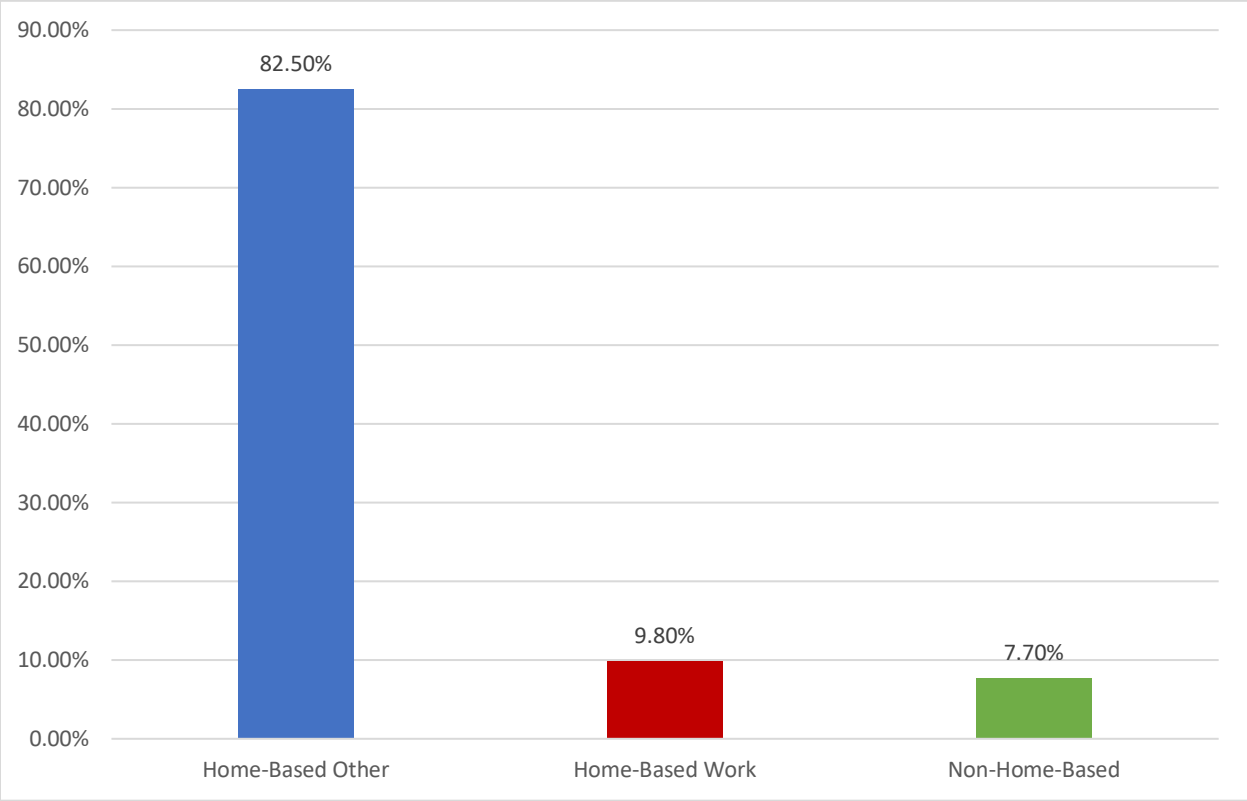


Table 9 – Total Daily Residential Trips and VMT in the Unincorporated County compared to Trip Purpose

Category	Total Residential Trips	Percent of Total Residential Trips	Total Residential VMT	Percent of Total Residential VMT
Unincorporated County	24,988	--	141,076	--
HBO	20,619	82.52%	110,974	78.66%
HBW	2,448	9.80%	11,793	8.36%
NHB	1,921	7.69%	18,309	12.98%

While all residential uses contribute significantly to the Unincorporated County's trips, homes larger than 5,750 square feet stand out. They represent just 14.36% of the housing stock, yet they account for:

- 19.51% of all daily residential trips, and
- 29.30% of total daily residential VMT.

The transportation intensity described above isn't just the result of resident behavior. In fact, employee trips—such as those made by landscapers, caretakers, cleaners, and contractors—grow steeply with home size at a unit level. Moreover, while the majority of trips are home-based errands, this trip purpose stays

relatively flat as unit size grows, while non-home-based service trips grow rapidly, a phenomenon not accounted for in standard transportation planning assumptions. Employee trips per household climb from just 0.5 trips/day for homes under 3,000 square feet to 4.87 trips/day for the largest homes. These trips are often longer as well, increasing VMT. **This pattern supports a broader finding: as homes get larger, they demand more labor, services, and travel—even when unoccupied.** The COVID-19 contractor survey showed a breakpoint at 8,000 sq ft, where large homes began attracting the most employee trips relative to smaller homes, which gives the model external validation. In summary, this reflects a transportation footprint tied to both the operation of the home as well as its occupation.

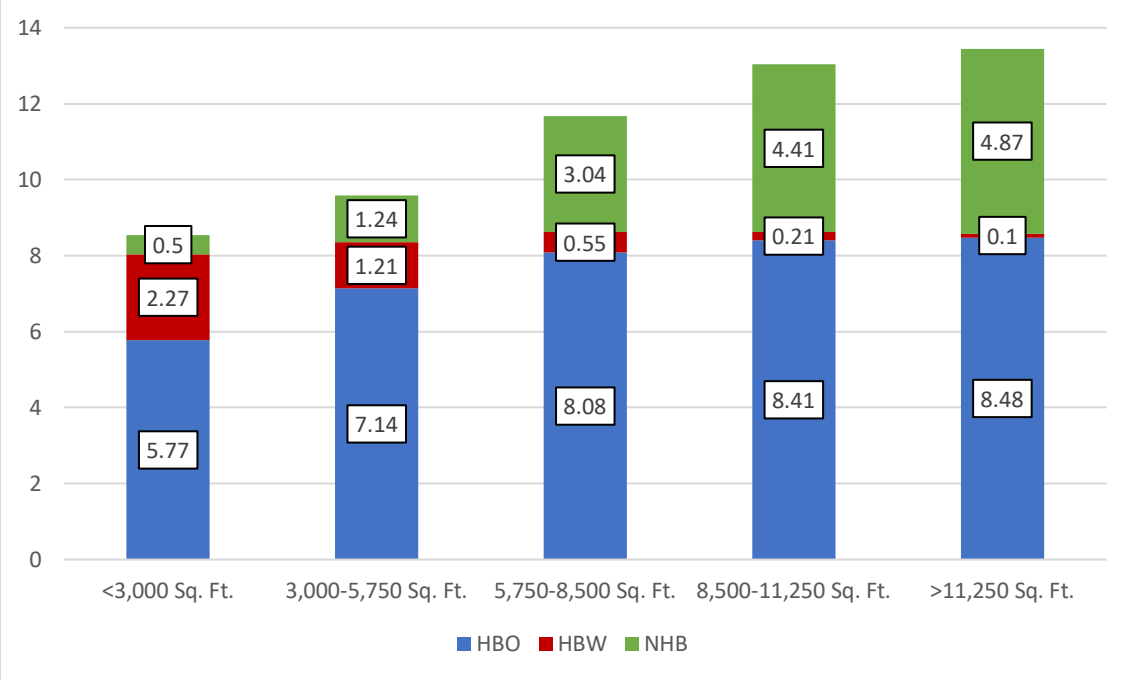
Trip-Based Efficiency Metrics

Approaching intensity at the unit-level based on size was identified as the best available metric as a result of this analysis to quantify residential transportation intensity, addressing study goal #2:

Goal 2: Identify metrics or proxies that can best quantify residential transportation intensity.

The average resident trips, employee trip, and daily VMT produced by residential home were evaluated at different size ranges to visualize these metrics. The total number of daily trips by trip purpose was analyzed for size ranges starting at below 3,000 square feet and at increasing intervals of 2,750 up to greater than 11,250 square feet. The results are depicted in **Figure 11**, showing that total trips increase with house size, with NHB trips increase faster than either other category[10]. Results regarding Daily VMT production are shown in **Figure 12**. Resident trips per home and employee trips per home metrics are summarized in **Table 10**. Daily VMT production associated with different home sizes are defined in **Table 10**.

Figure 11 – Average Daily Trips by Purpose



10 While NHB employee trips are most closely associated to larger homes in the results of this analysis, it is expected that units of all sizes will receive NHB trips. When assessing the smallest home categories, this represents occasional cleaning service and other O&M employment, supported by the results of the 2014 Aspen Homeowner Survey.

Figure 12 – Average Daily VMT Produced by Home Size

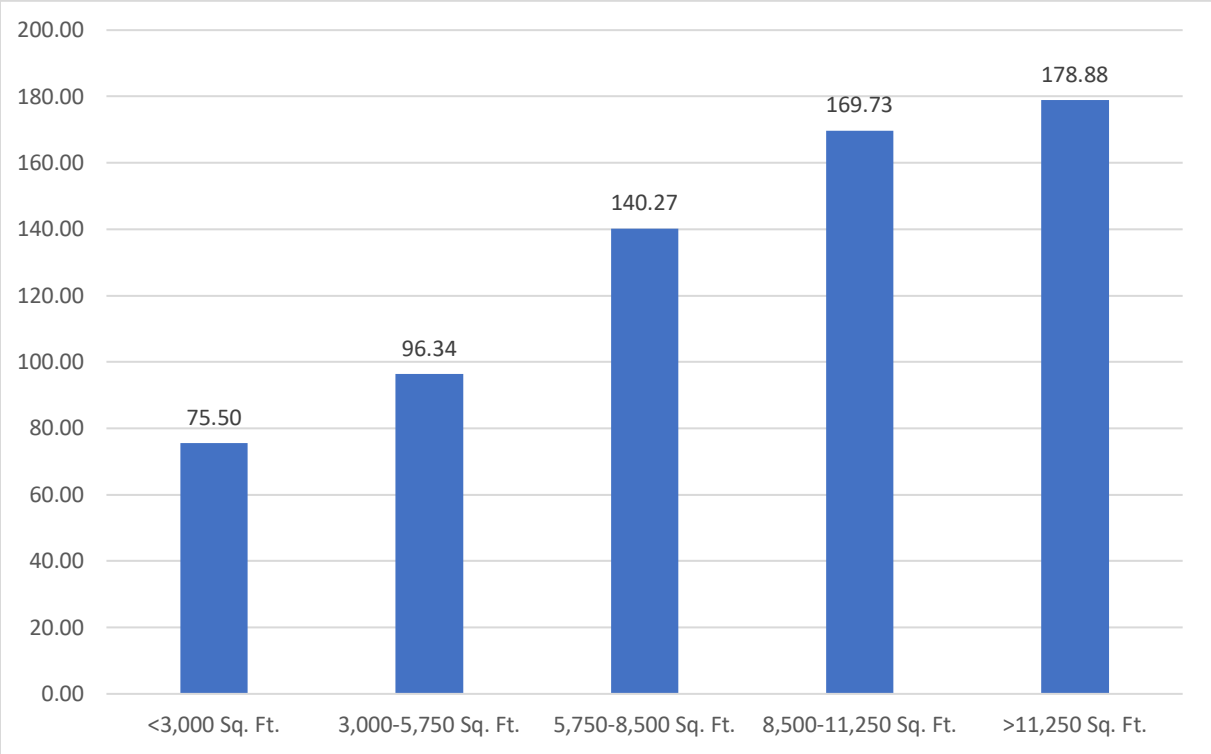


Table 10 – Average Resident Trips and Employee Trips per Household

Metric	<3,000 Sq. Ft.	3,000-5,750 Sq. Ft.	5,750-8,500 Sq. Ft.	8,500-11,250 Sq. Ft.	>11,250 Sq. Ft
Average Resident Trips per Home	8.04	8.35	8.63	8.62	8.58
Average Employee Trips per Home	0.50	1.23	3.04	4.41	4.87
Average Daily VMT per Home	75.5	96.34	140.27	169.73	178.88

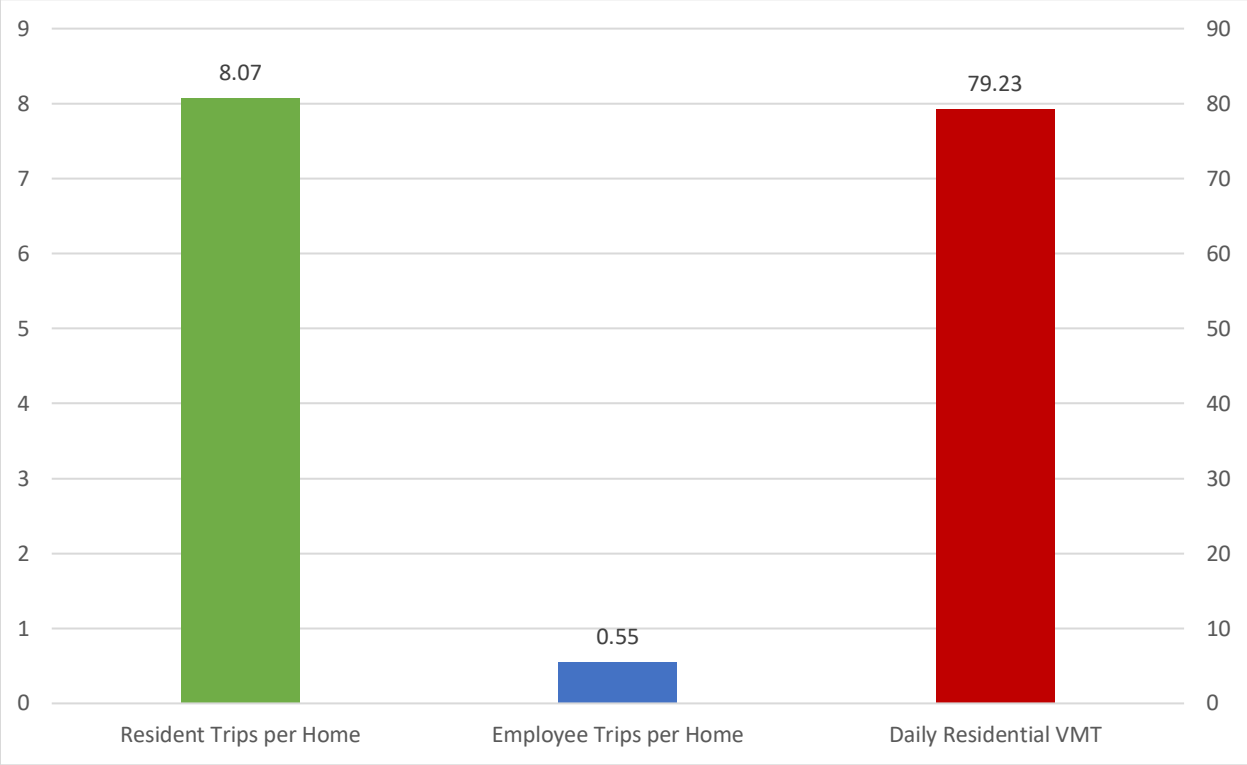
Quantitative Baseline

The same analysis was conducted for the average home size (3,278 Sq. Ft.) to establish a quantitative baseline for how residential development will impact transportation intensity, addressing the remaining guiding study goal:

> Goals 3: Establish a quantitative baseline for transportation intensity, including trip-based efficiency metrics for Unincorporated Pitkin County

To establish a quantitative baseline for transportation intensity, the daily resident trips, employee trips, and VMT produced by the average home in size in Unincorporated County are presented in **Figure 13**. It should be noted that because this home is smaller than 5,750 square feet, these metrics are expected to remain constant year-round.

Figure 13 – Quantitative Baseline for Residential Development Transportation Intensity: Daily resident trips, employee trips, and VMT for the average home size in Unincorporated Pitkin County



Using these metrics as the baseline to determine development-based impacts to transportation intensity, it is observed that residential travel behavior remains relatively stable across home sizes while large homes produce noticeably greater employee non-home-based trips. As displayed in **Figure 11**, the largest homes are estimated to produce 13.45 trips per day, 4.87 of which are non-home-based employee trips, 56.0% higher as compared to 8.62 trips per day in the average sized home, despite resident trips only growing by 7.2%. Additionally, the largest homes in Pitkin County are estimated to produce 42.6% more trips than the 9.43 trips ITE estimates that single-family homes generate.

OPPORTUNITY FOR FUTURE ASSESSMENTS

Future analyses present the opportunity to integrate empirically observed traffic count data. While historical traffic volumes were reviewed and considered for this analysis, a future analysis of trip generation rates as a function of household size and residential characteristics to accurately reflect the special market characteristics residential land uses in UPC display would require highly localized data collection.

To accurately capture the relationship between household size, structure value, and associated travel demand, future traffic counts should be conducted at the neighborhood level, specifically targeting residential areas characterized by homogenous housing stock. Ideal study sites would include rural neighborhoods where units are similar in both size and assessed value and which feature a single ingress/egress point. This configuration would allow for the complete capture of vehicular trips generated by all residential units within the study area, minimizing the influence of through-traffic or external trip generators.

To ensure generalizability and support stratification across housing types, future data collection should span a diverse sample of residential neighborhoods representing a range of household sizes and values. Although Unincorporated Pitkin County includes several self-contained neighborhoods, available historical traffic count datasets do not provide the spatial resolution or temporal alignment necessary to disaggregate trip generation by household characteristics.

In addition to traffic counts, future analyses could be significantly strengthened through the implementation of a cross-sectional household travel survey. A targeted survey—similar in design to the methodology employed in the Aspen Residential Employment Generation Study—would provide direct insights into household-level trip-making behavior. Such a dataset would enable the estimation of key efficiency metrics, including trips per household, trips per employee, and trips per capita, allowing for a more robust understanding of travel demand generation patterns in relation to residential built form. A longitudinal household travel survey could also strengthen this analysis by capturing temporal variability and enabling the tracking of behavioral change over time. This would provide valuable insights into seasonal travel patterns, long-term residential shifts, and the impact of land use or policy changes on trip-making behavior—ultimately supporting more dynamic and responsive trip generation modeling.