DOWNTOWN TAFT SPECIFIC PLAN
VEHICLE MILES TRAVELED ANALYSIS

Draft: May 27, 2022

Prepared for:

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Job Number 19403-T

TABLE OF CONTENTS

Tables

Exhibits

Appendices

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INTRODUCTION

The following Vehicle Miles Traveled (VMT) Analysis has been prepared for the Downtown Taft Specific Plan project in accordance with the *Technical Advisory on Evaluating Transportation Impacts in CEQA* (State of California Office of Planning and Research, December 2018). The study evaluates the project's potential Vehicle Miles Traveled (VMT) impacts as required by CEQA. The site is generally bounded by the mid-block alley between Kern Street (State Route 33) and Lucard Street to the north, Front Street to the south, 10th Street to the west, and State Route 33 (SR-33/Westside Highway) to the east. **Exhibit 1** shows the project vicinity map.

PROJECT DESCRIPTION

The Downtown Taft Specific Plan covers approximately 212 acres and would allow for the development of up to 3,120 residential dwelling units (DU), and would expand the downtown district to develop up to 891,059 square-feet (SF) of commercial retail uses and up to 1,132,718 square-feet of commercial office uses. In addition, up to 224,039 square-feet of public institutional uses and up to 229,281 square-feet of industrial uses would be developed within the Specific Plan. **Exhibit 2** shows the Downtown Taft Specific Plan preferred land use plan.

Below is a breakdown of the proposed land use types within the Downtown Taft Specific Plan:

Residential Uses	**3,120 DU**
• Single-Family Detached Dwelling Units:	665 DU
• Single-Family Attached Dwelling Units (Townhomes):	1,186 DU
• Multi-Family Dwelling Units:	1,269 DU
Retail Uses	**891,059 SF**
• Retail Services Building Area:	695,038 SF
• Restaurants Building Area:	59,762 SF
• Arts & Entertainment Building Area:	71,715 SF
• Accommodation Building Area	64,543 SF
Office Uses	**1,132,718 SF**
• Office Services Building Area	471,455 SF
• Medical Services Building Area	661,262 SF
Public Administration Uses	**224,039 SF**
• Public Administration Building Area	116,500 SF
• Education Building Area	107,539 SF
Industrial Uses	**229,281 SF**
• Transportation/Warehousing Building Area	170,457 SF
• Wholesale Building Area	58,824 SF

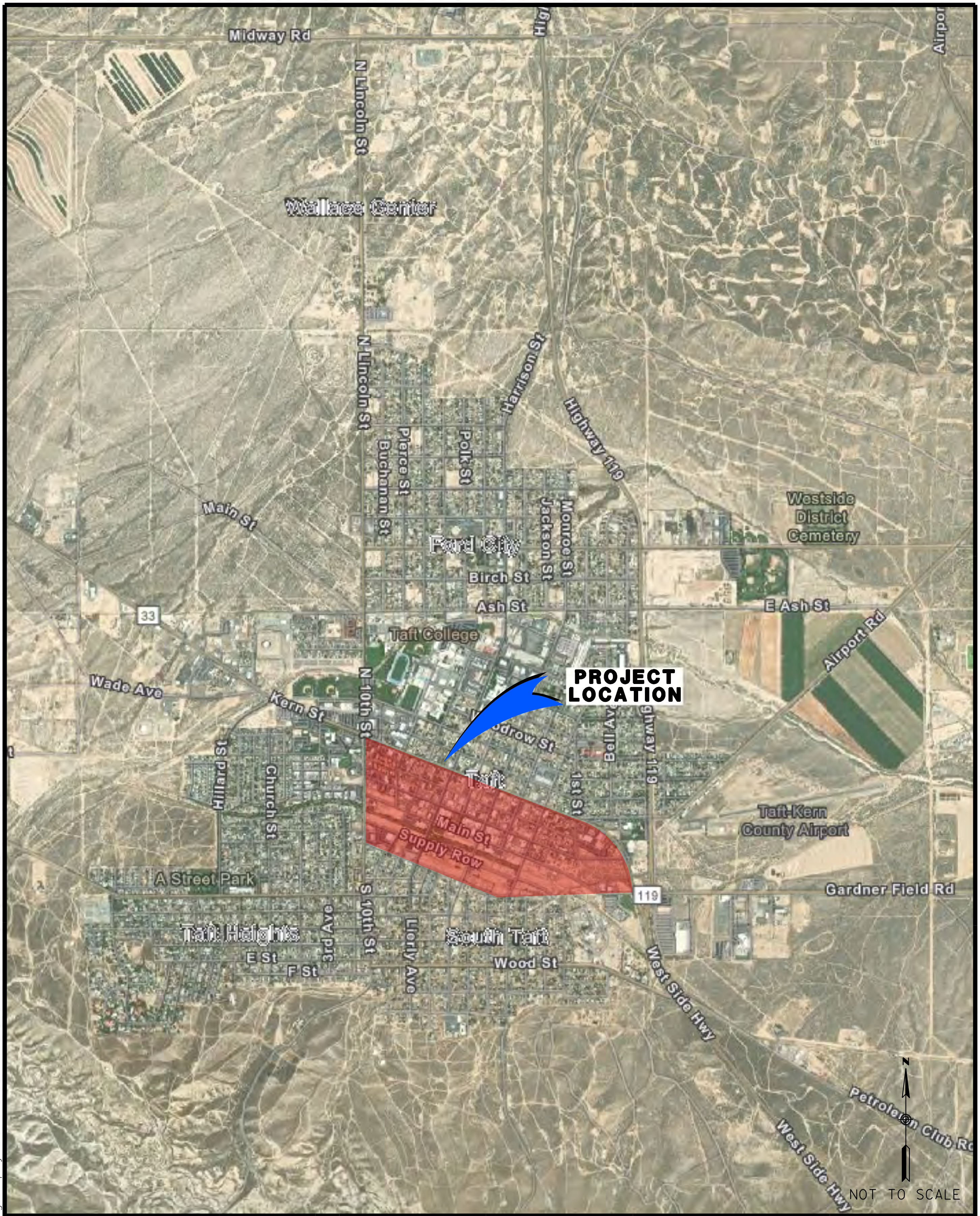

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EXHIBIT 1

PROJECT VICINITY MAP

DOWNTOWN TAFT SPECIFIC PLAN VMT ANALYSIS

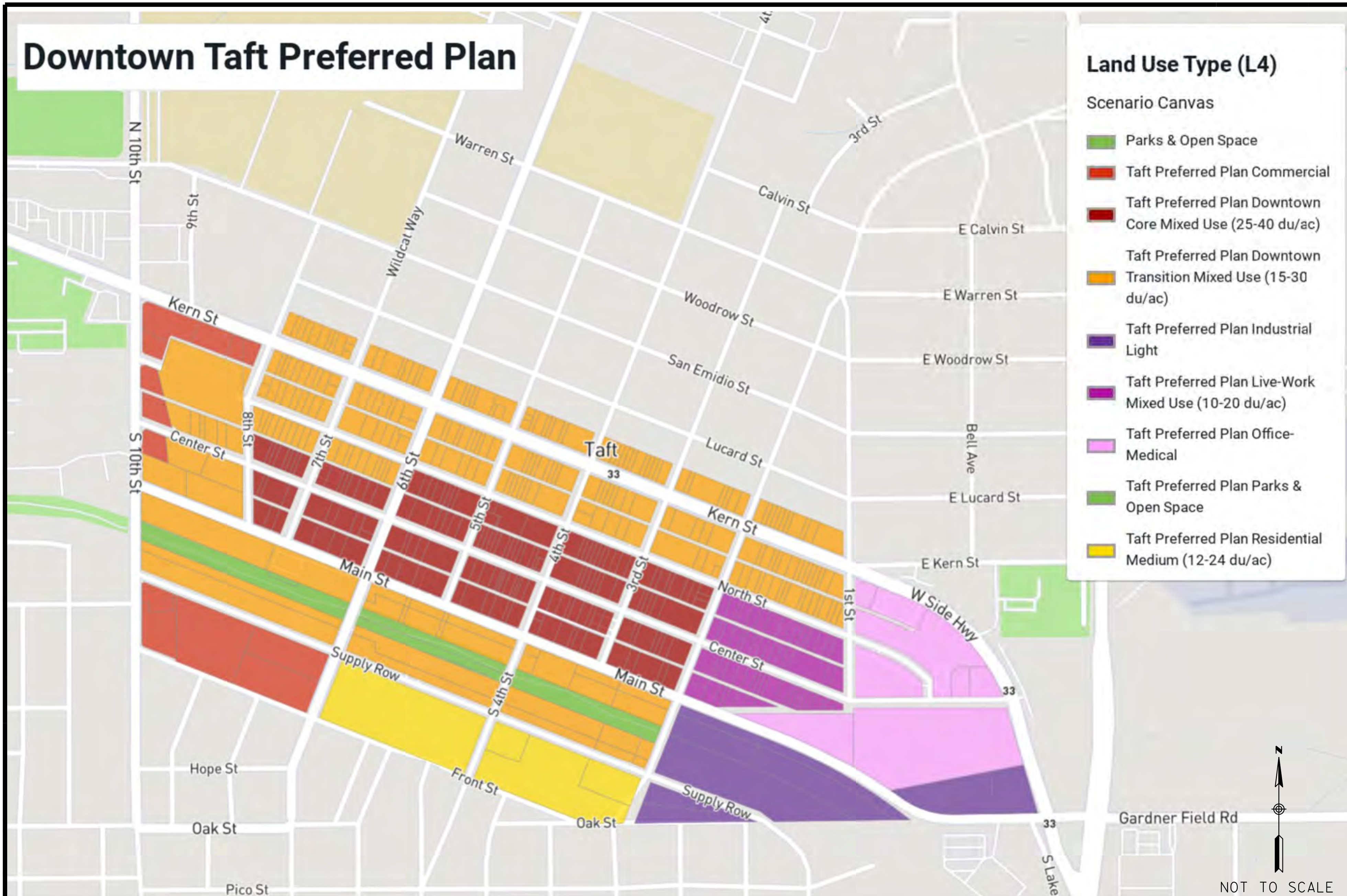

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EXHIBIT 2

DOWNTOWN TAFT SPECIFIC PLAN CONCEPTUAL MAP

DOWNTOWN TAFT SPECIFIC PLAN VMT ANALYSIS

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PROJECT TRIP GENERATION

The trip generation for the Downtown Taft Specific Plan project was calculated based on the published Institute of Transportation Engineers (ITE) 11th Edition Trip Generation Manual (September 2021) trip rates for the proposed land uses.

The specific ITE trip generation rates for the proposed residential land use types were applied, but due to the greater uncertainty of what specific types of retail or office uses would ultimately occupy the Specific Plan area, the "Shopping Center Over 150K" (ITE Land Use Code 820) trip rate was applied to all uses under the "Retail" category. In addition, the "Office Park" (ITE Land Use Code 750) trip rate was applied to all uses under the "Office" category.

Although 661,262 square-feet of the office uses is proposed as "medical services", the only medical office trip rate in the 11th Edition ITE Trip Generation Manual is the "Medical-Dental Office Building Stand-Alone" (ITE Land Use Code 720), which is intended to only be used for a stand-alone medical office building. Applying the ITE Land Use Code 720 trip rate to the 661,262 square-feet of medical services use would result in an artificially high trip generation compared to the other proposed uses, and therefore the general "Office Park" ITE Land Use Code 750) trip rate was applied to the 661,262 square-feet of proposed medical services.

The average ITE trip rates were applied to the proposed residential land use types, but for all non-residential uses, fitted curve equations were applied, where available, to calculate the trip generation of the retail, office, public administration and industrial uses.

Table 1 shows the ITE trip generation rates that were applied to the proposed Downtown Taft Specific Plan land uses, and **Table 2** presents the trip generation of the buildout of the Downtown Taft Specific Plan. **Appendix A** contains the 11th Edition ITE Trip Generation Manual (September 2021) trip rate sheets.

As shown in Table 2, the Downtown Taft Specific Plan project is forecast to generate a net total of 58,925 trips per day, with a net total of 3,862 trips occurring during the AM peak hour (2,350 IN, 1,512 OUT), and a net total of 5,145 trips occurring during the PM peak hour (2,109 IN, 3,036 OUT).

The net total trip generation of the Downtown Taft Specific Plan project accounts for an internal capture trip reduction that was calculated using the NCHRP Report 684 Internal Capture Estimation Tool, which is also shown in Table 2. The internal capture calculation worksheets are also provided in Appendix A.

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TABLE 1
ITE TRIP GENERATION RATES

Land Use	Unit	Daily Rate (per unit)	AM Peak Hour			PM Peak Hour		
			Rate	Inbound (% AM)	Outbound (% AM)	Rate	Inbound (% PM)	Outbound (% PM)
Single-Family Detached (LU Code 210)	DU	9.43	0.70	26%	74%	0.94	63%	37%
Single-Family Attached (LU Code 215)	DU	7.20	0.48	31%	69%	0.57	57%	43%
Multi-Family Low-Rise (LU Code 220)	DU	6.74	0.40	24%	76%	0.51	63%	37%
Shopping Center >150k (LU Code 820)	KSF	T = 26.11(X) + 5863.73[a]	T = 0.59(X) + 133.55[a]	62%	38%	Ln(T) = 0.72Ln(X) + 3.02[a]	48%	52%
Office Park (LU Code 750)	KSF	Ln(T) = 0.89Ln(X) + 3.10[a]	T = 0.94(X) + 194.06[a]	89%	11%	T = 1.26(X) + 20.98[a]	14%	86%
Public Administration (LU Code 730)	KSF	22.59	3.34	75%	25%	Ln(T) = 0.97Ln(X) + 0.62[a]	25%	75%
Warehousing (LU Code 150)	KSF	T = 1.58(X) + 38.29[a]	T = 0.12(X) + 23.62[a]	77%	23%	T = 0.12(X) + 26.48[a]	28%	72%

Footnotes:
Source: ITE Trip Generation Manual, 11th Edition (2021)
DU = Dwelling Unit; KSF = Thousand Square-Feet
[a]Fitted curve equation provided to calculate the trip generation.

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TABLE 2
PROJECT TRIP GENERATION

Land Use	Size	Unit	Daily Trips	AM Peak Hour			PM Peak Hour		
				Total	Inbound	Outbound	Total	Inbound	Outbound
Single-Family Detached (LU Code 210)	665	DU	6,271	466	121	345	625	394	231
Single-Family Attached (LU Code 215)	1,186	DU	8,539	569	176	393	676	385	291
Multi-Family Low-Rise (LU Code 220)	1,269	DU	8,553	508	122	386	647	408	239
Retail (LU Code 820)	891.059	KSF	29,129	659	409	250	2,726	1,308	1,418
Office Park (LU Code 750)	1132.718	KSF	11,601	1,259	1,121	138	1,448	203	1,245
Public Administration (LU Code 730)	224.039	KSF	5,061	748	561	187	355	89	266
Warehousing (LU Code 150)	229.281	KSF	401	51	39	12	54	15	39
Subtotal Project Trips			**69,555**	**4,260**	**2,549**	**1,711**	**6,531**	**2,802**	**3,729**
Internal Capture Trip Reduction[a]			*-10,630*	*-398*	*-199*	*-199*	*-1,386*	*-693*	*-693*
NET TOTAL PROJECT TRIPS			**58,925**	**3,862**	**2,350**	**1,512**	**5,145**	**2,109**	**3,036**

Footnotes:
Source: ITE Trip Generation Manual, 11th Edition (2021)
DU = Dwelling Unit; KSF = Thousand Square-Feet
[a]Internal capture was calculated using the NCHRP Report 684 Internal Capture Estimation Tool (See Appendix A).

VEHICLE MILES TRAVELED (VMT) ANALYSIS

Background

Senate Bill (SB) 743 was signed by Governor Brown in 2013 and required the Governor's Office of Planning and Research (OPR) to amend the CEQA Statute & Guidelines to provide an alternative to LOS for evaluating Transportation impacts. SB743 specified that the new criteria should promote the reduction of greenhouse gas emissions, the development of multimodal transportation networks and a diversity of land uses. The bill also specified that delay-based level of service could no longer be considered an indicator of a significant impact on the environment. In response, Section 15064.3 was added to the CEQA Statute & Guidelines beginning January 1, 2019. Section 15064.3: Determining the Significance of Transportation Impacts states that Vehicle Miles Traveled (VMT) is the most appropriate measure of transportation impacts and provides lead agencies with the discretion to choose the most appropriate methodology and thresholds for evaluating VMT. Section 15064.3(c) states that the provisions of the section shall apply statewide beginning on July 1, 2020.

VMT Screening Assessment

The *Technical Advisory on Evaluating Transportation Impacts in CEQA* (State of California Office of Planning and Research, December 2018) recommends the following VMT screening criteria for land development projects to determine if a project is presumed to have a less than significant transportation impact per CEQA:

- Screening Threshold for Small Projects (<110 daily trips)
- Map-Based Screening for Residential and Office Projects (low VMT generating area)
- Presumption of Less Than Significant Impact Near Transit Stations
- Presumption of Less Than Significant Impact for Local-Serving Retail (<50,000 sq. ft.)
- Presumption of Less Than Significant Impact for Affordable Residential Development

As previously shown in Table 2 (Project Trip Generation), the Downtown Taft Specific Plan does not meet the screening threshold for a small project, which is fewer than 110 daily trips. Map-based screening with the Kern COG regional travel demand model is currently not yet available, and the City of Taft is presumably not located in a low VMT generating area. A transit center was recently constructed at 550 Supply Row within the Downtown Taft Specific Plan area, but the transit center currently serves only one bus route (Kern Transit Route 120) that only operates during the morning and afternoon peak periods. Therefore, the location of the existing transit center was not determined to be sufficient to screen out the Downtown Taft Specific Plan project from VMT analysis. Although some of the proposed retail uses may be locally-serving, the size of the retail component exceeds the maximum size of the screening threshold (less than 50,000 square feet). Although some of the proposed residential development may ultimately be affordable housing, it is not yet known if affordable housing will be provided. Therefore, the project would also not meet the affordable housing screening threshold.

Due to the size, location, and land use composition, none of the above-listed screening criteria are applicable to the Downtown Taft Specific Plan area. Therefore, the project was not presumed to have a less than significant transportation impact, and a VMT analysis is required per CEQA.

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VMT Analysis Methodology

A VMT analysis was prepared in accordance with the *Technical Advisory on Evaluating Transportation Impacts in CEQA* (State of California Office of Planning and Research, December 2018). The analysis was conducted using the Kern Council of Governments (Kern COG) regional travel demand model for Baseline Year 2020 and Horizon Year 2042. RICK provided Kern COG the proposed land uses to input into the five Travel Analysis Zones (TAZs) that make up the Downtown Taft Specific Plan area in the Kern COG model, which are listed below:

- TAZ 1805
- TAZ 1806
- TAZ 1816
- TAZ 1817
- TAZ 1819

The average VMT per capita resident, average VMT per employee, and total VMT without the Downtown Taft Specific Plan were calculated for the entire Greater Taft Area subarea of the Kern COG model for both the Baseline Year 2020 and Horizon Year 2042 scenarios to compare against the VMT per capita resident, VMT per employee, and total VMT with the Downtown Taft Specific Plan. VMT per capita resident is used for all residential land use types, VMT per employee is used for the office and industrial uses, and total VMT is used for the retail uses, as recommended by the State of California Office of Planning and Research (OPR).

VMT Significance Thresholds

The *Technical Advisory on Evaluating Transportation Impacts in CEQA* (State of California Office of Planning and Research, December 2018) recommends the following VMT significance thresholds for various land development projects:

- **Recommended Significance Threshold for Residential Projects:** VMT exceeding 85% of average regional or subregional VMT per capita resident.
- **Recommended Significance Threshold for Office Projects:** VMT exceeding 85% of average regional or subregional VMT per employee.
- **Recommended Significance Threshold for Retail Projects:** A net increase in total VMT in the region or subregion.

The significance thresholds listed above were utilized to determine the potential significant impacts associated with the Downtown Taft Specific Plan. The Greater Taft Area subarea of the Kern COG model is considered the "subregion" against which the average VMT per capita resident, VMT per employee, and total VMT without the Downtown Taft Specific Plan are compared with the VMT per capita resident, VMT per employee, and total VMT with the Downtown Taft Specific Plan.

The *Technical Advisory on Evaluating Transportation Impacts in CEQA* (State of California Office of Planning and Research, December 2018) does not include a separate VMT significance threshold for industrial projects. As a result, and because the proposed warehousing industrial uses within the Downtown Taft Specific Plan generate relatively few trips compared to the office-related uses, the VMT per employee significance threshold would apply to both the office-related uses and industrial uses within the Downtown Taft Specific Plan.

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VMT Analysis Findings / CEQA Significance Determination

Kern COG provided VMT data for the Baseline Year 2020 and Horizon Year 2042 scenarios, for both the Greater Taft Subarea and the project-specific VMT with the Downtown Taft Specific Plan. **Table 3** below summarizes the findings of the VMT analysis and project significance determination per CEQA. A spreadsheet summarizing the VMT data provided by Kern COG is contained in **Appendix B**.

TABLE 3
VMT ANALYSIS FINDINGS / CEQA SIGNIFICANCE DETERMINATION

Scenario	VMT Per Land Use		
	VMT per Capita Resident	VMT per Employee (For Office/ Industrial Uses)	Total Subregion VMT (For Retail Use)
Baseline Year 2020 Without Project: (Subregional Average VMT)	88.40	136.41	1,808,842
Horizon Year 2042 Without Project: (Subregional Average VMT)	94.62	165.98	2,575,003
Horizon Year 2042 With Project: (Subregional Average VMT)	78.59	135.92	2,807,891
Horizon Year 2042 With Project: (Project-Specific VMT)	47.77	103.78	443,188
Project % of Subregional Average: (Project-Specific VMT/ Baseline Year 2042 Without Project VMT)	50.5%	62.5%	NA
Change in Total Subregional VMT:	NA	NA	+232,888
CEQA Significance Threshold:	80.4 (85%)	141.1 (85%)	Net Increase
Significant Impact?:	**No**	**No**	**Yes**

Source: Kern COG Regional Travel Demand Model for 2022 Regional Transportation Plan (RTP)
NA = Not Applicable

As shown in Table 3, the "Project-Specific" VMT per capita resident for the Downtown Taft Specific Plan is approximately 50.5% of the Horizon Year 2042 Without Project Greater Taft subregional average VMT per capita resident. Therefore, based on the CEQA significance threshold of 85% of the subregional average VMT per capita resident, the VMT per capita resident for the Downtown Taft Specific Plan residential land uses is presumed to be less than significant.

Table 3 also shows that the "Project-Specific" VMT per employee for the Downtown Taft Specific Plan is approximately 62.5% of the Horizon Year 2042 Without Project Greater Taft subregional average VMT per employee. Therefore, based on the CEQA significance threshold of 85% of the subregional average VMT per employee, the VMT per employee for the Downtown Taft Specific Plan office and industrial land uses is presumed to be less than significant.

As also shown in Table 3, the Horizon Year 2042 Total Greater Taft Subregional VMT with the buildout of the Downtown Taft Specific Plan is forecast to increase by 232,888 miles versus the Horizon Year 2042 Total Greater Taft Subregional VMT without the project. Based on the CEQA significance threshold of "net increase in total regional VMT" for retail uses, the Total Greater Taft Subregional VMT with the buildout of the Downtown Taft Specific Plan is presumed to be significant.

Although the identified significant VMT impact based on net increase in the Total Greater Taft Subregional VMT is associated with the CEQA significance threshold for retail uses, the increase in the Total Greater Taft Subregional VMT is attributed to the increase in the total resident and employee population in the Greater Taft Subregion. The Horizon Year 2042 Without Project total resident and employee populations are 27,213 and 15,514, respectively, and the total resident and employee populations increase to 35,729 and 20,659, respectively with the buildout of the Downtown Taft Specific Plan.

It is anticipated that the less-than-significant project-specific VMT per capita resident and VMT per employee is attributed to the mix of residential, office/industrial and retail in the same area. Although there are no significant impacts attributed to the VMT per capita resident or VMT per employee, the net increase in the Total Greater Taft Subregional VMT does result in a significant impact per CEQA and mitigation measures are required.

RECOMMENDED PROJECT FEATURE VMT REDUCTION MEASURES

The increase in the total Greater Taft Subregion resident and employee populations result in a net increase of 232,888 miles, which is a net increase of 9.04% over the Horizon Year 2042 Total Greater Taft Subregional VMT without the project. Therefore, VMT-reducing mitigation measures that provide a 9.04% or more reduction in VMT are required.

The DRAFT *Downtown Taft Specific Plan Local Transportation Analysis* (Rick Engineering Company, May 27, 2022) recommends improvements to the pedestrian, bicycle and transit networks and facilities within the Specific Plan area, which are considered VMT-reducing measures per the *Technical Advisory on Evaluating Transportation Impacts in CEQA* (State of California Office of Planning and Research, December 2018). The recommended pedestrian, bicycle and transit network/facility improvements per the DRAFT *Downtown Taft Specific Plan Local Transportation Analysis* are listed below:

<u>Recommended Pedestrian Facility Improvements</u>

- North Street from 8th Street to 1st Street: Improve existing sidewalks and provide high-visibility crosswalks at all intersections.
- Center Street from 2nd Street to Westside Highway (SR-33): Improve existing sidewalks, close the existing sidewalk gaps, and provide high-visibility crosswalks at all intersections.
- Main Street from 10th Street to 2nd Street: Close the existing sidewalk gaps and provide wide sidewalks (10+ feet in width) along both sides of the street. Provide high-visibility crosswalks at all intersections.
- Main Street from 2nd Street to Westside Highway (SR-33): Improve existing sidewalks, close the existing sidewalk gaps, and provide high-visibility crosswalks at all intersections.
- Supply Row from 10th Street to 2nd Street: Provide wide sidewalks (10+ feet in width) along both sides of the street, close the existing sidewalk gaps, and provide high-visibility crosswalks at all intersections.

- 6th Street from Main Street to Front Street: Improve existing sidewalks, close the existing sidewalk gaps, and provide high-visibility crosswalks at all intersections.
- 4th Street from Kern Street (SR-33) to Front Street: Improve existing sidewalks and provide high-visibility crosswalks at all intersections.
- 2nd Street/Olive Avenue from Kern Street (SR-33) to Front Street: Improve existing sidewalks, close the existing sidewalk gaps, and provide high-visibility crosswalks at all intersections.
- Front Street from 10th Street to Oak Street: Improve existing sidewalks, close the existing sidewalk gaps, and provide high-visibility crosswalks at all intersections.

<u>Planned Bicycle Facility Improvements Per Kern Region ATP (Class I, II or IV only)</u>

- Kern Street (SR-33) from 10th Street to 1st Street: Class II Buffered Bike Lanes
- Westside Highway (SR-33) from 1st Street to SR-119: Class II Bike Lanes
- 10th Street from Kern Street (SR-33) to Center Street: Class IV Cycle Track
- 10th Street from Center Street to Front Street: Class II Bike Lanes
- 6th Street from Kern Street (SR-33) to Front Street: Class II Buffered Bike Lanes
- 1st Street from Calvin Street to Kern Street: Class II Buffered Bike Lanes

<u>Recommended Bicycle Facility Improvements (Class I, II or IV only)</u>

- 2nd Street from Kern Street (SR-33) to Supply Row: Provide Class II bike lanes (upgrade from planned Class III Bike Boulevard in *Kern Region Active Transportation Plan*)
- 1st Street from Kern Street (SR-33) to Center Street: Provide Class II bike lanes
- Center Street from 2nd Street to West Side Highway (SR-33): Provide Class II bike lanes
- Main Street from 2nd Street to West Side Highway (SR-33): Provide Class II bike lanes

<u>Recommended Future Transit Network and Facility Improvements</u>

- Coordinate with Taft Area Transit (TAT) to provide benches, shelters and trash receptacles at the existing bus stops along Kern Street (SR-33).
- Coordinate with Taft Area Transit (TAT) to expand the Taft-Maricopa Route to include 10th Street between Kern Street (SR-33) and Main Street, and Main Street between 10th Street and West Side Highway (SR-33), and to install sheltered bus stops along the expanded route.
- Coordinate with Taft Area Transit (TAT) to provide all-day service and to expand weekday hours of operation to between 6:00am and 7:00pm and to provide limited weekend service for the Taft-Maricopa Route.
- Coordinate with Kern Transit to expand Route 120 to include Kern Street (SR-33) between 6th Street and 2nd Street, 2nd Street between Kern Street (SR-33) and Main Street, and Main Street between 4th Street and 2nd Street.
- Coordinate with Kern Transit to provide additional sheltered bus stops along both the existing Route 120 and the recommended expanded Route 120 within the Downtown Taft Specific Plan area.
- Coordinate with Kern Transit to expand the Route 120 weekday and Saturday hours of operation with the first eastbound bus leaving Taft at 6:00am, and with the last westbound bus arriving in Taft at 9:00pm.

The effectiveness of the above-listed mitigation measures is calculated using the methodology provided in the California Air Pollution Control Officers Association (CAPCOA) *Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity* (Final Draft, December 2021), hereafter referred to as the 2021 CAPCOA manual.

VMT reduction equations from the following measures in the 2021 CAPCOA manual were utilized to estimate the percent reduction in VMT with implementation of the recommended project improvements:

- CAPCOA Measure T-18 (Provide Pedestrian Network Improvement): This measure is described as increasing the sidewalk coverage to improve pedestrian access, which includes improving existing degraded or substandard sidewalks.
- CAPCOA Measure T-20 (Expand Bikeway Network): This measure is described as increasing the length of a city or community bikeway network (only Class I, II or IV bicycle lane facilities).
- CAPCOA Measure T-25 (Extend Transit Network Coverage or Hours): This measure is described as expanding the local transit network by either adding or modifying existing transit service or extending the operation hours to enhance the service near the project site.

VMT Reduction With Pedestrian Network Improvements (CAPCOA Measure T-18)
The VMT reduction resulting from construction of additional sidewalks is calculated using the following equation: A = {(C/B) – 1} x D, where A is the percent reduction in VMT, B is the existing sidewalk length in study area, C is the sidewalk length in study area with measure, and D is the elasticity of household VMT with respect to the ratio of sidewalks-to-streets {constant of -0.05 per 2021 CAPCOA manual).

The study area used in this calculation is the entire Downtown Taft Specific Plan area, and both sides of all streets with existing sidewalk were measured to calculate the total existing sidewalk length, which is 9.33 miles. The total future sidewalk length with the buildout of the Specific Plan was measured to be 13.29 miles.

The following calculation shows the reduction in VMT: A = {(13.29/9.33) – 1} x -0.05. The construction of additional sidewalks within the Downtown Taft Specific Plan area is estimated to result in a reduction in VMT of **2.12%**.

VMT Reduction With Bikeway Network Improvements (CAPCOA Measure T-20)
The VMT reduction resulting from expanding the bikeway network within the Downtown Taft Specific Plan area is calculated using the following equation: A = -1 x {((C - B)/B) x D x F x H}/(E x G), where A is the percent reduction in VMT, B is the existing bikeway miles in plan/community, C is the future bikeway miles in plan/community with measure, D is the bike mode share in plan/community (estimated at 1.62% with implementation of expanded bikeway network from DRAFT *Downtown Taft Specific Plan Local Transportation Analysis*), E is the vehicle mode share in plan/ community (estimated at 92.66% with implementation of recommended pedestrian, bikeway and transit improvements from DRAFT *Downtown Taft Specific Plan Local Transportation Analysis*), F is the average one-way bike trip length in plan/community (estimated at 2.0 miles based on averages across state per 2021 CAPCOA Table T-10.1), G is the average one-way vehicle trip length in plan/community (estimated at 23.88 miles based on project-specific VMT per resident from the Kern COG model run), and H is the elasticity of bike commuters with respect to bikeway miles per 10,000 population (0.25 per 2021 CAPCOA manual).

The Taft Bike Path is the only existing bicycle facility in Taft and has a length of 2.0 miles. The planned and recommend future bikeway network improvements in the Downtown Taft Specific Plan area would increase the total bikeway network length to 7.05 miles.

The following calculation shows the reduction in VMT: A = -1 x {((7.05 – 2.0)/2.0) x 1.62% x 2.0 x 0.25}/(92.66% x 23.88). The expansion of the bikeway network within the Downtown Taft Specific Plan area is estimated to result in a reduction in VMT of **0.06%**.

VMT Reduction With Transit Network Improvements (CAPCOA Measure T-25)

The VMT reduction resulting from extending the transit network within the Downtown Taft Specific Plan area is calculated using the following equation: A = -1 x {(C-B)/B} x D x E x F x G, where A is the percent reduction in VMT, B is the total transit service miles or service hours in plan/community before expansion (64.75 hours per week), C is the total transit service miles or service hours in plan/community after expansion (148.27 hours per week), D is the transit mode share in plan/community (estimated at 1.12% after implementation of transit network improvements), E is the elasticity of transit demand with respect to service miles or service hours (0.7 per 2021 CAPCOA manual), F is the Statewide mode shift factor (57.8% per CAPCOA manual), and G is the ratio of vehicle trip reduction to VMT (1.0 per 2021 CAPCOA manual).

The Measure T-25 equation was calculated using both transit service miles and service hours, but the transit service hours provide a greater percent reduction in VMT and therefore was used for calculating the Specific Plan's VMT reduction with the recommended transit network improvements. The total transit service hours per week was used in the equation because of the existing and recommended expanded Saturday transit service hours in addition to weekday transit service hours.

The following calculation shows the reduction in VMT: A = -1 x {(148.27-64.75)/64.75} x 1.12% x 0.7 x 57.8% x 1.0. The recommended transit network improvements within the Downtown Taft Specific Plan area is estimated to result in a reduction in VMT of **0.53%**.

Excerpts from the 2021 CAPCOA manual showing the descriptions and equations for each VMT reduction measure are contained in **Appendix C**. Appendix C also includes analysis worksheets for each VMT reduction measure.

The Transportation chapter of the 2021 CAPCOA manual provides a methodology for calculating the effectiveness of multiple VMT reduction measures using the following equation that diminishes the effectiveness of subsequent VMT reduction measures when proposed simultaneously:

- Overall % VMT Reduction = 1 – (1 – A) x (1 – B) x (1 – C) x (1 – D) …

Where A, B, C, D, etc. are the individual VMT reduction measure percentages.

Using the diminishing effectiveness equation shown above, the total percent VMT reduction with the future planned improvements and recommended pedestrian, bikeway and transit improvements from the DRAFT *Downtown Taft Specific Plan Local Transportation Analysis* is summarized below:

CAPCOA VMT Reduction Measure	**VMT Reduction (%)**
Measure T-18: Provide Pedestrian Network Improvement:	-2.12%
Measure T-20: Expand Bikeway Network:	-0.06%
Measure T-25: Extend Transit Network Coverage or Hours:	-0.53%
Total Percent VMT Reduction:	**-2.69%**

As shown above, the future planned and recommended pedestrian, bikeway and transit improvements are anticipated to result in a total VMT reduction of 2.69%. The minimum percent VMT reduction that is needed to mitigate the project's VMT impact is 9.04%. Therefore, additional VMT reduction measures are required to mitigate the project's impact to a level below significance.

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RECOMMENDED ADDITIONAL VMT REDUCTION MITIGATION MEASURES

The following additional VMT reduction measures from the 2021 CAPCOA manual are required, of which VMT reduction equations were utilized to estimate the percent reduction in VMT with implementation of the recommended mitigation measures:

- CAPCOA Measure T-7 (Implement Commute Trip Reduction Marketing): This measure is described as implementing a marketing strategy to promote a commute trip reduction program that would educate employees about their transportation options to their places of employment such as carpooling, transit, bicycling or walking. This measure can be required for all larger employers within the Specific Plan area.
- CAPCOA Measure T-8 (Provide Rideshare Program): This measure is described as implementing a rideshare program for employees to encourage carpooling and reduce single-occupancy vehicle trips. This measure can be required for all larger employers within the Specific Plan area.
- CAPCOA Measure T-10 (Provide End-of-Trip Bicycle Facilities): This measure is described as installing and maintaining end-of-trip bicycle facilities for employee use, which would include bike parking, showers and lockers. This measure can be required for all larger employers within the Specific Plan area.
- CAPCOA Measure T-11 (Provide Employer-Sponsored Vanpool): This measure is described as implementing an employer-sponsored vanpool service to encourage carpool trips. This measure can be required for all larger employers within the Specific Plan area for employees who may be commuting to Taft from outside of the community.
- CAPCOA Measure T-23 (Provide Community-Based Travel Planning): This measure is described as a residential-based approach to outreach that provides households with customized information, incentives, and support to encourage the use of transportation alternatives in place of single-occupancy vehicles. This measure can be applied to all future residences within the Specific Plan area.
- CAPCOA Measure T-26 (Increase Transit Service Frequency): This measure is described as increasing the transit frequency on one or more transit lines serving the plan/community. Specifically, this measure proposes to increase the frequency of both the Taft Area Transit (TAT) Taft-Maricopa Route and Kern Transit Route 120 to 30-minute headways throughout the day.

VMT Reduction With Implementing Commute Trip Reduction Marketing (CAPCOA Measure T-7)
The VMT reduction resulting from implementing a marketing strategy to promote a commute trip reduction program for employers within the Downtown Taft Specific Plan area is calculated using the following equation: A = B x C x D, where A is the percent reduction in VMT, B is the percent of employees eligible for program (default of 100% per CAPCOA manual), C is the percent reduction in employee commute vehicle trips (low end of range is -4% per CAPCOA manual), and D is the adjustment from vehicle trips to VMT (default is 1.0 per 2021 CAPCOA manual).

The following calculation shows the reduction in VMT: A = 100% x -4% x 1.0. The recommended commute trip reduction marketing within the Downtown Taft Specific Plan area is estimated to result in a reduction in VMT of **4.00%**.

VMT Reduction With Providing Rideshare Program (CAPCOA Measure T-8)
The VMT reduction resulting from employers within the Downtown Taft Specific Plan area providing a rideshare program for employees to encourage carpool trips is calculated using the following equation: A = B x C, where A is the percent reduction in VMT, B is the percent of employees eligible for program (default of 100% per 2021 CAPCOA manual), and C is the percent reduction in employee commute vehicle trips (-4% for suburban areas per 2021 CAPCOA manual).

The following calculation shows the reduction in VMT: A = 100% x -4%. The recommended implementation of employer-sponsored rideshare programs within the Downtown Taft Specific Plan area is estimated to result in a reduction in VMT of **4.00%**.

VMT Reduction With Providing End-of-Trip Bicycle Facilities (CAPCOA Measure T-10)

The VMT reduction resulting from employers within the Downtown Taft Specific Plan area providing end-of-trip bicycle facilities for employee use that include bicycle parking, showers and lockers is calculated using the following equation: A = {C x {E – (B x E)} / (D x F), where A is the percent reduction in VMT, B is the bike mode adjustment factor (calculated at 2.55 assuming that 100% of Specific Plan employers would provide bicycle parking and that 25% of Specific Plan employers would provide showers and lockers), C is the existing bicycle trip length for all trips in region (estimated at 2.0 miles based on averages across state per CAPCOA Table T-10.1), D is the existing vehicle trip length for all trips in region (estimated at 23.88 miles based on project-specific VMT per resident from the Kern COG model run), E is the bicycle mode share for work trips in region (estimated at 1.62% with implementation of expanded bikeway network from DRAFT *Downtown Taft Specific Plan Local Transportation Analysis*), and F is the vehicle mode share for work trips in region (estimated at 92.66% with implementation of recommended pedestrian, bikeway and transit improvements from DRAFT *Downtown Taft Specific Plan Local Transportation Analysis*).

The following calculation shows the reduction in VMT: A = {2.0 x {1.62% – (2.55 x 1.62%)} / (23.88 x 92.66%). The expansion of the bikeway network within the Downtown Taft Specific Plan area is estimated to result in a reduction in VMT of **0.23%**.

VMT Reduction With Providing Employer-Sponsored Vanpool (CAPCOA Measure T-11)

The VMT reduction resulting from larger employers within the Downtown Taft Specific Plan area providing vanpool programs for employees is calculated using the following equation: A = [{(1 - B) x C} + {B x (D/E)}]/C - 1, where A is the percent reduction in VMT, B is the percent of employees that participate in vanpool programs (default value of 2.7% per 2021 CAPCOA manual), C is the average length of one-way vehicle commute trip in region (estimated at 36.0 miles based on distance between Taft and Bakersfield), D is the average length of one-way vanpool commute trip (estimated at 36.0 miles based on distance between Taft and Bakersfield), and E is the average vanpool occupancy including the driver (6.25 per 2021 CAPCOA manual).

The following calculation shows the reduction in VMT: A = [{(1 – 2.7%) x 36.0} + {2.7% x (36.0/6.25)}]/36.0 - 1. The recommended implementation of employer-sponsored vanpool programs within the Downtown Taft Specific Plan area is estimated to result in a reduction in VMT of **2.27%**.

VMT Reduction With Providing Community-Based Travel Planning (CAPCOA Measure T-23)

The VMT reduction resulting from providing community-based travel planning (CBTP) to residences within the Downtown Taft Specific Plan area is calculated using the following equation: A = (C/B) x D x -E x F, where A is the percent reduction in VMT, B is the total number of residences in plan/community (calculated at 12,015 future residences in Greater Taft Area based on population data provided by the Kern COG model run), C is the number of residences in plan/community targeted with CBTP (3,120 future dwelling units within Specific Plan area), D is the percent of targeted residences that participate (average of 19% per 2021 CAPCOA manual), E is the percent vehicle trip reduction by participating residences (average of 12% per 2021 CAPCOA manual), and F is the adjustment factor from vehicle trips to VMT (default is 1.0 per 2021 CAPCOA manual).

The following calculation shows the reduction in VMT: A = (3,120/12,015) x 19% x -12% x 1.0. The recommended community-based travel planning within the Downtown Taft Specific Plan area is estimated to result in a reduction in VMT of **0.59%**.

VMT Reduction With Increasing Transit Service Frequency (CAPCOA Measure T-26)
The VMT reduction resulting from increasing the transit service frequency within the Downtown Taft Specific Plan area is calculated using the following equation: A = -C x (B x E x D x G)/F, where A is the percent reduction in VMT, B is the percent increase in transit frequency (calculated at 275% based on proposed increase to 30-minute headways throughout the day), C is the level of implementation (100% of all transit routes in Specific Plan area), D is the elasticity of transit ridership with respect to frequency of service (0.5 per 2021 CAPCOA manual), E is the transit mode share in plan/community (estimated at 1.12% after implementation of transit network improvements from DRAFT *Downtown Taft Specific Plan Local Transportation Analysis*), F is the vehicle mode share in plan/community (estimated at 92.66% with implementation of recommended pedestrian, bikeway and transit improvements from DRAFT *Downtown Taft Specific Plan Local Transportation Analysis*), and G is the Statewide mode shift factor (57.8% per 2021 CAPCOA manual).

Variable "B" of the Measure T-26 equation was calculated by first calculating the combined existing average transit frequency of the Taft Area Transit Taft-Maricopa Route and Kern Transit Route 120, which is 0.73 transit arrivals per hour. The proposed combined average transit frequency is 2.0 transit arrivals per hour, an increase of 275%.

The following calculation shows the reduction in VMT: A = -100% x (275% x 1.12% x 0.5 x 57.8%)/92.66%. The recommended increase of transit frequency within the Downtown Taft Specific Plan area is estimated to result in a reduction in VMT of **0.96%**.

Excerpts from the 2021 CAPCOA manual showing the descriptions and equations for each additional VMT reduction measure, as well as analysis worksheets, are contained in **Appendix C**.

As previously discussed, the Transportation chapter of the 2021 CAPCOA manual provides a methodology for calculating the effectiveness of multiple VMT reduction measures using the following equation that diminishes the effectiveness of subsequent VMT reduction measures when proposed simultaneously:

- Overall % VMT Reduction = 1 – (1 – A) x (1 – B) x (1 – C) x (1 – D) …

Where A, B, C, D, etc. are the individual VMT reduction measure percentages. The above equation was applied to both the recommended project feature VMT reduction measures and the additional VMT reduction mitigation measures.

Using the diminishing effectiveness equation shown above, the total percent VMT reduction associated with the recommended pedestrian, bikeway and transit improvements from the DRAFT *Downtown Taft Specific Plan Local Transportation Analysis*, plus the additional VMT reducing mitigation measures as described above, are summarized in **Table 4**.

As shown in Table 4, the total percent VMT reduction with the recommended additional mitigation measures is calculated to be **13.90%**. The minimum percent VMT reduction that is needed to mitigate the project's VMT impact is 9.04%. Therefore, the VMT impact associated with the buildout of the Downtown Taft Specific Plan would be reduced to a level that is less than significant with the measures described above.

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TABLE 4
TOTAL VMT REDUCTION WITH RECOMMENDED MITIGATION MEASURES

CAPCOA VMT Reduction Measure	Description of Measure	Calculated VMT Reduction (%)
Future Planned and Recommended Improvements from Local Transportation Analysis[1]		
Measure T-18: Provide Pedestrian Network Improvement	Recommended improvements to improve existing sidewalks and to construct new sidewalks along roadways where sidewalks currently do not exist.	2.12%
Measure T-20: Expand Bikeway Network	Includes the planned bikeway network improvements within the Specific Plan area per the Kern Region Active Transportation Plan, and the additional recommended bikeway improvements within the Specific Plan area (includes only Class I, II and IV bikeway facilities).	0.06%
Measure T-25: Extend Transit Network Coverage or Hours	Recommended transit network improvements to expand the Taft Area Transit route and the Kern Transit Route 120 within the Specific Plan area. Recommendations also include expanding the hours of operation for both Taft Area Transit and Kern Transit Route 120.	0.53%
	Subtotal Percent VMT Reduction:	***2.69%[2]***
Recommended Additional Mitigation Measures		
Measure T-7: Implement Commute Trip Reduction Marketing	Require larger employers within Specific Plan area to implement a marketing strategy to promote a commute trip reduction program that would educate employees about their transportation options to their places of employment such as carpooling, transit, bicycling or walking.	4.00%
Measure T-8: Provide Rideshare Program	Require larger employers within Specific Plan area to implement a rideshare program for employees to encourage carpooling and reduce single-occupancy vehicle trips.	4.00%
Measure T-10: Provide End-of-Trip Bicycle Facilities	Assumes bicycle parking (racks) would be provided for all places of employment in Specific Plan area, with up to 25% of employers providing showers and lockers.	0.23%
Measure T-11: Provide Employer-Sponsored Vanpool	Assumes vanpools would be provided by the larger employers within Specific Plan.	2.27%
Measure T-23: Provide Community-Based Travel Planning	Travel advisors would visit all households within Specific Plan area to educate residents about various and alternative transportation options available to them.	0.59%
Measure T-26: Increase Transit Service Frequency	Increase transit service frequency to 30-minute headways throughout the day for both Taft Area Transit and Kern Transit Route 120.	0.96%
	Total Percent VMT Reduction With Additional Mitigation Measures:	**13.90%[2]**

Source: CAPCOA *Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity* (Final Draft, December 2021)

[1] DRAFT *Downtown Taft Specific Plan Local Transportation Analysis* (Rick Engineering Company, May 27, 2022)

[2] Subtotal and total percent VMT reductions were calculated using the CAPCOA diminishing effectiveness equation, and these values do NOT reflect the sum of the percent VMT reductions for the individual measures.

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REFERENCES

1. State of California Office of Planning and Research, Technical Advisory on Evaluating Transportation Impacts in CEQA, December 2018.

2. Institute of Transportation Engineers (ITE), Trip Generation Manual, 11th Edition, September 2021.

3. Association of Environmental Professionals. 2019 CEQA Statute & Guidelines, January 1, 2019.

4. Rick Engineering Company, DRAFT Downtown Taft Specific Plan Local Transportation Analysis, May 27, 2022.

5. California Air Pollution Control Officers Association (CAPCOA), Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity, Final Draft, December 2021.

APPENDIX A

ITE TRIP GENERATION RATE SHEETS / NCHRP REPORT 684 INTERNAL CAPTURE WORKSHEETS

Land Use: 210
Single-Family Detached Housing

Description

A single-family detached housing site includes any single-family detached home on an individual lot. A typical site surveyed is a suburban subdivision.

Specialized Land Use

Data have been submitted for several single-family detached housing developments with homes that are commonly referred to as patio homes. A patio home is a detached housing unit that is located on a small lot with little (or no) front or back yard. In some subdivisions, communal maintenance of outside grounds is provided for the patio homes. The three patio home sites total 299 dwelling units with overall weighted average trip generation rates of 5.35 vehicle trips per dwelling unit for weekday, 0.26 for the AM adjacent street peak hour, and 0.47 for the PM adjacent street peak hour. These patio home rates based on a small sample of sites are lower than those for single-family detached housing (Land Use 210), lower than those for single-family attached housing (Land Use 251), and higher than those for senior adult housing -- single-family (Land Use 251). Further analysis of this housing type will be conducted in a future edition of *Trip Generation Manual*.

Additional Data

The technical appendices provide supporting information on time-of-day distributions for this land use. The appendices can be accessed through either the ITETripGen web app or the trip generation resource page on the ITE website (https://www.ite.org/technical-resources/topics/trip-and-parking-generation/).

For 30 of the study sites, data on the number of residents and number of household vehicles are available. The overall averages for the 30 sites are 3.6 residents per dwelling unit and 1.5 vehicles per dwelling unit.

The sites were surveyed in the 1980s, the 1990s, the 2000s, and the 2010s in Arizona, California, Connecticut, Delaware, Illinois, Indiana, Kentucky, Maryland, Massachusetts, Minnesota, Montana, New Jersey, North Carolina, Ohio, Ontario (CAN), Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Vermont, Virginia, and West Virginia.

Source Numbers

100, 105, 114, 126, 157, 167, 177, 197, 207, 211, 217, 267, 275, 293, 300, 319, 320, 356, 357, 367, 384, 387, 407, 435, 522, 550, 552, 579, 598, 601, 603, 614, 637, 711, 716, 720, 728, 735, 868, 869, 903, 925, 936, 1005, 1007, 1008, 1010, 1033, 1066, 1077,1078, 1079

Single-Family Detached Housing
(210)

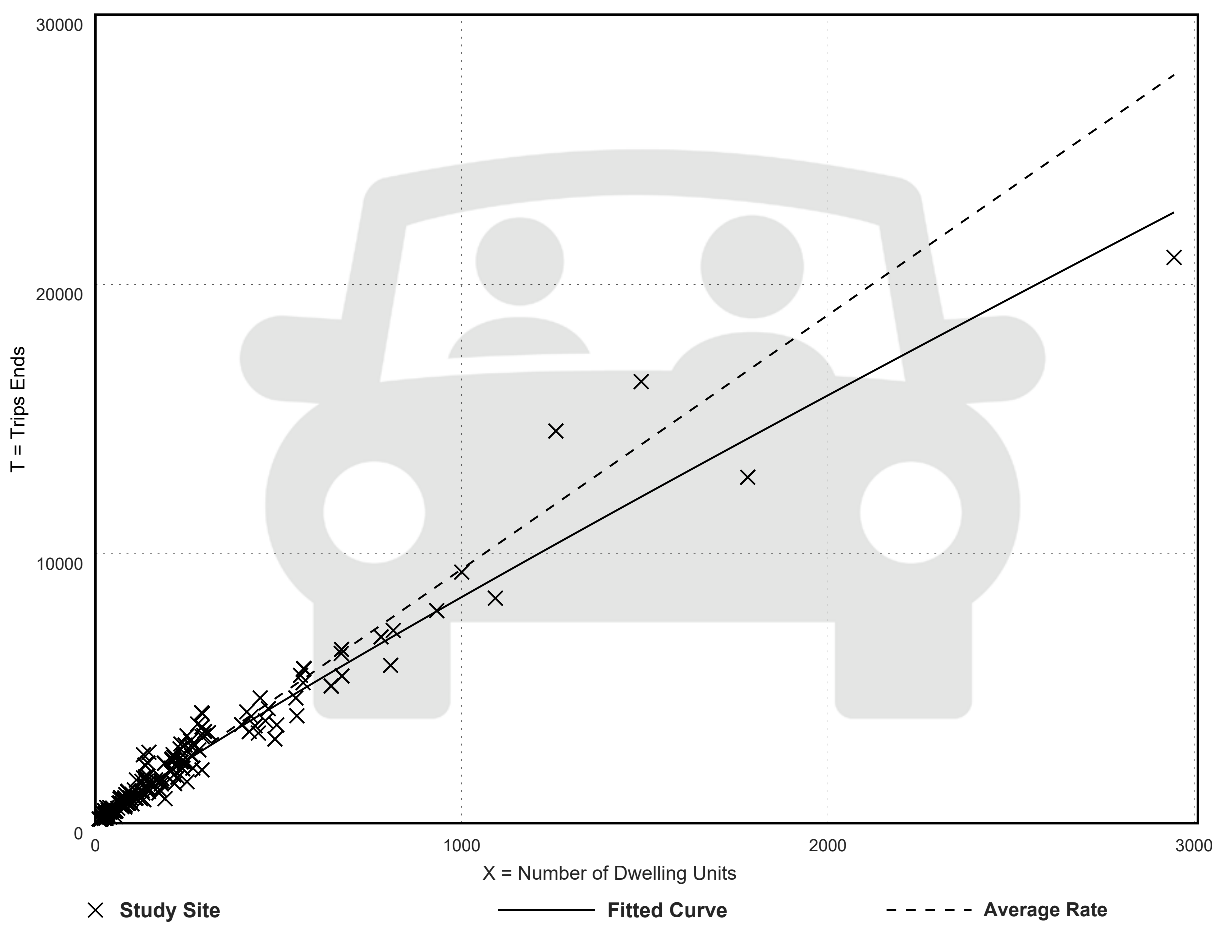
Vehicle Trip Ends vs: Dwelling Units
On a: Weekday

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

Data Plot and Equation



Fitted Curve Equation: Ln(T) = 0.92 Ln(X) + 2.68 **R^2= 0.95**

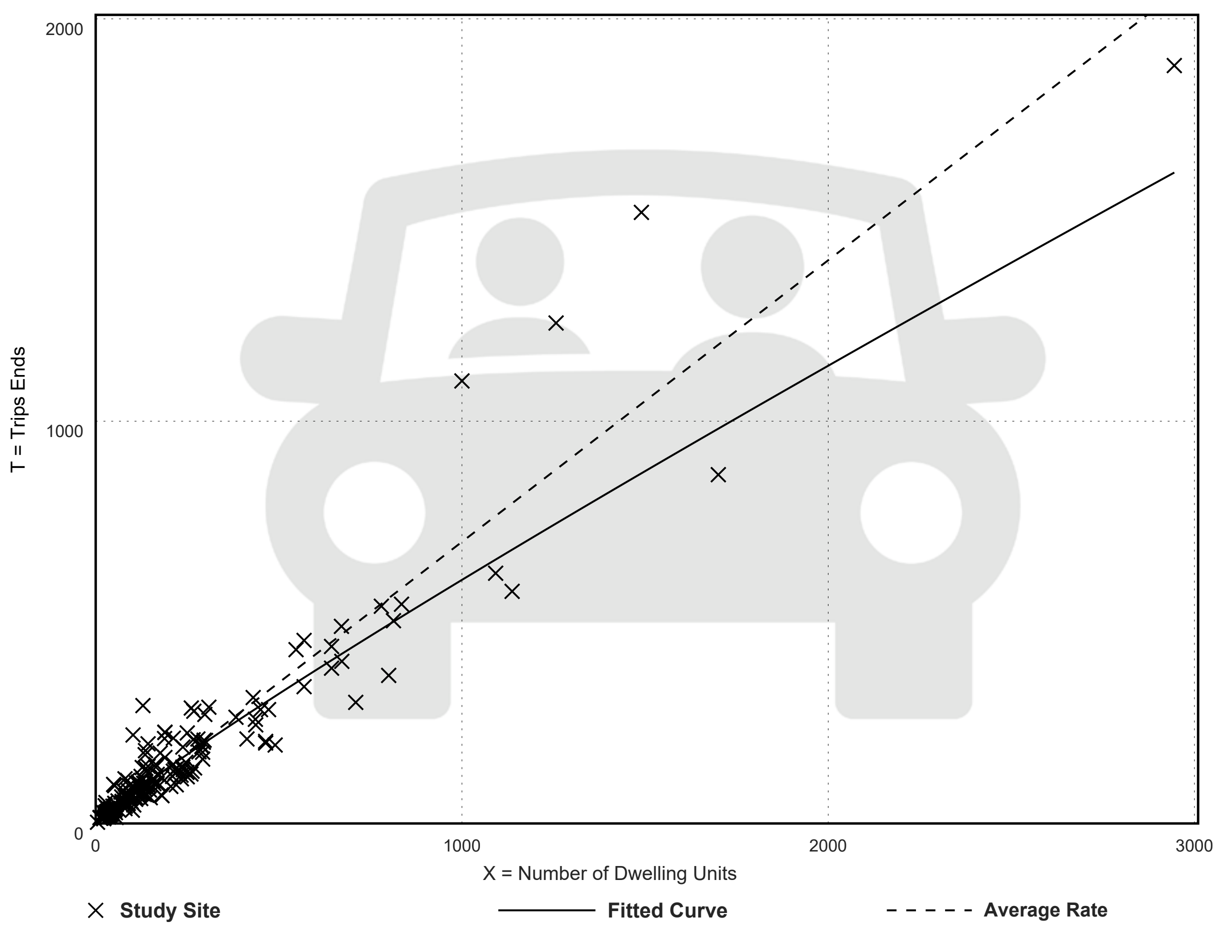
Single-Family Detached Housing
(210)

Vehicle Trip Ends vs:	**Dwelling Units**
On a:	**Weekday,**
	Peak Hour of Adjacent Street Traffic,
	One Hour Between 7 and 9 a.m.
Setting/Location:	**General Urban/Suburban**
Number of Studies:	192
Avg. Num. of Dwelling Units:	226
Directional Distribution:	26% entering, 74% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.70	0.27 - 2.27	0.24

Data Plot and Equation



Fitted Curve Equation: Ln(T) = 0.91 Ln(X) + 0.12

R^2= 0.90

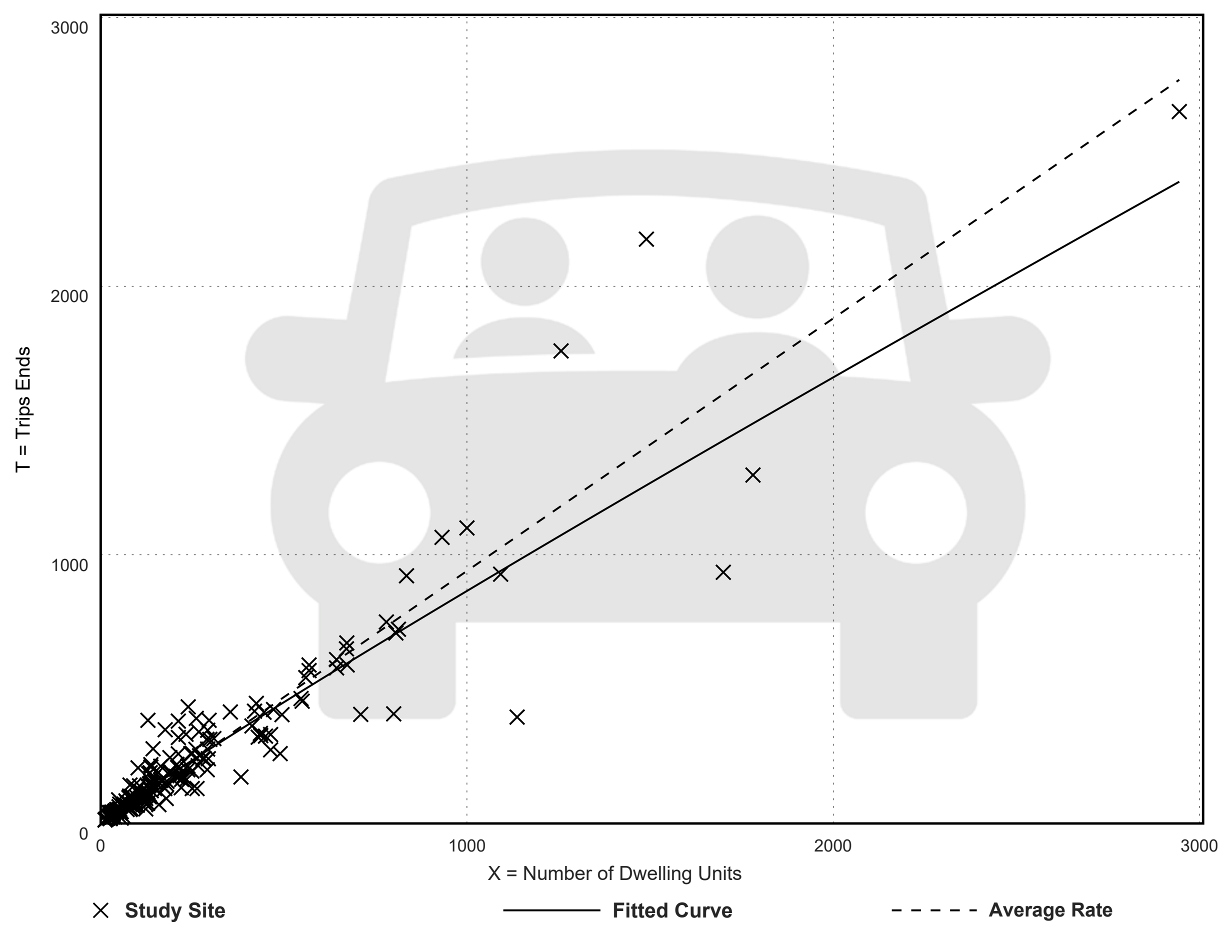
Single-Family Detached Housing (210)

Vehicle Trip Ends vs:	**Dwelling Units**
On a:	**Weekday, Peak Hour of Adjacent Street Traffic, One Hour Between 4 and 6 p.m.**
Setting/Location:	**General Urban/Suburban**
Number of Studies:	208
Avg. Num. of Dwelling Units:	248
Directional Distribution:	63% entering, 37% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.94	0.35 - 2.98	0.31

Data Plot and Equation



Fitted Curve Equation: $Ln(T) = 0.94\ Ln(X) + 0.27$ **$R^2 = 0.92$**

Land Use: 215
Single-Family Attached Housing

Description

Single-family attached housing includes any single-family housing unit that shares a wall with an adjoining dwelling unit, whether the walls are for living space, a vehicle garage, or storage space.

Additional Data

The database for this land use includes duplexes (defined as a single structure with two distinct dwelling units, typically joined side-by-side and each with at least one outside entrance) and townhouses/rowhouses (defined as a single structure with three or more distinct dwelling units, joined side-by-side in a row and each with an outside entrance).

The technical appendices provide supporting information on time-of-day distributions for this land use. The appendices can be accessed through either the ITETripGen web app or the trip generation resource page on the ITE website (https://www.ite.org/technical-resources/topics/trip-and-parking-generation/).

The sites were surveyed in the 1980s, the 1990s, the 2000s, and the 2010s in British Columbia (CAN), California, Georgia, Illinois, Maryland, Massachusetts, Minnesota, New Jersey, Ontario (CAN), Oregon, Pennsylvania, South Dakota, Utah, Virginia, and Wisconsin.

Source Numbers

168, 204, 211, 237, 305, 306, 319, 321, 357, 390, 418, 525, 571, 583, 638, 735, 868, 869, 870, 896, 912, 959, 1009, 1046, 1056, 1058, 1077

Single-Family Attached Housing
(215)

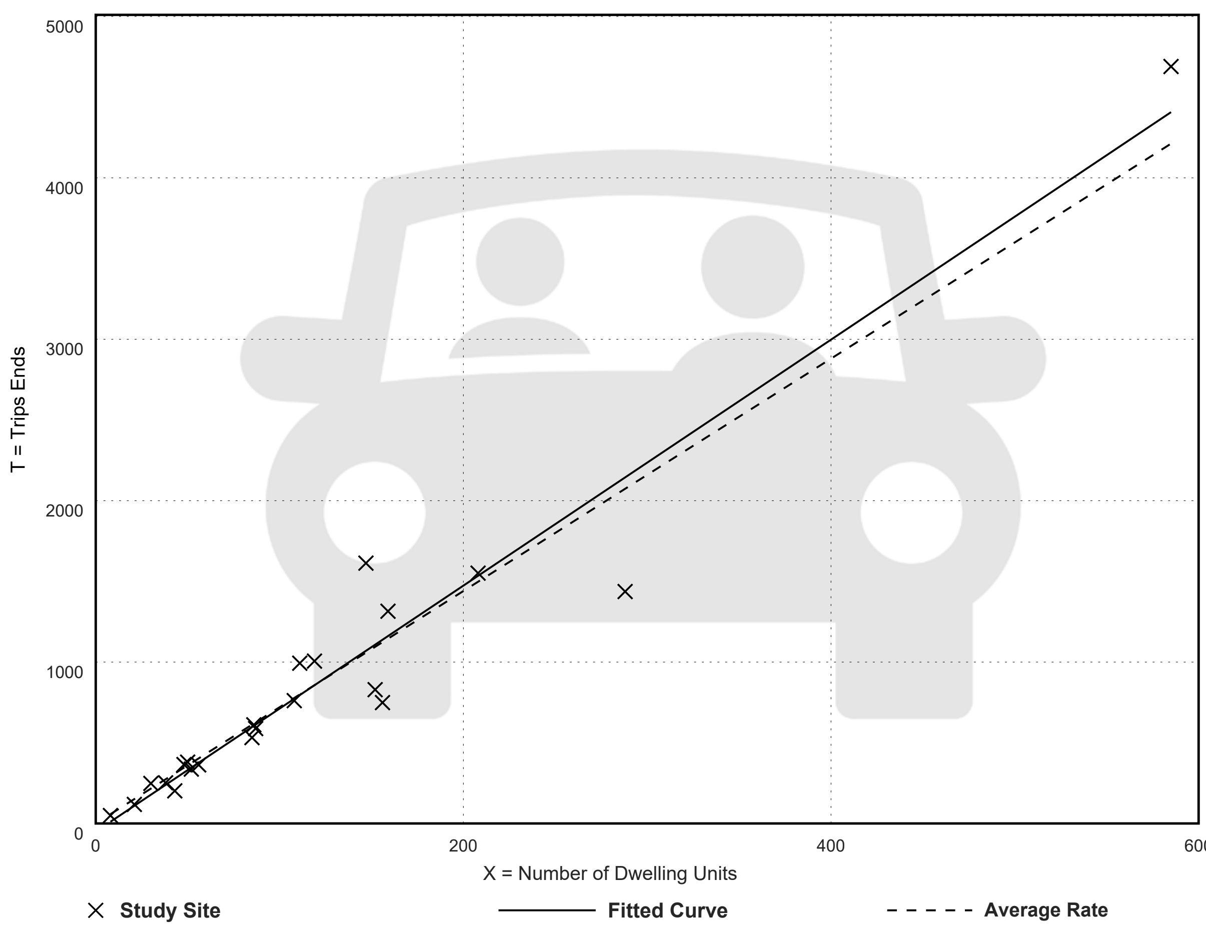
Vehicle Trip Ends vs: Dwelling Units
On a: Weekday

Setting/Location: General Urban/Suburban
Number of Studies: 22
Avg. Num. of Dwelling Units: 120
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
7.20	4.70 - 10.97	1.61

Data Plot and Equation



Fitted Curve Equation: T = 7.62(X) - 50.48 **R^2= 0.94**

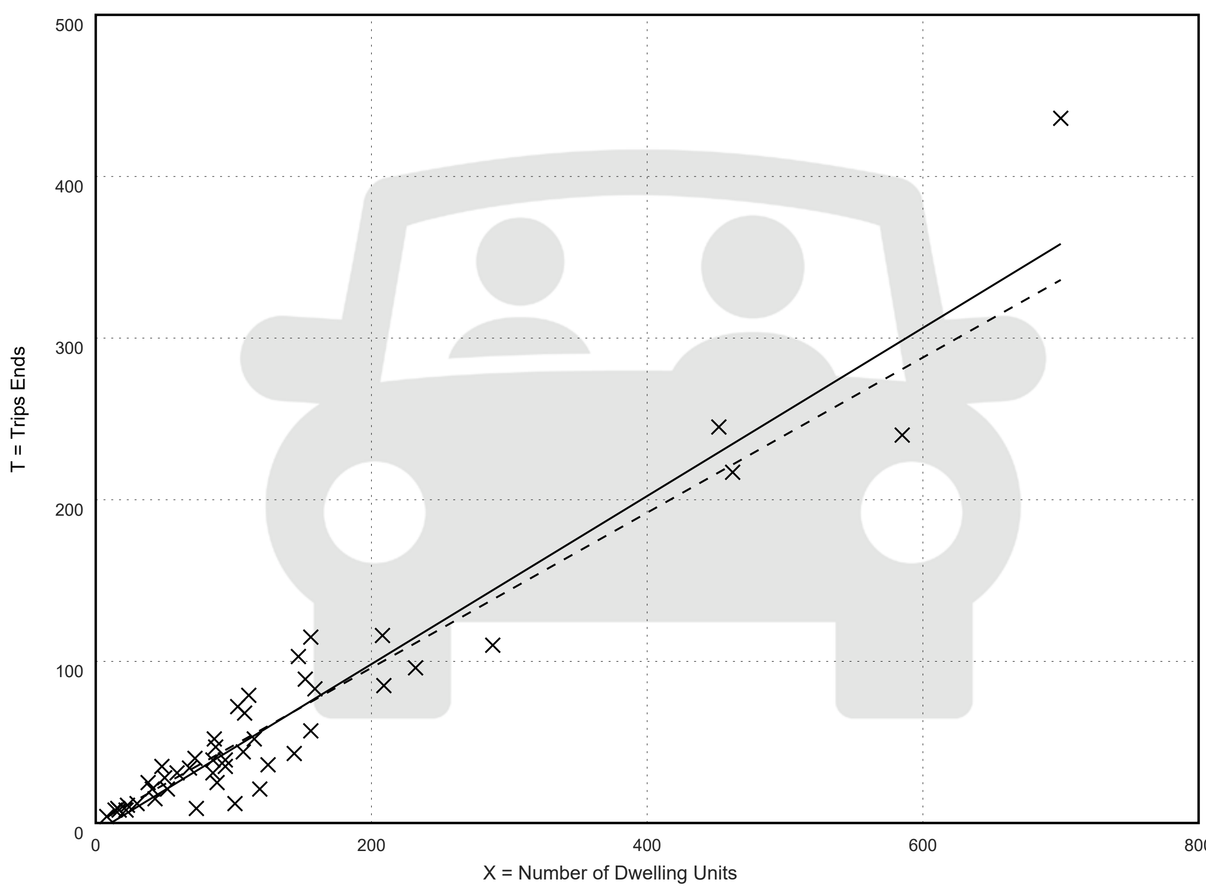
Single-Family Attached Housing (215)

Vehicle Trip Ends vs:	**Dwelling Units**
On a:	**Weekday,**
	Peak Hour of Adjacent Street Traffic,
	One Hour Between 7 and 9 a.m.
Setting/Location:	**General Urban/Suburban**
Number of Studies:	46
Avg. Num. of Dwelling Units:	135
Directional Distribution:	31% entering, 69% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.48	0.12 - 0.74	0.14

Data Plot and Equation



× **Study Site** ——— **Fitted Curve** - - - - - **Average Rate**

Fitted Curve Equation: T = 0.52(X) - 5.70 **R^2= 0.92**

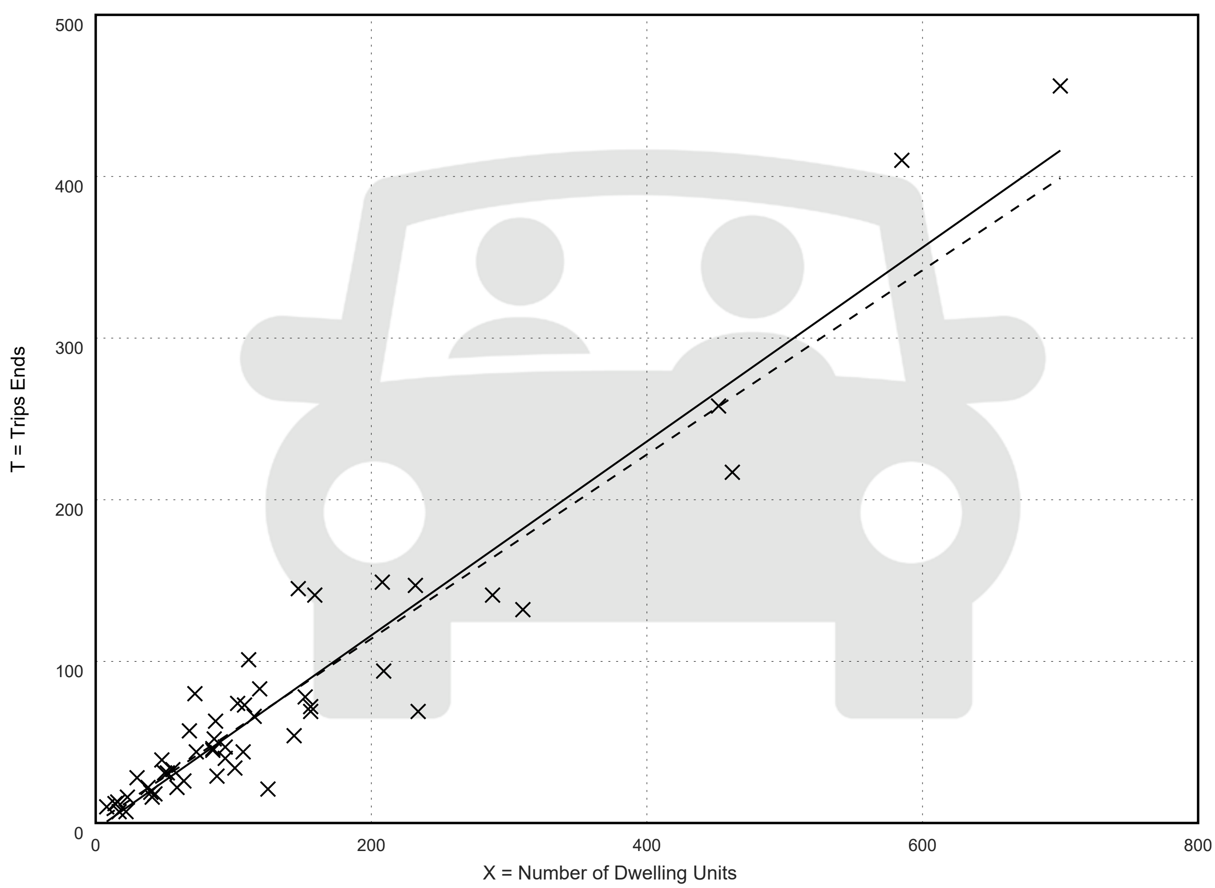
Single-Family Attached Housing
(215)

Vehicle Trip Ends vs:	**Dwelling Units**
On a:	**Weekday,**
	Peak Hour of Adjacent Street Traffic,
	One Hour Between 4 and 6 p.m.
Setting/Location:	**General Urban/Suburban**
Number of Studies:	51
Avg. Num. of Dwelling Units:	136
Directional Distribution:	57% entering, 43% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.57	0.17 - 1.25	0.18

Data Plot and Equation



× **Study Site** ——— **Fitted Curve** - - - - **Average Rate**

Fitted Curve Equation: $T = 0.60(X) - 3.93$ **R^2= 0.91**

Land Use: 220
Multifamily Housing (Low-Rise)

Description

Low-rise multifamily housing includes apartments, townhouses, and condominiums located within the same building with at least three other dwelling units and that have two or three floors (levels). Various configurations fit this description, including walkup apartment, mansion apartment, and stacked townhouse.

- A walkup apartment typically is two or three floors in height with dwelling units that are accessed by a single or multiple entrances with stairways and hallways.
- A mansion apartment is a single structure that contains several apartments within what appears to be a single-family dwelling unit.
- A fourplex is a single two-story structure with two matching dwelling units on the ground and second floors. Access to the individual units is typically internal to the structure and provided through a central entry and stairway.
- A stacked townhouse is designed to match the external appearance of a townhouse. But, unlike a townhouse dwelling unit that only shares walls with an adjoining unit, the stacked townhouse units share both floors and walls. Access to the individual units is typically internal to the structure and provided through a central entry and stairway.

Multifamily housing (mid-rise) (Land Use 221), multifamily housing (high-rise) (Land Use 222), affordable housing (Land Use 223), and off-campus student apartment (low-rise) (Land Use 225) are related land uses.

Land Use Subcategory

Data are presented for two subcategories for this land use: (1) not close to rail transit and (2) close to rail transit. A site is considered close to rail transit if the walking distance between the residential site entrance and the closest rail transit station entrance is ½ mile or less.

Additional Data

For the three sites for which both the number of residents and the number of occupied dwelling units were available, there were an average of 2.72 residents per occupied dwelling unit.

For the two sites for which the numbers of both total dwelling units and occupied dwelling units were available, an average of 96.2 percent of the total dwelling units were occupied.

The technical appendices provide supporting information on time-of-day distributions for this land use. The appendices can be accessed through either the ITETripGen web app or the trip generation resource page on the ITE website (https://www.ite.org/technical-resources/topics/trip-and-parking-generation/).

For the three sites for which data were provided for both occupied dwelling units and residents, there was an average of 2.72 residents per occupied dwelling unit.

It is expected that the number of bedrooms and number of residents are likely correlated to the trips generated by a residential site. To assist in future analysis, trip generation studies of all multifamily housing should attempt to obtain information on occupancy rate and on the mix of residential unit sizes (i.e., number of units by number of bedrooms at the site complex).

The sites were surveyed in the 1980s, the 1990s, the 2000s, the 2010s, and the 2020s in British Columbia (CAN), California, Delaware, Florida, Georgia, Illinois, Indiana, Maine, Maryland, Massachusetts, Minnesota, New Jersey, Ontario (CAN), Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, and Washington.

Source Numbers

188, 204, 237, 300, 305, 306, 320, 321, 357, 390, 412, 525, 530, 579, 583, 638, 864, 866, 896, 901, 903, 904, 936, 939, 944, 946, 947, 948, 963, 964, 966, 967, 1012, 1013, 1014, 1036, 1047, 1056, 1071, 1076

Multifamily Housing (Low-Rise) Not Close to Rail Transit (220)

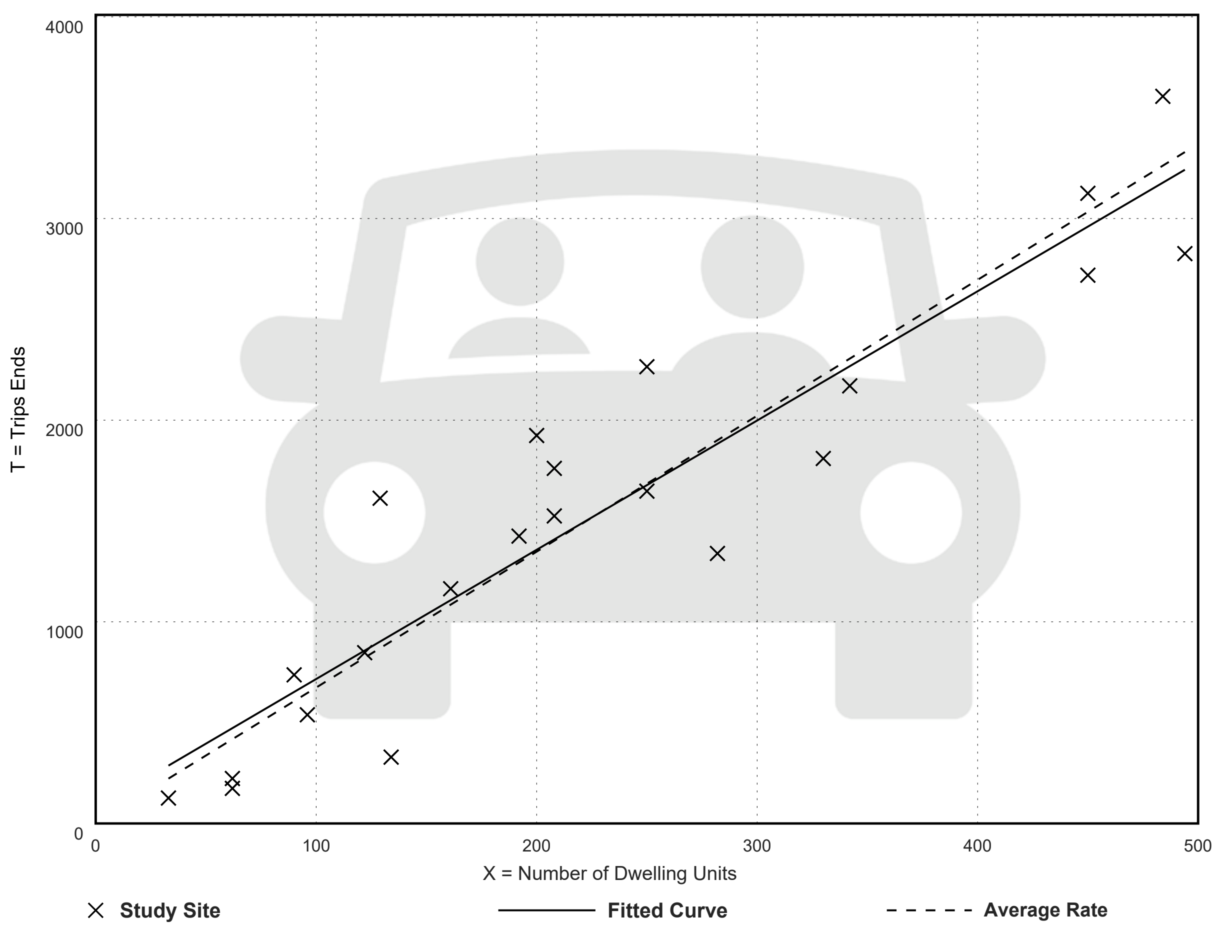
Vehicle Trip Ends vs: Dwelling Units
On a: Weekday

Setting/Location: General Urban/Suburban
Number of Studies: 22
Avg. Num. of Dwelling Units: 229
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
6.74	2.46 - 12.50	1.79

Data Plot and Equation



Fitted Curve Equation: $T = 6.41(X) + 75.31$ **$R^2 = 0.86$**

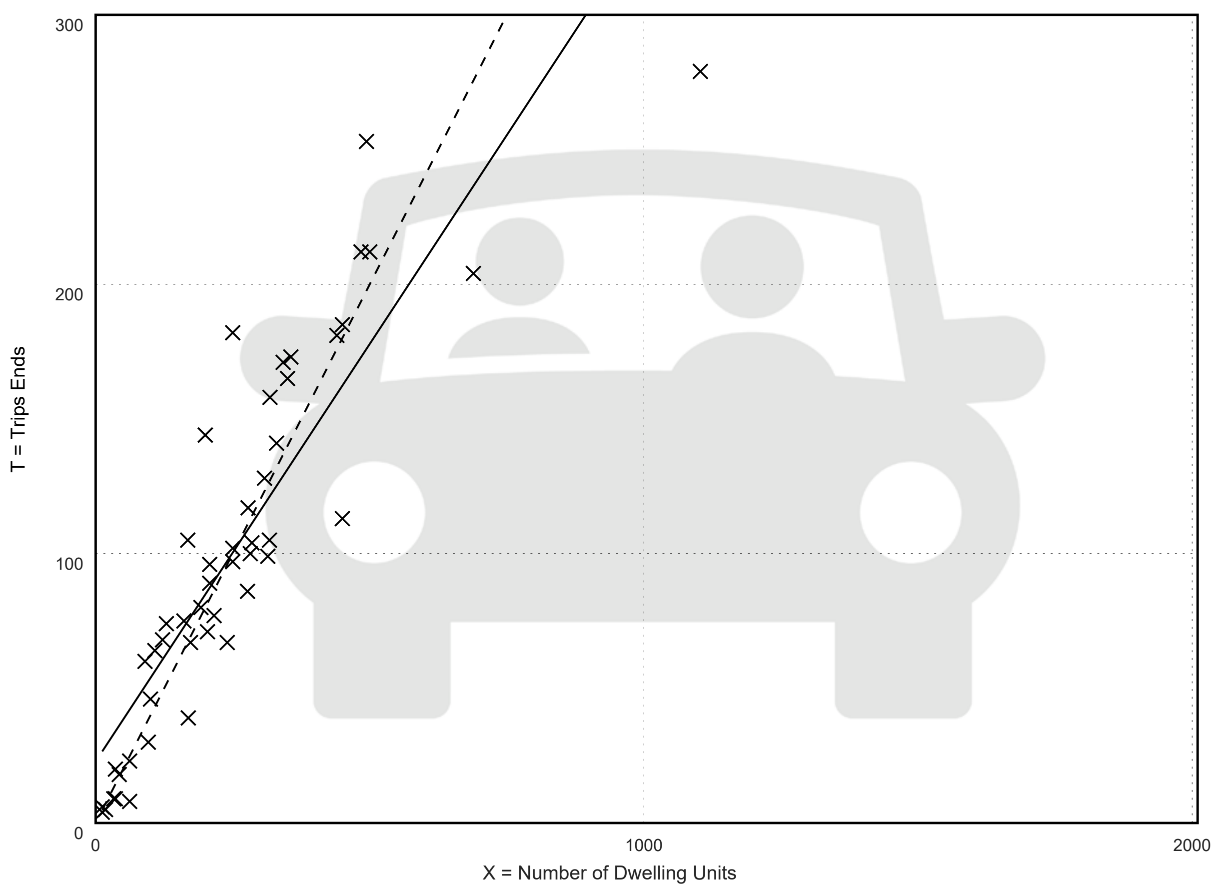
Multifamily Housing (Low-Rise) Not Close to Rail Transit (220)

Vehicle Trip Ends vs: Dwelling Units
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.
Setting/Location: General Urban/Suburban
Number of Studies: 49
Avg. Num. of Dwelling Units: 249
Directional Distribution: 24% entering, 76% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.40	0.13 - 0.73	0.12

Data Plot and Equation



× **Study Site** ——— **Fitted Curve** - - - - - **Average Rate**

Fitted Curve Equation: T = 0.31(X) + 22.85 **R^2= 0.79**

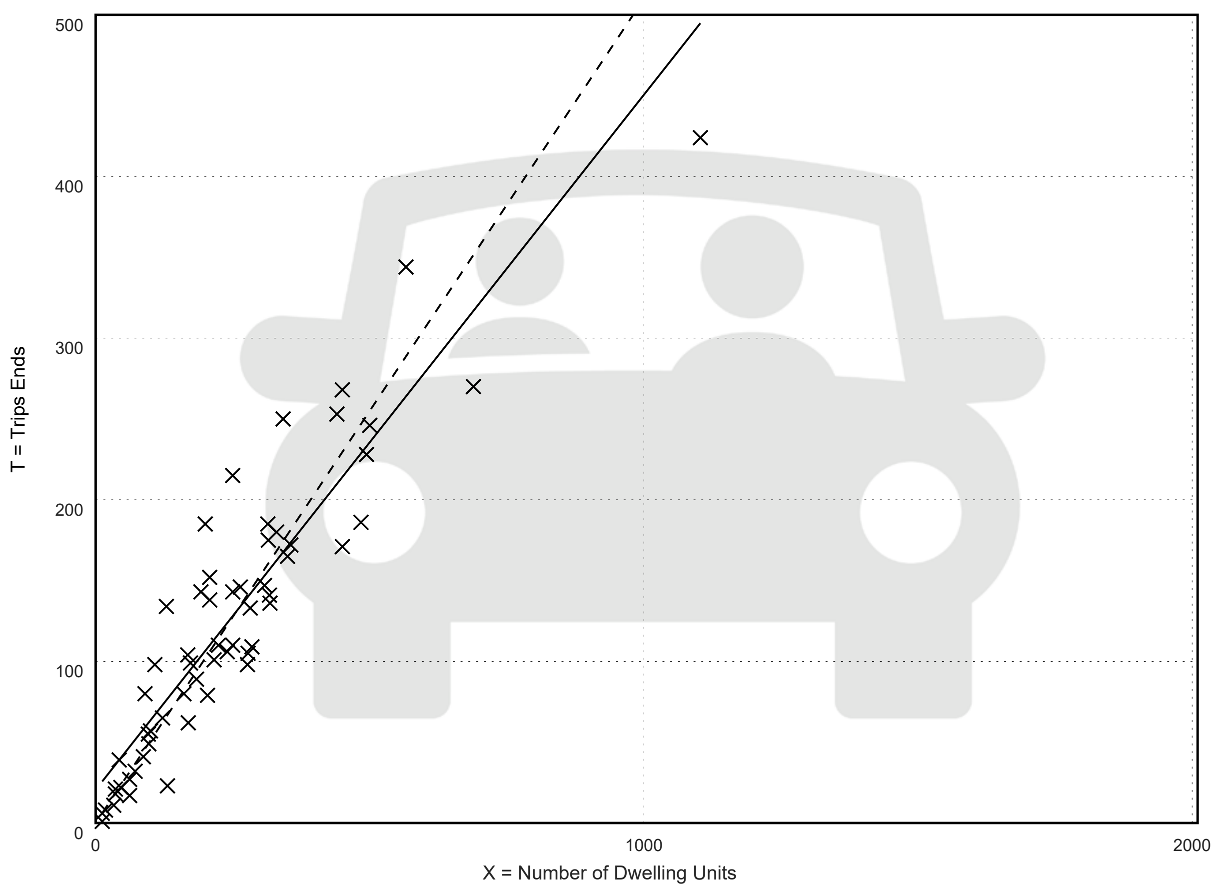
Multifamily Housing (Low-Rise) Not Close to Rail Transit (220)

Vehicle Trip Ends vs: **Dwelling Units**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.
Setting/Location: **General Urban/Suburban**
Number of Studies: 59
Avg. Num. of Dwelling Units: 241
Directional Distribution: 63% entering, 37% exiting

Vehicle Trip Generation per Dwelling Unit

Average Rate	Range of Rates	Standard Deviation
0.51	0.08 - 1.04	0.15

Data Plot and Equation



× **Study Site** —— **Fitted Curve** - - - - **Average Rate**

Fitted Curve Equation: $T = 0.43(X) + 20.55$ **$R^2 = 0.84$**

Land Use: 820
Shopping Center (>150k)

Description

A shopping center is an integrated group of commercial establishments that is planned, developed, owned, and managed as a unit. Each study site in this land use has at least 150,000 square feet of gross leasable area (GLA). It often has more than one anchor store. Various names can be assigned to a shopping center within this size range, depending on its specific size and tenants, such as community center, regional center, superregional center, fashion center, and power center.

A shopping center of this size typically contains more than retail merchandising facilities. Office space, a movie theater, restaurants, a post office, banks, a health club, and recreational facilities are common tenants.

A shopping center of this size can be enclosed or open-air. The vehicle trips generated at a shopping center are based upon the total GLA of the center. In the case of a smaller center without an enclosed mall or peripheral buildings, the GLA is the same as the gross floor area of the building.

The 150,000 square feet GLA threshold value between community/regional shopping center and shopping plaza (Land Use 821) is based on an examination of trip generation data. For a shopping plaza that is smaller than the threshold value, the presence or absence of a supermarket within the plaza has a measurable effect on site trip generation. For a shopping center that is larger than the threshold value, the trips generated by its other major tenants mask any effects of the presence or absence of an on-site supermarket.

Shopping plaza (40-150k) (Land Use 821), strip retail plaza (<40k) (Land Use 822), and factory outlet center (Land Use 823) are related uses.

Additional Data

Many shopping centers—in addition to the integrated unit of shops in one building or enclosed around a mall—include outparcels (peripheral buildings or pads located on the perimeter of the center adjacent to the streets and major access points). These buildings are typically drive-in banks, retail stores, restaurants, or small offices. Although the data herein do not indicate which of the centers studied include peripheral buildings, it can be assumed that some of the data show their effect.

The technical appendices provide supporting information on time-of-day distributions for this land use. The appendices can be accessed through either the ITETripGen web app or the trip generation resource page on the ITE website (https://www.ite.org/technical-resources/topics/trip-and-parking-generation/).

The sites were surveyed in the 1980s, the 1990s, the 2000s, and the 2010s in Alberta (CAN), California, Colorado, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Texas, Vermont, Virginia, Washington, West Virginia, and Wisconsin.

Source Numbers

77, 110, 154, 156, 159, 190, 199, 202, 204, 213, 251, 269, 294, 295, 299, 304, 305, 307, 308, 309, 311, 314, 315, 316, 317, 319, 365, 385, 404, 414, 423, 442, 446, 562, 629, 702, 715, 728, 868, 871, 880, 899, 912, 926, 946, 962, 973, 974, 978, 1034, 1040, 1067

Shopping Center (>150k)
(820)

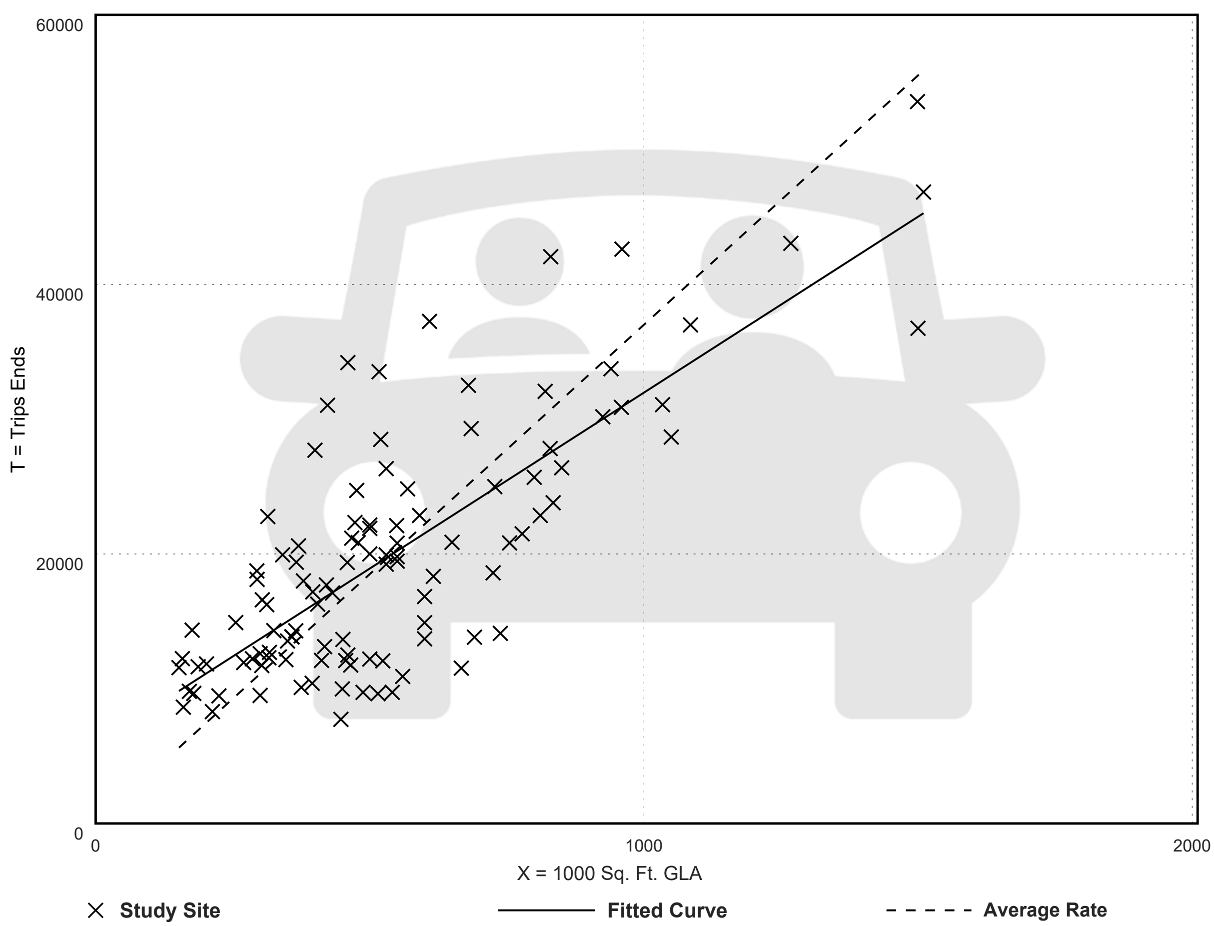
Vehicle Trip Ends vs: 1000 Sq. Ft. GLA
On a: Weekday

Setting/Location: General Urban/Suburban
Number of Studies: 108
Avg. 1000 Sq. Ft. GLA: 538
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GLA

Average Rate	Range of Rates	Standard Deviation
37.01	17.27 - 81.53	12.79

Data Plot and Equation



Fitted Curve Equation: $T = 26.11(X) + 5863.73$ **$R^2 = 0.60$**

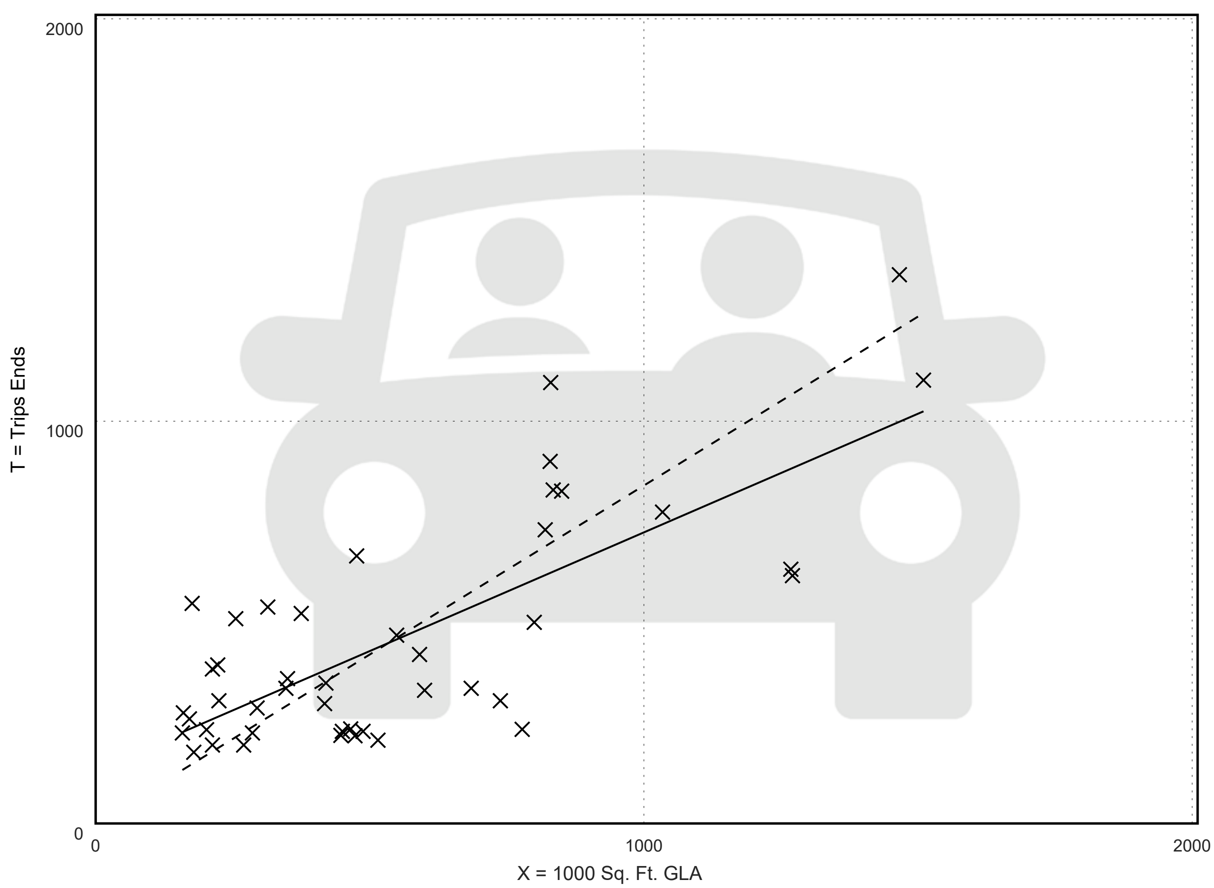
Shopping Center (>150k)
(820)

Vehicle Trip Ends vs: **1000 Sq. Ft. GLA**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.
Setting/Location: **General Urban/Suburban**
Number of Studies: 44
Avg. 1000 Sq. Ft. GLA: 546
Directional Distribution: 62% entering, 38% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GLA

Average Rate	Range of Rates	Standard Deviation
0.84	0.30 - 3.11	0.42

Data Plot and Equation



× **Study Site** ——— **Fitted Curve** - - - - - **Average Rate**

Fitted Curve Equation: $T = 0.59(X) + 133.55$ **$R^2 = 0.56$**

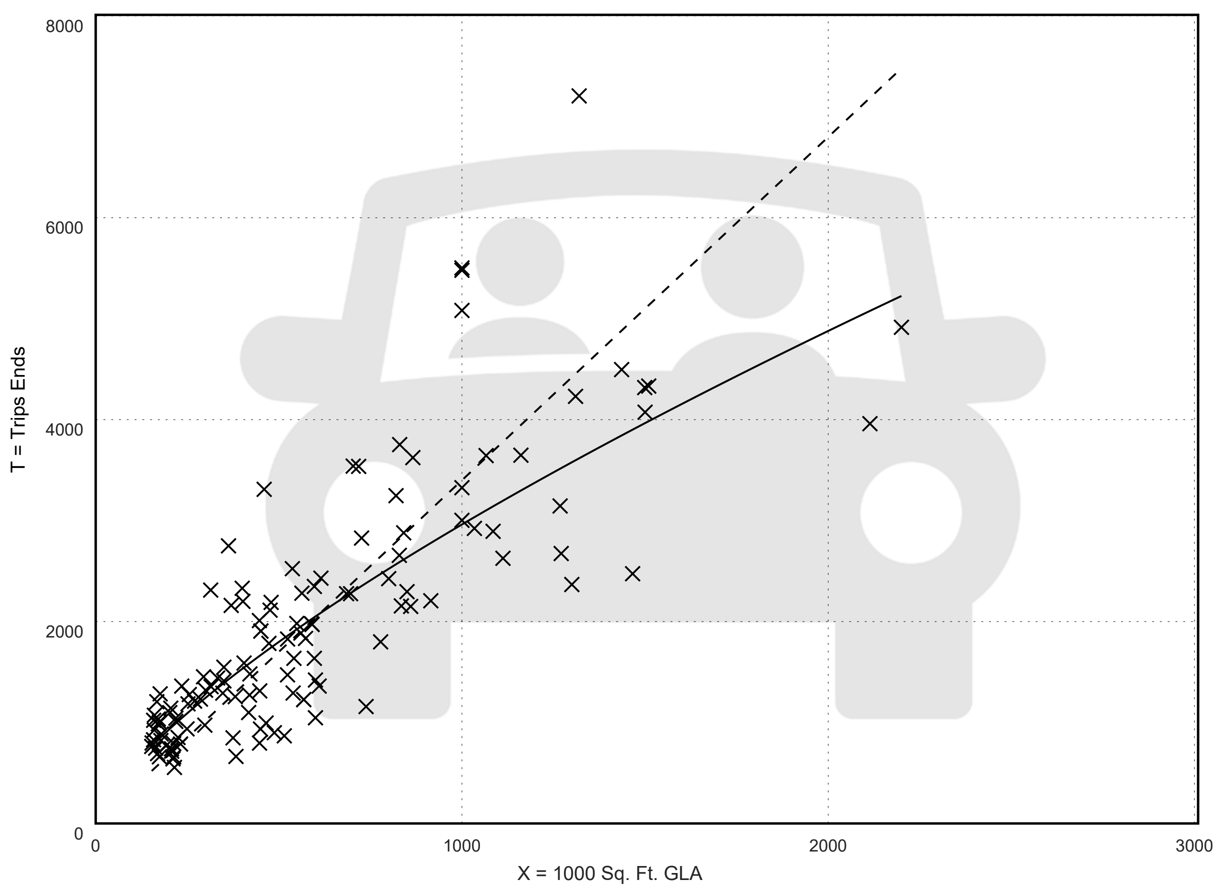
Shopping Center (>150k)
(820)

Vehicle Trip Ends vs: **1000 Sq. Ft. GLA**
On a: **Weekday,**
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.
Setting/Location: **General Urban/Suburban**
Number of Studies: 126
Avg. 1000 Sq. Ft. GLA: 581
Directional Distribution: 48% entering, 52% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GLA

Average Rate	Range of Rates	Standard Deviation
3.40	1.57 - 7.58	1.26

Data Plot and Equation



× **Study Site** —— **Fitted Curve** - - - - **Average Rate**

Fitted Curve Equation: Ln(T) = 0.72 Ln(X) + 3.02 **R^2= 0.70**

Land Use: 750
Office Park

Description

An office park is typically a suburban subdivision or planned unit development that contains general office buildings and support services, such as banks, restaurants, and service stations, arranged in a park- or campus-like atmosphere. General office building (Land Use 710), corporate headquarters building (Land Use 714), single tenant office building (Land Use 715), research and development center (Land Use 760), and business park (Land Use 770) are related uses.

Additional Data

The sites were surveyed in the 1980s, the 1990s, the 2000s, and the 2010s in Alberta (CAN), Connecticut, Georgia, Indiana, Massachusetts, New Jersey, New York, and Pennsylvania.

Source Numbers

160, 161, 184, 185, 253, 300, 301, 356, 550, 618, 912, 972, 973

Office Park
(750)

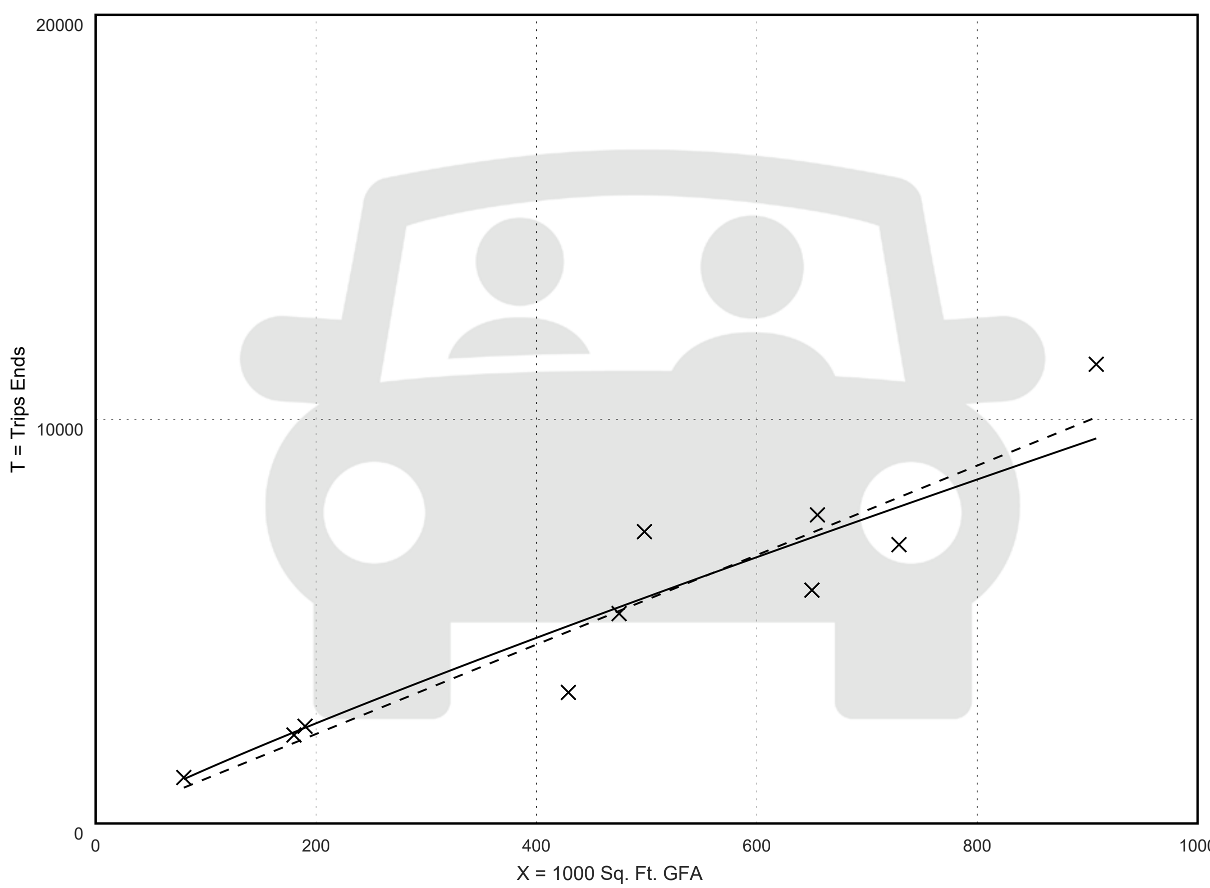
Vehicle Trip Ends vs: 1000 Sq. Ft. GFA
On a: Weekday

Setting/Location: General Urban/Suburban
Number of Studies: 10
Avg. 1000 Sq. Ft. GFA: 479
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
11.07	7.56 - 14.50	2.14

Data Plot and Equation



× **Study Site** —— **Fitted Curve** - - - - **Average Rate**

Fitted Curve Equation: Ln(T) = 0.89 Ln(X) + 3.10 **R^2= 0.93**

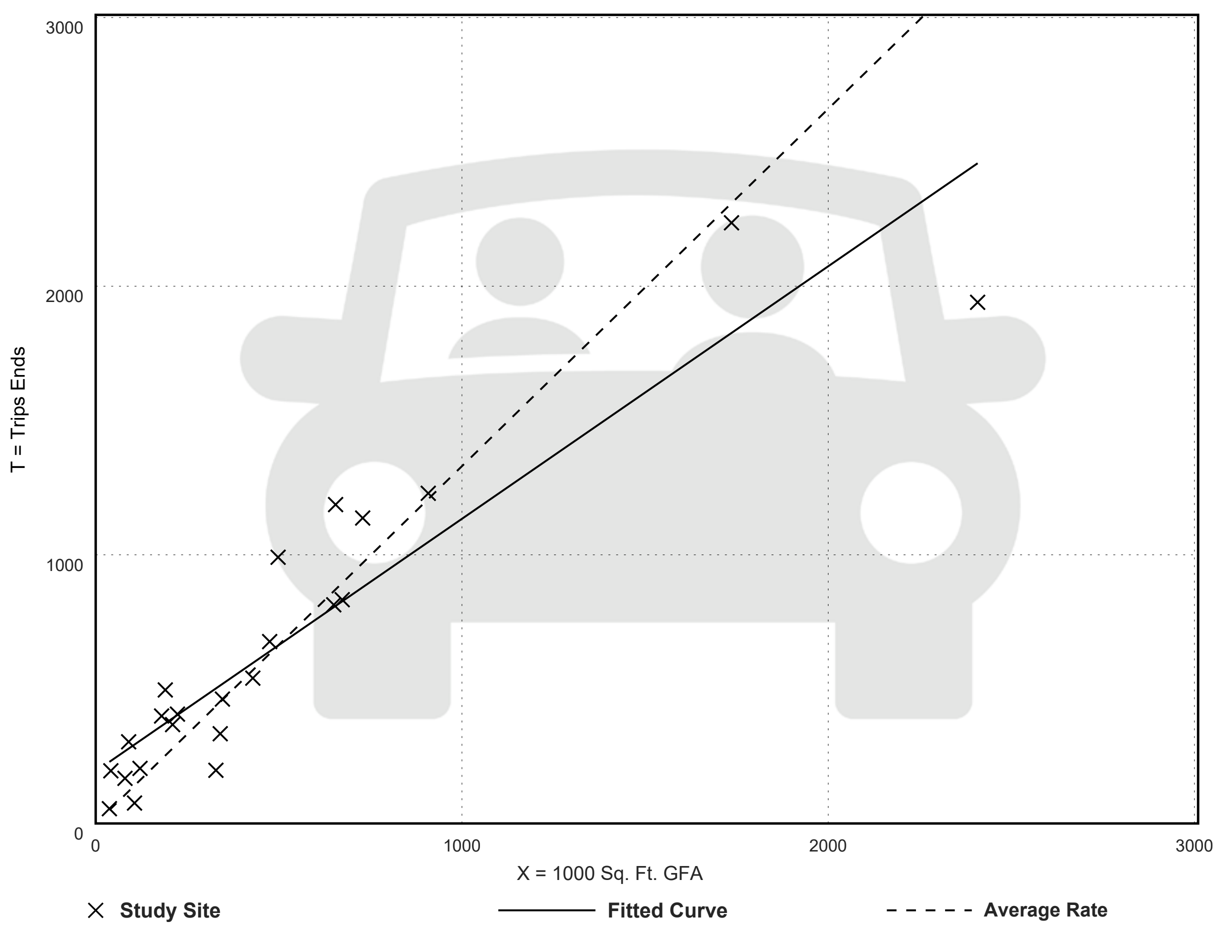
Office Park
(750)

Vehicle Trip Ends vs:	**1000 Sq. Ft. GFA**
On a:	**Weekday,**
	Peak Hour of Adjacent Street Traffic,
	One Hour Between 7 and 9 a.m.
Setting/Location:	**General Urban/Suburban**
Number of Studies:	23
Avg. 1000 Sq. Ft. GFA:	498
Directional Distribution:	89% entering, 11% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
1.33	0.60 - 4.74	0.51

Data Plot and Equation



Fitted Curve Equation: $T = 0.94(X) + 194.06$ **$R^2 = 0.86$**

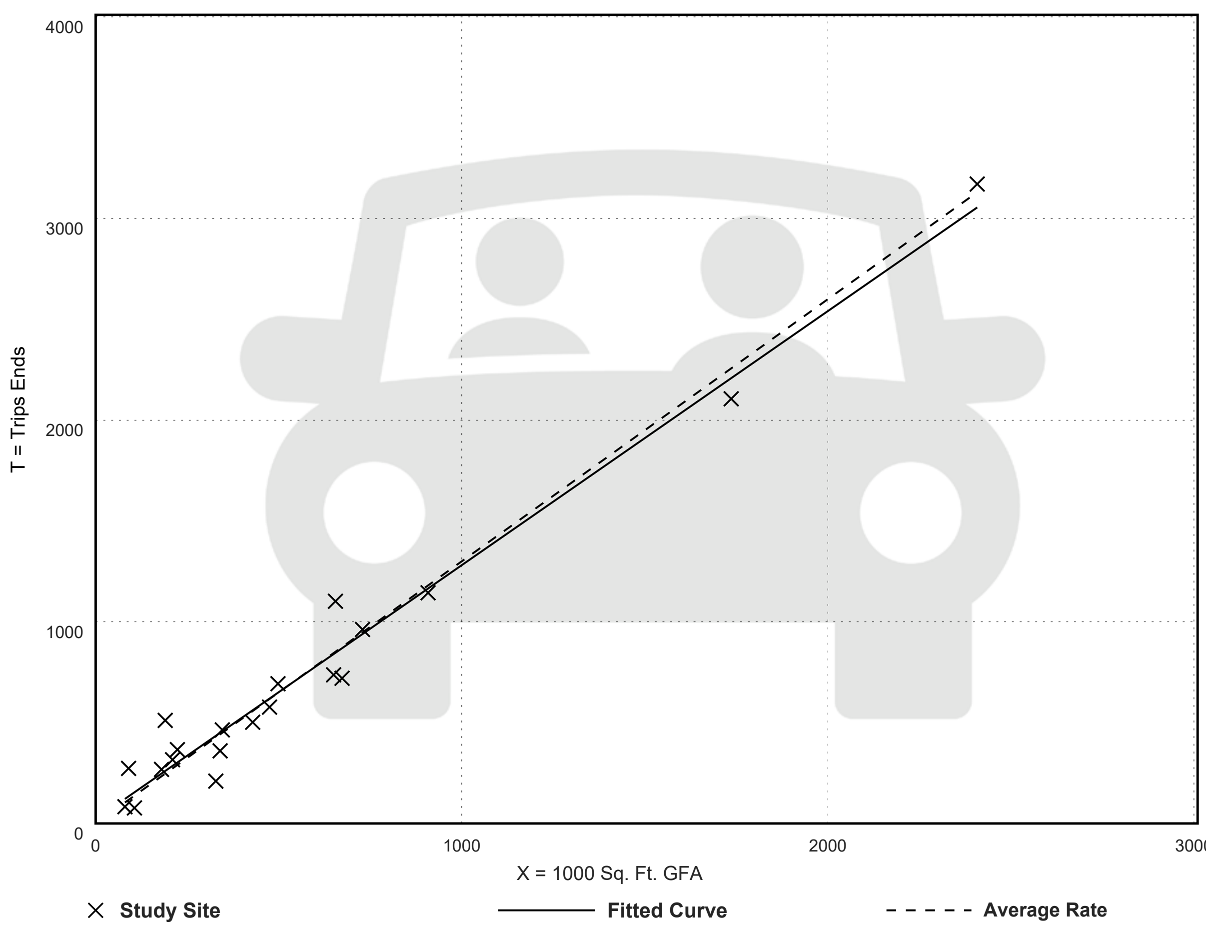
Office Park
(750)

Vehicle Trip Ends vs:	**1000 Sq. Ft. GFA**
On a:	**Weekday,**
	Peak Hour of Adjacent Street Traffic,
	One Hour Between 4 and 6 p.m.
Setting/Location:	**General Urban/Suburban**
Number of Studies:	20
Avg. 1000 Sq. Ft. GFA:	563
Directional Distribution:	14% entering, 86% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
1.30	0.64 - 3.03	0.32

Data Plot and Equation



Fitted Curve Equation: $T = 1.26(X) + 20.98$

$R^2 = 0.97$

Land Use: 730
Government Office Building

Description

A government office building is an individual building containing either the entire function or simply one agency of a city, county, state, federal, or other governmental unit.

Additional Data

Each study site in the current database serves a municipal or county agency.

The technical appendices provide supporting information on time-of-day distributions for this land use. The appendices can be accessed through either the ITETripGen web app or the trip generation resource page on the ITE website (https://www.ite.org/technical-resources/topics/trip-and-parking-generation/).

The sites were surveyed in the 2000s and the 2010s in Oregon and Texas.

Source Numbers

579, 889

Government Office Building
(730)

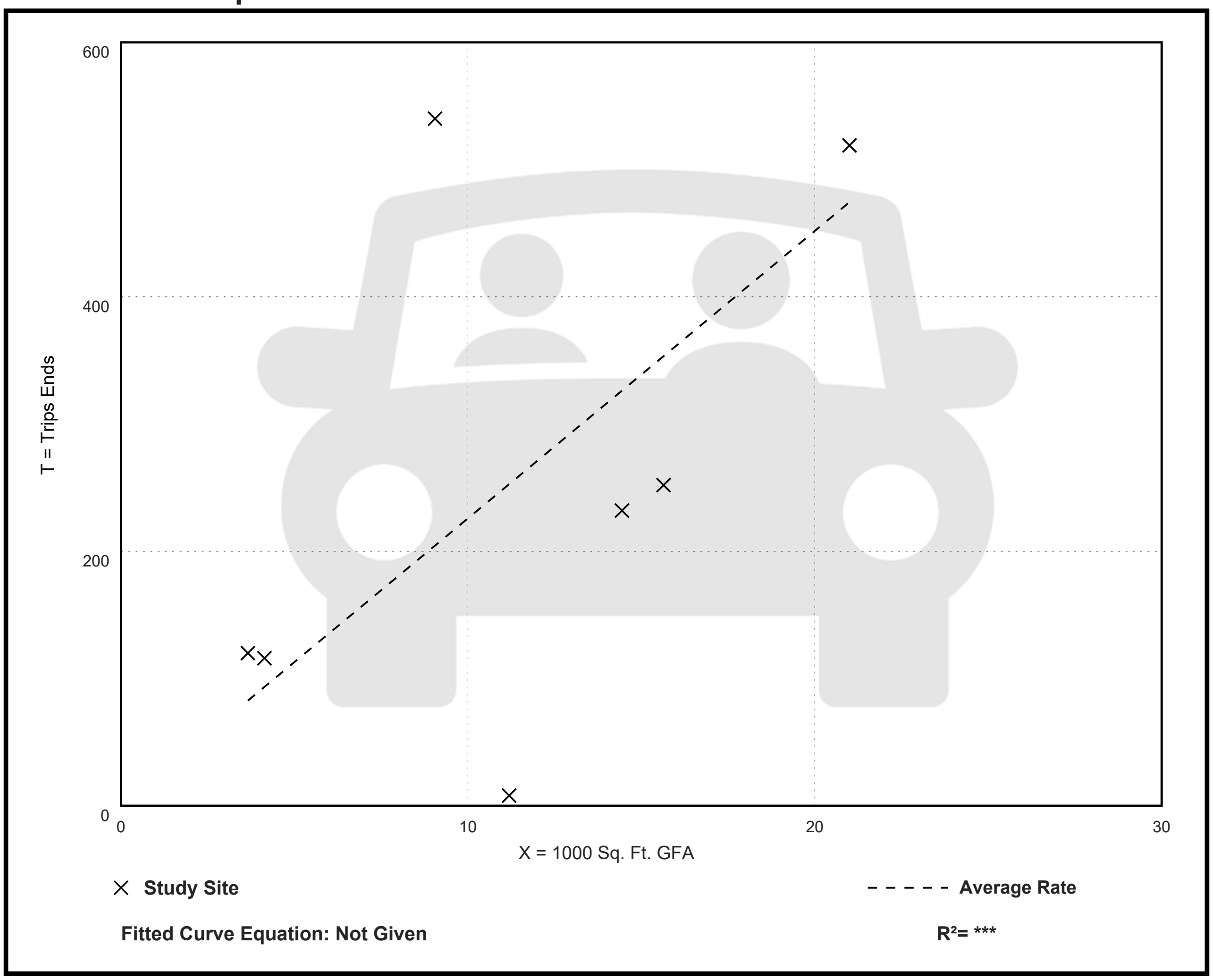
Vehicle Trip Ends vs: 1000 Sq. Ft. GFA
On a: Weekday

Setting/Location: General Urban/Suburban
Number of Studies: 7
Avg. 1000 Sq. Ft. GFA: 11
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
22.59	0.71 - 59.66	17.03

Data Plot and Equation



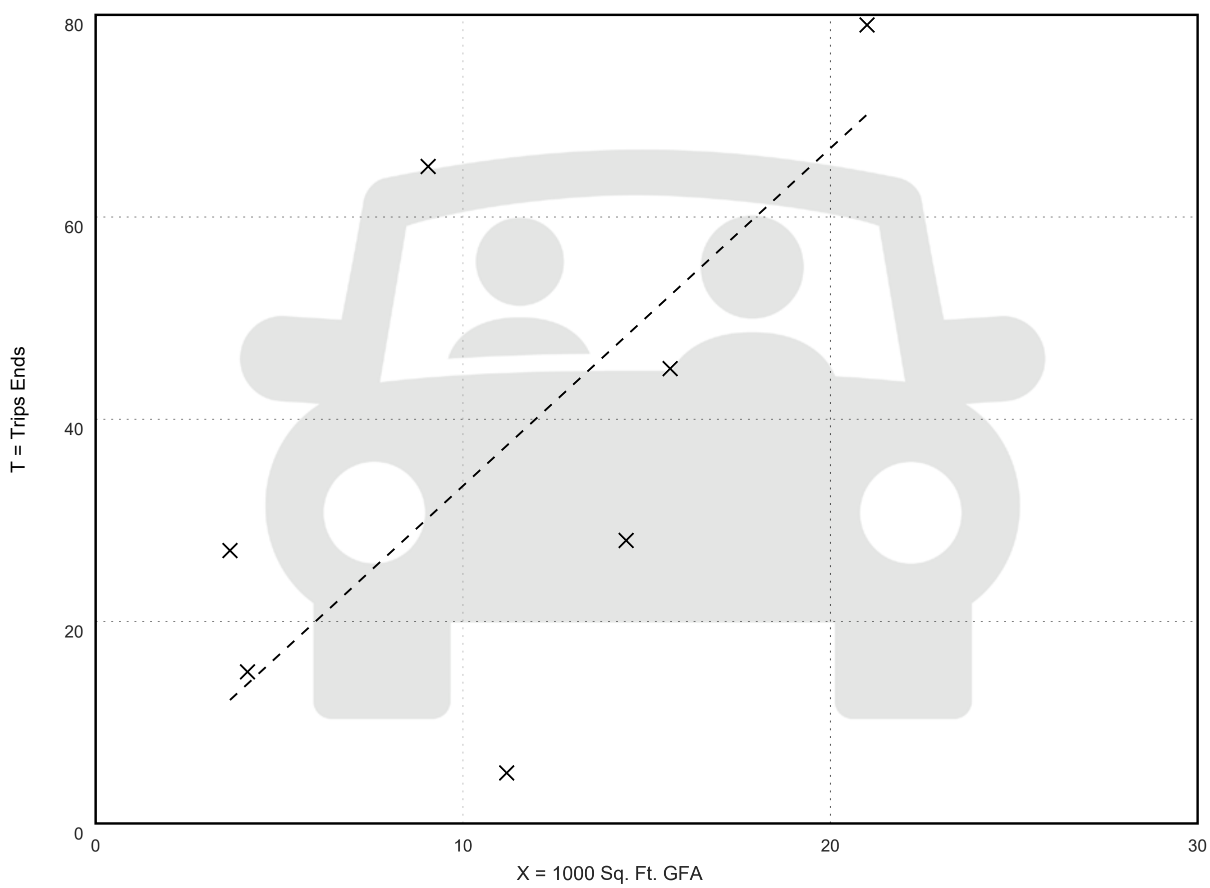
Government Office Building (730)

Vehicle Trip Ends vs: 1000 Sq. Ft. GFA
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.
Setting/Location: General Urban/Suburban
Number of Studies: 7
Avg. 1000 Sq. Ft. GFA: 11
Directional Distribution: 75% entering, 25% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
3.34	0.45 - 7.38	2.18

Data Plot and Equation



Fitted Curve Equation: Not Given

R^2= ***

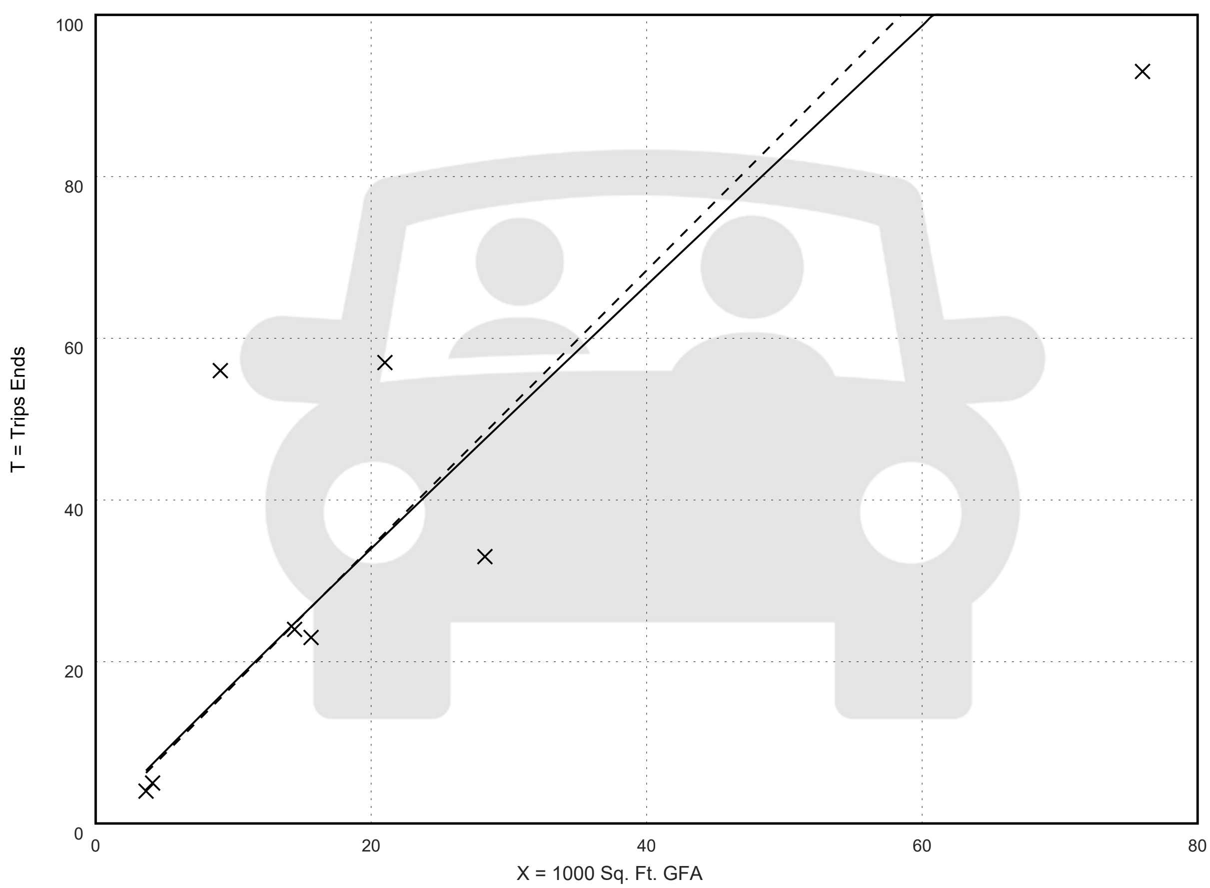
Government Office Building
(730)

Vehicle Trip Ends vs: 1000 Sq. Ft. GFA
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.
Setting/Location: General Urban/Suburban
Number of Studies: 8
Avg. 1000 Sq. Ft. GFA: 22
Directional Distribution: 25% entering, 75% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
1.71	1.09 - 6.19	1.24

Data Plot and Equation



× **Study Site** —— **Fitted Curve** - - - - **Average Rate**

Fitted Curve Equation: Ln(T) = 0.97 Ln(X) + 0.62 **R^2= 0.73**

Land Use: 150
Warehousing

Description

A warehouse is primarily devoted to the storage of materials, but it may also include office and maintenance areas. High-cube transload and short-term storage warehouse (Land Use 154), high-cube fulfillment center warehouse (Land Use 155), high-cube parcel hub warehouse (Land Use 156), and high-cube cold storage warehouse (Land Use 157) are related uses.

Additional Data

The technical appendices provide supporting information on time-of-day distributions for this land use. The appendices can be accessed through either the ITETripGen web app or the trip generation resource page on the ITE website (https://www.ite.org/technical-resources/topics/trip-and-parking-generation/).

The sites were surveyed in the 1980s, the 1990s, the 2000s, and the 2010s in California, Connecticut, Minnesota, New Jersey, New York, Ohio, Oregon, Pennsylvania, and Texas.

Source Numbers

184, 331, 406, 411, 443, 579, 583, 596, 598, 611, 619, 642, 752, 869, 875, 876, 914, 940, 1050

Warehousing
(150)

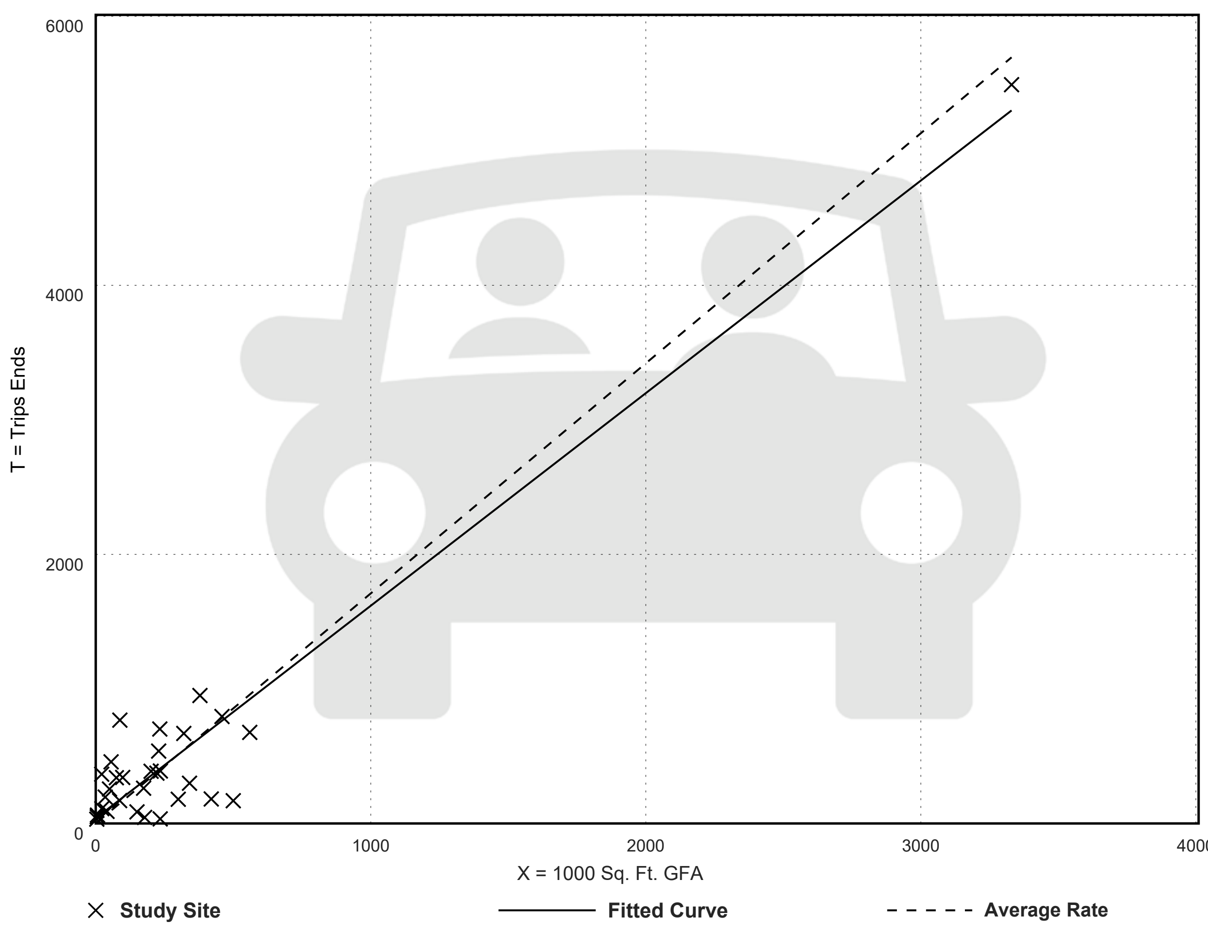
Vehicle Trip Ends vs: 1000 Sq. Ft. GFA
On a: Weekday

Setting/Location: General Urban/Suburban
Number of Studies: 31
Avg. 1000 Sq. Ft. GFA: 292
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
1.71	0.15 - 16.93	1.48

Data Plot and Equation



Fitted Curve Equation: $T = 1.58(X) + 38.29$ **$R^2 = 0.92$**

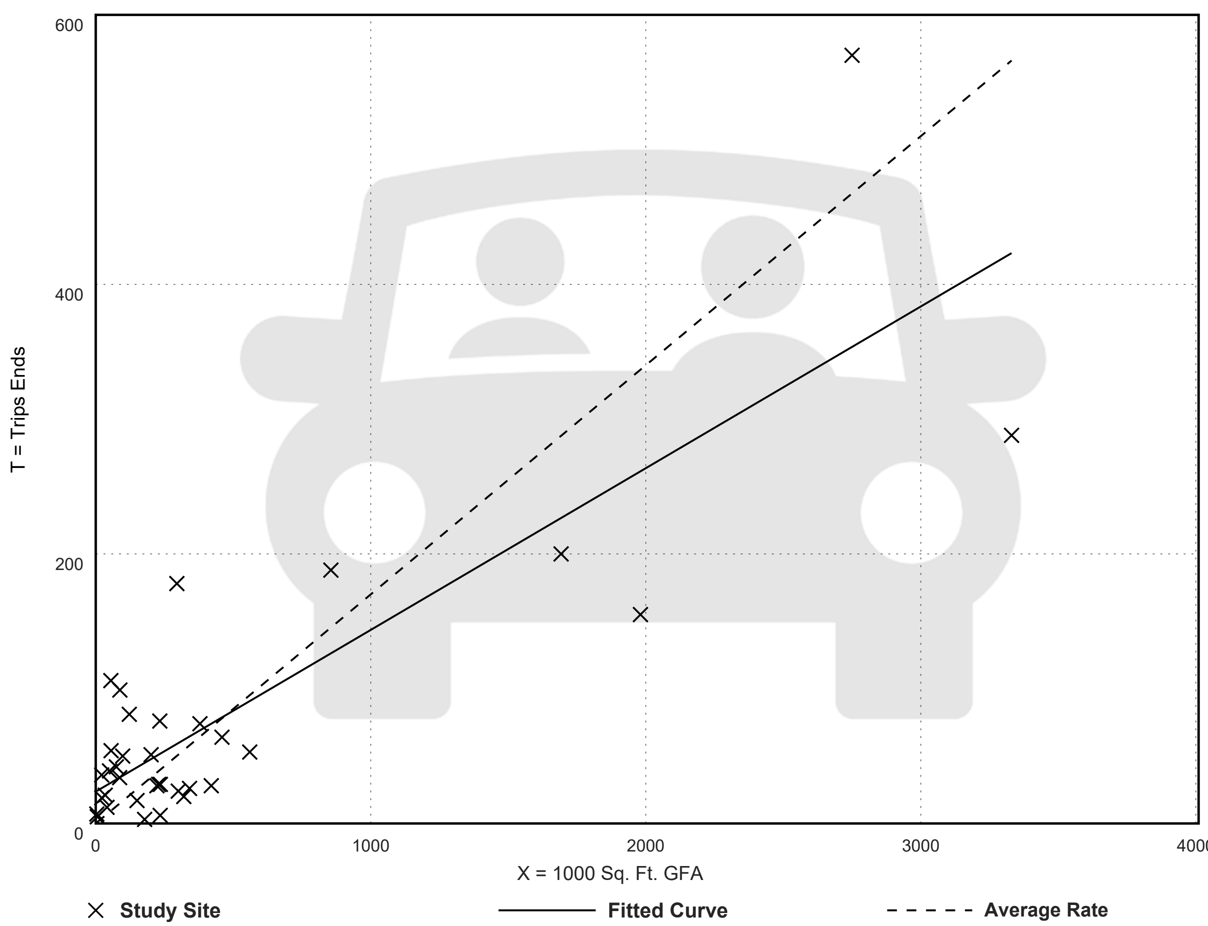
Warehousing
(150)

Vehicle Trip Ends vs:	**1000 Sq. Ft. GFA**
On a:	**Weekday,**
	Peak Hour of Adjacent Street Traffic,
	One Hour Between 7 and 9 a.m.
Setting/Location:	**General Urban/Suburban**
Number of Studies:	36
Avg. 1000 Sq. Ft. GFA:	448
Directional Distribution:	77% entering, 23% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
0.17	0.02 - 1.93	0.19

Data Plot and Equation



Fitted Curve Equation: $T = 0.12(X) + 23.62$ **$R^2 = 0.69$**

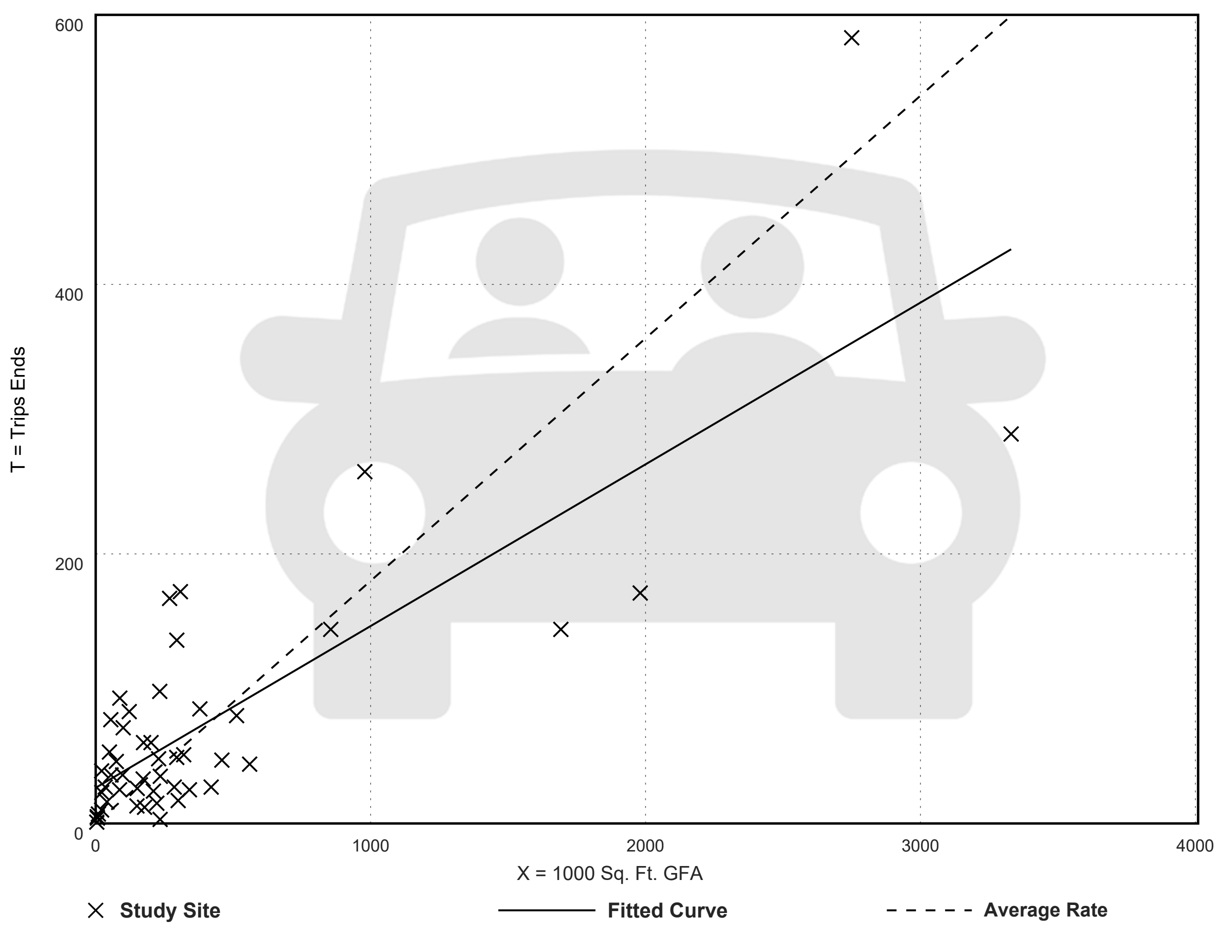
Warehousing
(150)

Vehicle Trip Ends vs:	**1000 Sq. Ft. GFA**
On a:	**Weekday,**
	Peak Hour of Adjacent Street Traffic,
	One Hour Between 4 and 6 p.m.
Setting/Location:	**General Urban/Suburban**
Number of Studies:	49
Avg. 1000 Sq. Ft. GFA:	400
Directional Distribution:	28% entering, 72% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
0.18	0.01 - 1.80	0.18

Data Plot and Equation



Fitted Curve Equation: $T = 0.12(X) + 26.48$ **$R^2 = 0.65$**

NCHRP 8-51 Internal Trip Capture Estimation Tool			
Project Name:	Downtown Taft Specific Plan	**Organization:**	
Project Location:	Taft, CA	**Performed By:**	
Scenario Description:		**Date:**	
Analysis Year:	Horizon Year 2042	**Checked By:**	
Analysis Period:	**AM Street Peak Hour**	**Date:**	

Table 1-A: Base Vehicle-Trip Generation Estimates (Single-Use Site Estimate)

Land Use	Development Data (*For Information Only*)			Estimated Vehicle-Trips		
	ITE LUCs[1]	Quantity	Units	Total	Entering	Exiting
Office				2007	1682	325
Retail				659	409	250
Restaurant				0		
Cinema/Entertainment				0		
Residential				1543	419	1124
Hotel				0		
All Other Land Uses[2]				51	39	12
Total				4260	2549	1711

Table 2-A: Mode Split and Vehicle Occupancy Estimates

Land Use	Entering Trips			Exiting Trips		
	Veh. Occ.	% Transit	% Non-Motorized	Veh. Occ.	% Transit	% Non-Motorized
Office	1.00			1.00		
Retail	1.00			1.00		
Restaurant	1.00			1.00		
Cinema/Entertainment						
Residential						
Hotel						
All Other Land Uses[2]						

Table 3-A: Average Land Use Interchange Distances (Feet Walking Distance)

Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office						
Retail						
Restaurant						
Cinema/Entertainment						
Residential						
Hotel						

Table 4-A: Internal Person-Trip Origin-Destination Matrix*

Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office		91	0	0	0	0
Retail	67		0	0	8	0
Restaurant	0	0		0	0	0
Cinema/Entertainment	0	0	0		0	0
Residential	22	11	0	0		0
Hotel	0	0	0	0	0	

Table 5-A: Computations Summary

	Total	Entering	Exiting
All Person-Trips	4,260	2,549	1,711
Internal Capture Percentage	9%	8%	12%
External Vehicle-Trips[3]	3,862	2,350	1,512
External Transit-Trips[4]	0	0	0
External Non-Motorized Trips[4]	0	0	0

Table 6-A: Internal Trip Capture Percentages by Land Use

Land Use	Entering Trips	Exiting Trips
Office	5%	28%
Retail	25%	30%
Restaurant	N/A	N/A
Cinema/Entertainment	N/A	N/A
Residential	2%	3%
Hotel	N/A	N/A

[1]Land Use Codes (LUCs) from *Trip Generation Informational Report*, published by the Institute of Transportation Engineers.

[2]Total estimate for all other land uses at mixed-use development site-not subject to internal trip capture computations in this estimator

[3]Vehicle-trips computed using the mode split and vehicle occupancy values provided in Table 2-A

[4]Person-Trips

*Indicates computation that has been rounded to the nearest whole number.

Estimation Tool Developed by the Texas Transportation Institute

Project Name:	Downtown Taft Specific Plan
Analysis Period:	**AM Street Peak Hour**

Table 7-A: Conversion of Vehicle-Trip Ends to Person-Trip Ends

Land Use	Table 7-A (D): Entering Trips				Table 7-A (O): Exiting Trips		
	Veh. Occ.	Vehicle-Trips	Person-Trips*		Veh. Occ.	Vehicle-Trips	Person-Trips*
Office	1.00	1682	1682		1.00	325	325
Retail	1.00	409	409		1.00	250	250
Restaurant	1.00	0	0		1.00	0	0
Cinema/Entertainment	1.00	0	0		1.00	0	0
Residential	1.00	419	419		1.00	1124	1124
Hotel	1.00	0	0		1.00	0	0

Table 8-A (O): Internal Person-Trip Origin-Destination Matrix (Computed at Origin)

Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office		91	205	0	3	0
Retail	73		33	0	35	0
Restaurant	0	0		0	0	0
Cinema/Entertainment	0	0	0		0	0
Residential	22	11	225	0		0
Hotel	0	0	0	0	0	

Table 8-A (D): Internal Person-Trip Origin-Destination Matrix (Computed at Destination)

Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office		131	0	0	0	0
Retail	67		0	0	8	0
Restaurant	235	33		0	21	0
Cinema/Entertainment	0	0	0		0	0
Residential	50	70	0	0		0
Hotel	50	16	0	0	0	

Table 9-A (D): Internal and External Trips Summary (Entering Trips)

Destination Land Use	Person-Trip Estimates				External Trips by Mode*		
	Internal	External	Total		Vehicles[1]	Transit[2]	Non-Motorized[2]
Office	89	1593	1682		1593	0	0
Retail	102	307	409		307	0	0
Restaurant	0	0	0		0	0	0
Cinema/Entertainment	0	0	0		0	0	0
Residential	8	411	419		411	0	0
Hotel	0	0	0		0	0	0
All Other Land Uses[3]	0	39	39		39	0	0

Table 9-A (O): Internal and External Trips Summary (Exiting Trips)

Origin Land Use	Person-Trip Estimates				External Trips by Mode*		
	Internal	External	Total		Vehicles[1]	Transit[2]	Non-Motorized[2]
Office	91	234	325		234	0	0
Retail	75	175	250		175	0	0
Restaurant	0	0	0		0	0	0
Cinema/Entertainment	0	0	0		0	0	0
Residential	33	1091	1124		1091	0	0
Hotel	0	0	0		0	0	0
All Other Land Uses[3]	0	12	12		12	0	0

[1]Vehicle-trips computed using the mode split and vehicle occupancy values provided in Table 2-A

[2]Person-Trips

[3]Total estimate for all other land uses at mixed-use development site-not subject to internal trip capture computations in this estimator

*Indicates computation that has been rounded to the nearest whole number.

NCHRP 8-51 Internal Trip Capture Estimation Tool			
Project Name:	Downtown Taft Specific Plan	**Organization:**	
Project Location:	Taft, CA	**Performed By:**	
Scenario Description:		**Date:**	
Analysis Year:	Horizon Year 2042	**Checked By:**	
Analysis Period:	**PM Street Peak Hour**	**Date:**	

Table 1-P: Base Vehicle-Trip Generation Estimates (Single-Use Site Estimate)

Land Use	Development Data (*For Information Only*)			Estimated Vehicle-Trips		
	ITE LUCs[1]	Quantity	Units	Total	Entering	Exiting
Office				1803	292	1511
Retail				2726	1308	1418
Restaurant				0		
Cinema/Entertainment				0		
Residential				1948	1187	761
Hotel				0		
All Other Land Uses[2]				54	15	39
Total				6531	2802	3729

Table 2-P: Mode Split and Vehicle Occupancy Estimates

Land Use	Entering Trips			Exiting Trips		
	Veh. Occ.	% Transit	% Non-Motorized	Veh. Occ.	% Transit	% Non-Motorized
Office	1.00			1.00		
Retail	1.00			1.00		
Restaurant	1.00			1.00		
Cinema/Entertainment						
Residential						
Hotel						
All Other Land Uses[2]						

Table 3-P: Average Land Use Interchange Distances (Feet Walking Distance)

Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office						
Retail						
Restaurant						
Cinema/Entertainment						
Residential						
Hotel						

Table 4-P: Internal Person-Trip Origin-Destination Matrix*

Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office		105	0	0	30	0
Retail	28		0	0	369	0
Restaurant	0	0		0	0	0
Cinema/Entertainment	0	0	0		0	0
Residential	30	131	0	0		0
Hotel	0	0	0	0	0	

Table 5-P: Computations Summary

	Total	Entering	Exiting
All Person-Trips	6,531	2,802	3,729
Internal Capture Percentage	21%	25%	19%
External Vehicle-Trips[3]	5,145	2,109	3,036
External Transit-Trips[4]	0	0	0
External Non-Motorized Trips[4]	0	0	0

Table 6-P: Internal Trip Capture Percentages by Land Use

Land Use	Entering Trips	Exiting Trips
Office	20%	9%
Retail	18%	28%
Restaurant	N/A	N/A
Cinema/Entertainment	N/A	N/A
Residential	34%	21%
Hotel	N/A	N/A

[1]Land Use Codes (LUCs) from *Trip Generation Informational Report*, published by the Institute of Transportation Engineers.
[2]Total estimate for all other land uses at mixed-use development site-not subject to internal trip capture computations in this estimator
[3]Vehicle-trips computed using the mode split and vehicle occupancy values provided in Table 2-P
[4]Person-Trips
*Indicates computation that has been rounded to the nearest whole number.

Estimation Tool Developed by the Texas Transportation Institute

Project Name:	Downtown Taft Specific Plan
Analysis Period:	**PM Street Peak Hour**

Table 7-P: Conversion of Vehicle-Trip Ends to Person-Trip Ends

Land Use	Table 7-P (D): Entering Trips				Table 7-P (O): Exiting Trips		
	Veh. Occ.	Vehicle-Trips	Person-Trips*		Veh. Occ.	Vehicle-Trips	Person-Trips*
Office	1.00	292	292		1.00	1511	1511
Retail	1.00	1308	1308		1.00	1418	1418
Restaurant	1.00	0	0		1.00	0	0
Cinema/Entertainment	1.00	0	0		1.00	0	0
Residential	1.00	1187	1187		1.00	761	761
Hotel	1.00	0	0		1.00	0	0

Table 8-P (O): Internal Person-Trip Origin-Destination Matrix (Computed at Origin)

Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office		302	60	0	30	0
Retail	28		411	57	369	71
Restaurant	0	0		0	0	0
Cinema/Entertainment	0	0	0		0	0
Residential	30	320	160	0		23
Hotel	0	0	0	0	0	

Table 8-P (D): Internal Person-Trip Origin-Destination Matrix (Computed at Destination)

Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office		105	0	0	47	0
Retail	91		0	0	546	0
Restaurant	88	654		0	190	0
Cinema/Entertainment	18	52	0		47	0
Residential	166	131	0	0		0
Hotel	0	26	0	0	0	

Table 9-P (D): Internal and External Trips Summary (Entering Trips)

Destination Land Use	Person-Trip Estimates				External Trips by Mode*		
	Internal	External	Total		Vehicles[1]	Transit[2]	Non-Motorized[2]
Office	58	234	292		234	0	0
Retail	236	1072	1308		1072	0	0
Restaurant	0	0	0		0	0	0
Cinema/Entertainment	0	0	0		0	0	0
Residential	399	788	1187		788	0	0
Hotel	0	0	0		0	0	0
All Other Land Uses[3]	0	15	15		15	0	0

Table 9-P (O): Internal and External Trips Summary (Exiting Trips)

Origin Land Use	Person-Trip Estimates				External Trips by Mode*		
	Internal	External	Total		Vehicles[1]	Transit[2]	Non-Motorized[2]
Office	135	1376	1511		1376	0	0
Retail	397	1021	1418		1021	0	0
Restaurant	0	0	0		0	0	0
Cinema/Entertainment	0	0	0		0	0	0
Residential	161	600	761		600	0	0
Hotel	0	0	0		0	0	0
All Other Land Uses[3]	0	39	39		39	0	0

[1]Vehicle-trips computed using the mode split and vehicle occupancy values provided in Table 2-P
[2]Person-Trips
[3]Total estimate for all other land uses at mixed-use development site-not subject to internal trip capture computations in this estimator
*Indicates computation that has been rounded to the nearest whole number.

APPENDIX B

KERN COG HORIZON YEAR 2042 WITH SPECIFIC PLAN MODEL VMT DATA SUMMARY

	Sub Area	VMT	VMT per capita resident	VMT per employee
2020	Greater Taft	1,808,842	88.40	136.41
2042	Greater Taft	2,575,003	94.62	165.98
2042 with Taft SP	Greater Taft	2,807,891	78.59	135.92
	Taft SP only	443,188	47.77	103.78

		TOTPOP	TOTEMP
2020	County	943977.07	349600.45
	Greater Taft	20461.08	13260.43
2042	County	1358477.93	483499.97
	Greater Taft	27213.42	15514.25
2042 Tadt SP	County	1404317.4	487301.55
	Greater Taft	35729.44	20658.88
	Taft SP	9278.26	4270.35

	2020		2042		2042 Taft SP	
	TOTPOP	TOTEMP	TOTPOP	TOTEMP	TOTPOP	TOTEMP
1805	178.79	234.72	174.89	382.95	3919.82	769
1806	331.74	119.95	260.58	275.37	883.18	2359
1816	184.41	7.33	183.59	35.19	366.19	486
1817	347.74	100.72	342.61	136.19	2587.45	575.35
1819	73.57	6.28	65.01	83.07	1521.62	81
	1116.25	469	1026.68	912.77	9278.26	4270.35

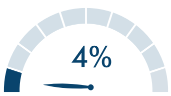
APPENDIX C

2021 CAPCOA MANUAL VMT REDUCTION MEASURES AND ANALYSIS WORKSHEETS

T-7. Implement Commute Trip Reduction Marketing

Photo Credit: Sacramento Area Council of Governments, 2012

GHG Mitigation Potential



Up to 4.0% of GHG emissions from project/site employee commute VMT

Co-Benefits (icon key on pg. 34)

Climate Resilience

Commute trip reduction programs could result in less traffic, potentially reducing congestion or delays on major roads during peak AM and PM traffic periods. When this reduction occurs during extreme weather events, it better allows emergency responders to access a hazard site. Lower transportation costs would also increase community resilience by freeing up resources for other purposes.

Health and Equity Considerations

Design of CTR programs needs to consider existing mobility options in diverse communities and ensure equitable access and benefit to all employees. CTR programs may need to include multi-language materials.

Measure Description

This measure will implement a marketing strategy to promote the project site employer's CTR program. Information sharing and marketing promote and educate employees about their travel choices to the employment location beyond driving such as carpooling, taking transit, walking, and biking, thereby reducing VMT and GHG emissions.

Subsector

Trip Reduction Programs

Locational Context

Urban, suburban

Scale of Application

Project/Site

Implementation Requirements

The following features (or similar alternatives) of the marketing strategy are essential for effectiveness.

- Onsite or online commuter information services.
- Employee transportation coordinators.
- Onsite or online transit pass sales.
- Guaranteed ride home service.

Cost Considerations

Employer costs include labor and materials for development and distribution of survey and marketing materials to promote the program and educate potential participants.

Expanded Mitigation Options

This measure could be packaged with other commute trip reduction measures (Measures T-8 through T-13) as a comprehensive CTR program (Measure T-5 or T-6).

GHG Reduction Formula

A = **B** × C × D

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from project/site employee commute VMT	0–4.0	%	calculated
User Inputs				
B	Percent of employees eligible for program	0–100	%	user input
Constants, Assumptions, and Available Defaults				
C	Percent reduction in employee commute vehicle trips	-4	%	TRB 2010
D	Adjustment from vehicle trips to VMT	1	unitless	assumed

Further explanation of key variables:

- (B) – This refers to the percent of employees that would be able to participate in the program. This will usually be 100 percent. Employees who might not be able to participate could include those who work nighttime hours when transit and rideshare services are not available or employees who are required to drive to work as part of their job duties. This input does not refer to the percent of employees who actually participate in the program.
- (C) – A review of studies measuring the effect of transportation demand management measures on traveler behavior notes that the average empirically-based estimate of reductions in vehicle trips for full-scale, site-specific employer support programs is 4 to 5 percent. To be conservative, the low end of the range is cited (TRB 2010).
- (D) – The adjustment factor from vehicle trips to VMT is 1. This assumes that all vehicle trips will average out to typical trip length ("assumes all trip lengths are equal"). Thus, it can be assumed that a percentage reduction in vehicle trips will equal the same percentage reduction in VMT.

GHG Calculation Caps or Maximums

Measure Maximum

(A_{max}) The maximum GHG reduction from this measure is 4 percent. This maximum scenario is presented in the below example quantification.

Subsector Maximum

($\sum A_{max_{T\text{-}5 \text{ through } T\text{-}13}} \leq 45\%$) This measure is in the Trip Reduction Programs subsector. This subcategory includes Measures T-5 through T-13. The employee commute VMT reduction from the combined implementation of all measures within this subsector is capped at 45 percent.

Mutually Exclusive Measures

If this measure is selected, the user may not also take credit for either Measure T-5 or T-6. However, this measure may be implemented alongside other individual CTR measures (Measures T-8 through T-13). The efficacy of individual programs may vary highly based on individual employers and local contexts.

Example GHG Reduction Quantification

The user reduces employee commute VMT by requiring that employers of a project market to employees travel options for modes alternative to single-occupied vehicles. In this example, the percent of employees eligible (B) is 100 percent, which would reduce GHG emissions from employee commute VMT by 4 percent.

$$A = \mathbf{100\%} \times -4\% \times 1 = -4\%$$

Quantified Co-Benefits

Improved Local Air Quality

The percent reduction in GHG emissions (A) would be the same as the percent reduction in NO_X, CO, NO_2, SO_2, and PM. Reductions in ROG emissions can be calculated by multiplying the percent reduction in GHG emissions (A) by an adjustment factor of 87 percent. See *Adjusting VMT Reductions to Emission Reductions* above for further discussion.

Energy and Fuel Savings

The percent reduction in vehicle fuel consumption would be the same as the percent reduction in GHG emissions (A).

VMT Reductions

The percent reduction in VMT would be the same as the percent reduction in GHG emissions (A).

Sources

- Transportation Research Board (TRB). 2010. *Traveler Response to Transportation System Changes Handbook, Third Edition: Chapter 19, Employer and Institutional TDM Strategies*. June. Available: http://www.trb.org/Publications/Blurbs/163781.aspx. Accessed: January 2021.

Measure T-7: Implement Commute Trip Reduction Marketing

A= B*C*D

A = Percent VMT reduction
B = Percent of employees eligible for program (100%)
C = Percent reduction in employee commute VMT (-4%)
D = Adjustment from vehicle trips to VMT (1.0)

VMT Reduction (A) =	**-4.00%**

T-8. Provide Ridesharing Program

GHG Mitigation Potential

8%

Up to 8.0% of GHG emissions from project/site employee commute VMT

Co-Benefits (icon key on pg. 34)

Climate Resilience

Ridesharing programs could result in less traffic, potentially reducing congestion or delays on major roads during peak AM and PM traffic periods. When this reduction occurs during extreme weather events, it better allows emergency responders to access a hazard site. Lower transportation costs would also increase community resilience by freeing up resources for other purposes.

Health and Equity Considerations

Program should include all onsite workers, such as contractors, interns, and service workers. Because ridesharing is vehicle-based, and some employees may not be in areas with feasible rideshare networks, design of programs need to ensure equitable benefits to those with and without access to rideshare opportunities.

Measure Description

This measure will implement a ridesharing program and establish a permanent transportation management association with funding requirements for employers. Ridesharing encourages carpooled vehicle trips in place of single-occupied vehicle trips, thereby reducing the number of trips, VMT, and GHG emissions.

Subsector

Trip Reduction Programs

Locational Context

Urban, suburban

Scale of Application

Project/Site

Implementation Requirements

Ridesharing must be promoted through a multifaceted approach. Examples include the following.

- Designating a certain percentage of desirable parking spaces for ridesharing vehicles.
- Designating adequate passenger loading and unloading and waiting areas for ridesharing vehicles.
- Providing an app or website for coordinating rides.

Cost Considerations

Costs of developing, implementing, and maintaining a rideshare program in a way that encourages participation are generally borne by municipalities or employers. The beneficiaries include the program participants saving on commuting costs, the employer reducing onsite parking expenses, and the municipality reducing cars on the road, which leads to lower infrastructure and roadway maintenance costs.

Expanded Mitigation Options

When providing a ridesharing program, a best practice is to establish funding by a non-revocable funding mechanism for employer-provided subsidies. In addition, encourage use of low-emission ridesharing vehicles (e.g., shared Uber Green).

This measure could be paired with any combination of the other commute trip reduction strategies (Measures T-7 through T-13) for increased reductions.

GHG Reduction Formula

A = **B** × C

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from project/site employee commute VMT	0–8.0	%	calculated
User Inputs				
B	Percent of employees eligible for program	0–100	%	user input
Constants, Assumptions, and Available Defaults				
C	Percent reduction in employee commute VMT	Table T-8.1	%	SANDAG 2019

Further explanation of key variables:

- (B) – This refers to the percent of employees that would be able to participate in the program. This will usually be 100 percent. Employees who might not be able to participate could include those who work nighttime hours when transit and rideshare services are not available or employees who are required to drive to work as part of their job duties. This input does not refer to the percent of employees who actually participate in the program.
- (C) – The percent reduction in employee commute VMT by place type is provided in Table T-8.1 in Appendix C. The reduction differs by place type because the willingness and ability to participate in carpooling is higher in urban areas than in suburban areas. Note that this measure is not applicable for implementation in rural areas (SANDAG 2019).

GHG Calculation Caps or Maximums

Measure Maximum

(A_{max}) The maximum GHG reduction from this measure is 8 percent.

Subsector Maximum

($\sum A_{max_{T\text{-}5\ through\ T\text{-}13}} \leq 45\%$) This measure is in the Trip Reduction Programs subsector. This subcategory includes Measures T-5 through T-13. The employee commute VMT reduction from the combined implementation of all measures within this subsector is capped at 45 percent.

Mutually Exclusive Measures

If this measure is selected, the user may not also take credit for either Measure T-5 or T-6. However, this measure may be implemented alongside other individual CTR measures (Measures T-7 and T-9 through T-13). The efficacy of individual programs may vary highly based on individual employers and local contexts.

Example GHG Reduction Quantification

The user reduces employee commute VMT by requiring that employers of a project provide a ridesharing program to their employees. In this example, the percent of employees eligible (B) at a packaging and distribution center is 50 percent and the place type of the project is urban (C). GHG emissions from employee commute VMT would be reduced by 4 percent.

A = **50%** × -8% = -4%

Quantified Co-Benefits

Improved Local Air Quality

The percent reduction in GHG emissions (A) would be the same as the percent reduction in NO_X, CO, NO_2, SO_2, and PM. Reductions in ROG emissions can be calculated by multiplying the percent reduction in GHG emissions (A) by an adjustment factor of 87 percent. See *Adjusting VMT Reductions to Emission Reductions* above for further discussion.

Energy and Fuel Savings

The percent reduction in vehicle fuel consumption would be the same as the percent reduction in GHG emissions (A).

VMT Reductions

The percent reduction in VMT would be the same as the percent reduction in GHG emissions (A).

Sources

- San Diego Association of Governments (SANDAG). 2019. *Mobility Management VMT Reduction Calculator Tool–Design Document.* June. Available: https://www.icommutesd.com/docs/default-source/planning/tool-design-document_final_7-17-19.pdf?sfvrsn=ec39eb3b_2. Accessed: January 2021.

Measure T-8: Provide Ridesharing Program

A= B*C

A = Percent VMT reduction

B = Percent of employees eligible for program (100%)

C = Percent reduction in employee commute VMT (-4%)

VMT Reduction (A) =	**-4.00%**

T-10. Provide End-of-Trip Bicycle Facilities

GHG Mitigation Potential

4.4%

Up to 4.4% of GHG emissions from project/site employee commute VMT

Co-Benefits (icon key on pg. 34)

Climate Resilience

End-of-trip bicycle facilities could take more cars off the road, resulting in less traffic and better allowing emergency responders to access a hazard site during an extreme weather event. They could also make it easier for bicycle users to access resources in an extreme weather event.

Health and Equity Considerations

Facilities should be inclusive of all gender identities and expressions. Consider including gender-neutral, single-occupancy options to allow for additional privacy for those who want it.

Measure Description

This measure will install and maintain end-of-trip facilities for employee use. End-of-trip facilities include bike parking, bike lockers, showers, and personal lockers. The provision and maintenance of secure bike parking and related facilities encourages commuting by bicycle, thereby reducing VMT and GHG emissions.

Subsector

Trip Reduction Programs

Locational Context

Urban, suburban

Scale of Application

Project/Site

Implementation Requirements

End-of-trip facilities should be installed at a size proportional to the number of commuting bicyclists and regularly maintained.

Cost Considerations

Employer costs include capital and maintenance costs for construction and maintenance of facilities and potentially labor and materials costs for staff to monitor facilities and provide marketing to encourage use of new facilities. The beneficiaries include the program participants saving on commuting cost, the employer reducing onsite parking expenses, and the municipality reducing cars on the road, which leads to lower infrastructure and roadway maintenance costs.

Expanded Mitigation Options

Best practice is to include an onsite bicycle repair station and post signage on or near secure parking and personal lockers with information about how to reserve or obtain access to these amenities.

This measure could be paired with any combination of the other commute trip reduction strategies (Measures T-7 through T-13) for increased reductions.

GHG Reduction Formula

$$A = \frac{C \times (E - (B \times E))}{D \times F}$$

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from employee project/site commute VMT	0.1–4.4	%	calculated
User Inputs				
	None			
Constants, Assumptions, and Available Defaults				
B	Bike mode adjustment factor	1.78 or 4.86	unitless	Buehler 2012
C	Existing bicycle trip length for all trips in region	Table T-10.1	miles	FHWA 2017a
D	Existing vehicle trip length for all trips in region	Table T-10.1	miles	FHWA 2017a
E	Existing bicycle mode share for work trips in region	Table T-10.2	%	FHWA 2017b
F	Existing vehicle mode share for work trips in region	Table T-10.2	%	FHWA 2017b

Further explanation of key variables:

- (B) – The bike mode adjustment factor should be provided by the user based on type of bike facility. A study found that commuters with showers, lockers, and bike parking at work are associated with 4.86 times greater likelihood to commute by bicycle when compared to individuals without any bicycle facilities at work. Individuals with bike parking, but no showers and lockers at the workplace, are associated with 1.78 times greater likelihood to cycle to work than those without trip-end facilities (Buehler 2012).
- (C and D) – Ideally, the user will calculate bicycle and auto trip length for a Project/Site at a scale no larger than a census tract. Potential data sources include the U.S. Census, California Household Travel Survey (preferred), or local survey efforts. If the user is not able to provide a project-specific value using one of these data sources, they have the option to input the trip lengths for bicycles and vehicles for one of the six most populated CBSAs in California, as presented in Table T-10.1 in Appendix C (FHWA 2017a). Trip lengths are likely to be longer for areas not covered by the listed CBSAs, which represent the denser areas of the state.
- (E and F) – Ideally, the user will calculate bicycle and auto mode share for work trips for a Project/Site at a scale no larger than a census tract. Potential data sources include the U.S. Census, California Household Travel Survey (preferred), or local survey efforts. If the user is not able to provide a project-specific value using one of these data sources, they have the option to input the regional average mode shares for bicycle and vehicle

work trips for one of the six most populated CBSAs in California, as presented in Table T-10.2 in Appendix C (FHWA 2017b). If the project study area is not within the listed CBSAs or the user is able to provide a project-specific value, the user should replace these regional defaults in the GHG reduction formula. For areas not covered by the listed CBSAs, which represent the denser areas of the state, bicycle mode share is likely to be lower and vehicle share higher than presented in Table T-10.2.

GHG Calculation Caps or Maximums

Measure Maximum

(A_{max}) The maximum GHG reduction from this measure is 4.4 percent. This maximum scenario is presented in the below example quantification.

Subsector Maximum

($\sum A_{max_{\text{T-5 through T-13}}} \leq 45\%$) This measure is in the Trip Reduction Programs subsector. This subcategory includes Measures T-5 through T-13. The employee commute VMT reduction from the combined implementation of all measures within this subsector is capped at 45 percent.

Mutually Exclusive Measures

If this measure is selected, the user may not also take credit for either Measure T-5 or T-6. However, this measure may be implemented alongside other individual CTR measures (Measures T-7, T-8, T-9, and T-11 through T-13). The efficacy of individual programs may vary highly based on individual employers and local contexts.

Example GHG Reduction Quantification

The user reduces VMT by providing end-of-trip facilities for the project's employees, which encourages bicycle trips in place of vehicle trips. In this example, the type of bike facility provided by the project is parking with showers, bike lockers, and personal lockers (B). The project is within San Jose-Sunnyvale-Santa Clara CBSA, and the user does not have project-specific values for trip lengths and mode shares and for bicycles and vehicles. Per Tables T-10.1 and T-10.2 in Appendix C, inputs for these variables are 2.8 miles, 11.5 miles, 4.1 percent, and 86.6 percent, respectively (C, D, E, and F). GHG emissions from employee commute VMT would be reduced by 4.4 percent.

$$A = \frac{2.8 \text{ miles} \times \left(4.1\% - (4.86 \times 4.1\%)\right)}{11.5 \text{ miles} \times 86.6\%} = \text{-}4.4\%$$

Quantified Co-Benefits

Improved Local Air Quality

The percent reduction in GHG emissions (A) would be the same as the percent reduction in NO_X, CO, NO_2, SO_2, and PM. Reductions in ROG emissions can be calculated by multiplying the percent reduction in GHG emissions (A) by an adjustment factor of 87 percent. See *Adjusting VMT Reductions to Emission Reductions* above for further discussion.

Energy and Fuel Savings

The percent reduction in vehicle fuel consumption would be the same as the percent reduction in GHG emissions (A).

VMT Reductions

The percent reduction in VMT would be the same as the percent reduction in GHG emissions (A).

Sources

- Buehler, R. 2012. *Determinants of bicycle commuting in the Washington, DC region: The role bicycle parking, cyclist showers, and free car parking at work.* Transportation Research Part D, 17, 525–531. Available: http://www.pedbikeinfo.org/cms/downloads/DeterminantsofBicycleCommuting.pdf. Accessed: January 2021.
- Federal Highway Administration (FHWA). 2017a. *National Household Travel Survey–2017 Table Designer*. Travel Day PT by TRPTRANS by HH_CBSA. Available: https://nhts.ornl.gov/. Accessed: January 2021.
- Federal Highway Administration (FHWA). 2017b. *National Household Travel Survey–2017 Table Designer.* Workers by WRKTRANS by HH_CBSA. Available: https://nhts.ornl.gov/. Accessed: January 2021.

Measure T-10: Provide End-of-Trip Bicycle Facilities

A=(C*(E-(B*E)))/(D*F)

A = Percent VMT reduction
B = Bike mode adjustment factor (2.55)
C = Existing bicycle trip length for all trips in region (2.0)
D = Existing vehicle trip length for all trips in region (23.88)
E = Existing bicycle mode share for work trips in region (1.62%)
F = Existing vehicle mode share for work trips in region (92.66%)

VMT Reduction (A) = **-0.23%**

T-11. Provide Employer-Sponsored Vanpool

Photo Credit: UCLA Transportation/Flickr, 2021

GHG Mitigation Potential

20.4%

Up to 20.4% of GHG emissions from project/site employee commute VMT

Co-Benefits (icon key on pg. 34)

Climate Resilience

Employer-sponsored vanpools could result in less traffic, potentially reducing congestion or delays on major roads during peak AM and PM traffic periods. When this reduction occurs during extreme weather events, it better allows emergency responders to access a hazard site.

Health and Equity Considerations

Consider using zero-emission or plug-in electric vehicles (PHEVs) for additional emission reduction benefits.

Measure Description

This measure will implement an employer-sponsored vanpool service. Vanpooling is a flexible form of public transportation that provides groups of 5 to 15 people with a cost-effective and convenient rideshare option for commuting. The mode shift from long-distance, single-occupied vehicles to shared vehicles reduces overall commute VMT, thereby reducing GHG emissions.

Subsector

Trip Reduction Programs

Locational Context

Urban, suburban, rural

Scale of Application

Project/Site

Implementation Requirements

Vanpool programs are more appropriate for the building occupant or tenant (i.e., employer) to implement and monitor than the building owner or developer.

Cost Considerations

Employer costs primarily include the capital costs of vehicle acquisition and the labor costs of drivers, either through incentives to current employees or the hiring of dedicated drivers. The beneficiaries include the program participants saving on commuting cost, the employer reducing onsite parking expenses, and the municipality reducing cars on the road, which leads to lower infrastructure and roadway maintenance costs.

Expanded Mitigation Options

When implementing a vanpool service, best practice is to subsidize the cost for employees that have a similar origin and destination and provide priority parking for employees that vanpool.

This measure could be paired with any combination of the other commute trip reduction strategies (Measures T-7 through T-13) for increased reductions.

GHG Reduction Formula

$$A = \frac{\left((1 - B) \times C \times F\right) + \left(B \times \frac{D}{E} \times G\right)}{\left((1 - B) \times C \times F\right) + (B \times D \times F)} - 1$$

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from project/site employee commute VMT	3.4–20.4	%	calculated
User Inputs				
	None			
Constants, Assumptions, and Available Defaults				
B	Percent of employees that participate in vanpool program	2.7	%	SANDAG 2019
C	Average length of one-way vehicle commute trip in region	Table T-11.1	miles per trip	FHWA 2017
D	Average length of one-way vanpool commute trip	42.0	miles per trip	SANDAG 2019
E	Average vanpool occupancy (including driver)	6.25	occupants	SANDAG 2019
F	Average emission factor of average employee vehicle	307.5	g CO_2e per mile	CARB 2020
G	Vanpool emission factor	763.4	g CO_2e per mile	CARB 2020

Further explanation of key variables:

- (B) – The percent of employees that would participate in a vanpool program is based on a survey of commuters in San Diego County (SANDAG 2019). If the project is not within San Diego County or the user is able to provide a project-specific value for within San Diego County, the user should replace the default employee participation rate in the GHG reduction formula.
- (C) – Ideally, the user will calculate auto commute trip lengths for a Project/Site at a scale no larger than a census tract. Potential data sources include the U.S. Census, California Household Travel Survey (preferred), or local survey efforts. If the user is not able to provide a project-specific value using one of these data sources, they have the option to input the regional average one-way auto commute trip length for one of the six most populated CBSAs in California, as presented in Table T-11.1 in Appendix C (FHWA 2017). Trip lengths are likely to be longer for areas not covered by the listed CBSAs, which represent the denser areas of the state.
- (D and E) – The average one-way vanpool commute trip length and occupancy are based on data from the San Diego Association of Government's regional vanpool program (SANDAG 2019). If the project is not within San Diego County or the user is

able to provide a project-specific value for within San Diego County, the user should replace these defaults in the GHG reduction formula.

- (F and G) – The average GHG emission factors for employee commute and vanpool vehicles were calculated in terms of CO_2e per mile using EMFAC2017 (v1.0.3). The model was run for a 2020 statewide average using diesel and gasoline fuel. The average of the light-duty automobile (LDA) and light duty truck (LDT1/LDT2) vehicle categories represents employee non-vanpool vehicles and the light-heavy duty truck (LHDT1) vehicle category conservatively represents a large cargo vanpool vehicle. The running emission factors for CO_2, CH_4, and N_2O (CARB 2020) were multiplied by the corresponding 100-year GWP values from the IPCC's Fourth Assessment Report (IPCC 2007). If the user can provide a project-specific value (i.e., for a future year and project location), the user should run EMFAC to replace the defaults in the GHG reduction formula.

GHG Calculation Caps or Maximums

Measure Maximum

(A_{max}) For projects in San Diego County that use default CBSA data from Table T-11.1 and (B_{max}), the maximum percent reduction in GHG emissions (A) is 20.4 percent. This maximum scenario is presented in the below example quantification.

(B_{max}) The percent of employees that participate in the vanpool program is capped at 15 percent, which is based on the high end of vanpool participation survey data for several successful programs in the U.S. (SANDAG 2019).

Subsector Maximum

($\sum A_{max_{T\text{-}5 \text{ through } T\text{-}13}} \leq 45\%$) This measure is in the Trip Reduction Programs subsector. This subcategory includes Measures T-5 through T-13. The employee commute VMT reduction from the combined implementation of all measures within this subsector is capped at 45 percent.

Mutually Exclusive Measures

If this measure is selected, the user may not also take credit for either Measure T-5 or T-6. However, this measure may be implemented alongside other individual CTR measures (Measures T-7 through T-10, T-12, and T-13). The efficacy of individual programs may vary highly based on individual employers and local contexts.

Example GHG Reduction Quantification

The user reduces employee commute VMT by requiring that the employer of the project to sponsor a vanpool program. In this example, the project is in the San Diego-Carlsbad CBSA and would have an average vehicle commute trip length of 14.52 miles (C). The percent of employees that participate in the vanpool program is 15 percent (B_{max}). GHG emissions from employee commute would be reduced by 20.4 percent.

A=

$$\frac{\left((1-15\%)\times 14.52\ \frac{\text{miles}}{\text{trip}}\times 307.5\ \frac{\text{g CO}_2\text{e}}{\text{miles}}\right)+\left(15\%\times\frac{42\ \frac{\text{miles}}{\text{trip}}}{6.25\ \text{occupants}}\times 763.4\ \frac{\text{g CO}_2\text{e}}{\text{miles}}\right)}{\left((1-15\%)\times 14.52\ \frac{\text{miles}}{\text{trip}}\times 307.5\ \frac{\text{g CO}_2\text{e}}{\text{miles}}\right)+\left(15\%\times 42\ \frac{\text{miles}}{\text{trip}}\times 307.5\ \frac{\text{g CO}_2\text{e}}{\text{miles}}\right)}$$

$$-1 = \text{-}20.4\%$$

Quantified Co-Benefits

Improved Local Air Quality

The percent reduction in GHG emissions (A) would be the same as the percent reduction in NO_X, CO, NO_2, SO_2, and PM. Reductions in ROG emissions can be calculated by multiplying the percent reduction in GHG emissions (A) by an adjustment factor of 87 percent. See *Adjusting VMT Reductions to Emission Reductions* above for further discussion.

Energy and Fuel Savings

The percent reduction in vehicle fuel consumption (H) can be calculated using the GHG reduction formula except that (F) and (G) should be replaced by (I) and (J), as follows.

Fuel Use Reduction Formula

$$H = \frac{\left((1-B)\times C\times I\right)+\left(B\times\frac{D}{E}\times J\right)}{\left((1-B)\times C\times I\right)+(B\times D\times I)}-1$$

Fuel Use Reduction Calculation Variables

ID	Variable	Value	Unit	Source
Output				
H	Percent reduction in fuel use from project/site employee commute VMT	4.7–21.4	%	calculated
User Inputs				
	None			
Constants, Assumptions, and Available Defaults				
I	Fuel efficiency of average employee vehicle	0.03639	gallon (gal) per mile	CARB 2020
J	Fuel efficiency of vanpool vehicle	0.08328	gal per mile	CARB 2020

Further explanation of key variables:

- (I and J) – The average fuel efficiencies for employee commute and vanpool vehicles were calculated using EMFAC2017 (v1.0.3). The model was run for a 2020 statewide average using diesel and gasoline fuel. The average of the LDA, LDT1, and LDT2 vehicle categories represents employee non-vanpool vehicles, and the LHDT1 vehicle category conservatively represents a large cargo vanpool vehicle. If the user can provide a project-specific value (i.e., for a future year and project location), the user should run EMFAC to replace the defaults in the fuel use reduction formula.

- Please refer to the GHG Calculation Variables table above for definitions of variables that have been previously defined.

VMT Reductions

The percent reduction in VMT can be calculated using a modified version of the GHG reduction formula, as shown below.

$$\%\ \text{VMT Reduction} = \frac{((1 - B) \times C) + \left(B \times \frac{D}{E}\right)}{C} - 1$$

Sources

- California Air Resources Board (CARB). 2020. *EMFAC2017 v1.0.3*. August. Available: https://arb.ca.gov/emfac/emissions-inventory. Accessed: January 2021.
- Federal Highway Administration (FHWA). 2017. *National Household Travel Survey–2017 Table Designer*. Travel Day VT by HH_CBSA by TRPTRANS by TRIPPURP. Available: https://nhts.ornl.gov/. Accessed: January 2021.
- Intergovernmental Panel on Climate Change (IPCC). 2007. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp. Available: https://www.ipcc.ch/report/ar4/wg1/. Accessed: January 2021.
- San Diego Association of Governments (SANDAG). 2019. *Mobility Management VMT Reduction Calculator Tool–Design Document*. June. Available: https://www.icommutesd.com/docs/default-source/planning/tool-design-document_final_7-17-19.pdf?sfvrsn=ec39eb3b_2. Accessed: January 2021.

Measure T-11: Provide Employer-Sponsored Vanpool

A=((((1-B)*C)+(B*(D/E)))/C)-1

A = Percent VMT reduction
B = Percent of employees that participate in vanpool program (2.7%)
C = Average length of one-way commute trip in region (36.0)
D = Average length of one-way vanpool commute trip (36.0)
E = Average vanpool occupancy including driver (6.25)

VMT Reduction (A) =	**-2.27%**

T-18. Provide Pedestrian Network Improvement

GHG Mitigation Potential

6.4%

Up to 6.4% of GHG emissions from vehicle travel in the plan/community

Co-Benefits (icon key on pg. 34)

Climate Resilience

Improving pedestrian networks increases accessibility of outdoor spaces, which can provide health benefits and thus improve community resilience. This can also improve connectivity between residents and resources that may be needed in an extreme weather event.

Health and Equity Considerations

Ensure that the improvements also include accessibility features to allow for people of all abilities to use the network safely and conveniently. Ensure that sidewalks connect to nearby community assets, such as schools, retail, and healthcare.

Measure Description

This measure will increase the sidewalk coverage to improve pedestrian access. Providing sidewalks and an enhanced pedestrian network encourages people to walk instead of drive. This mode shift results in a reduction in VMT and GHG emissions.

Subsector

Neighborhood Design

Locational Context

Urban, suburban, rural

Scale of Application

Plan/Community

Implementation Requirements

The GHG reduction of this measure is based on the VMT reduction associated with expansion of sidewalk coverage expansion, which includes not only building of new sidewalks but also improving degraded or substandard sidewalk (e.g., damaged from street tree roots). However, pedestrian network enhancements with non-quantifiable GHG reductions are encouraged to be implemented, as discussed under *Expanded Mitigation Options*.

Cost Considerations

Depending on the improvement, capital and infrastructure costs may be high. However, improvements to the pedestrian network will increase pedestrian activity, which can increase businesses patronage and provide a local economic benefit. The local municipality may achieve cost savings through a reduction of cars on the road leading to lower infrastructure and roadway maintenance costs.

Expanded Mitigation Options

When improving sidewalks, a best practice is to ensure they are contiguous and link externally with existing and planned pedestrian facilities. Barriers to pedestrian access and interconnectivity, such as walls, landscaping buffers, slopes, and unprotected crossings should be minimized. Other best practice features could include high-visibility crosswalks, pedestrian hybrid beacons, and other pedestrian signals, mid-block crossing walks, pedestrian refuge islands, speed tables, bulb-outs (curb extensions), curb ramps, signage, pavement markings, pedestrian-only connections and districts, landscaping, and other improvements to pedestrian safety (see Measure T-35, *Provide Traffic Calming Measures*).

GHG Reduction Formula

$$A = \left(\frac{C}{B} - 1\right) \times D$$

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from household vehicle travel in plan/community	0–6.4	%	calculated
User Inputs				
B	Existing sidewalk length in study area	[ ]	miles	user input
C	Sidewalk length in study area with measure	[ ]	miles	user input
Constants, Assumptions, and Available Defaults				
D	Elasticity of household VMT with respect to the ratio of sidewalks-to-streets	-0.05	unitless	Frank et al. 2011

Further explanation of key variables:

- (B and C) – Sidewalk length should be measured on both sides of the street. For example, if one 0.5-mile-long street has full sidewalk coverage, the sidewalk length would be 1.0 mile. If there is only sidewalk on one side of the street, the sidewalk length would be 0.5 mile. The recommended study area is 0.6 mile around the pedestrian network improvement. This represents a 6- to 10-minute walking time.
- (D) – A study found that a 0.05 percent decrease in household vehicle travel occurs for every 1 percent increase in the sidewalk-to-street ratio (Frank et al. 2011; Handy et al. 2014).

GHG Calculation Caps or Maximums

Measure Maximum

(A_{max}) The percent reduction in GHG emissions (A) is capped at 3.4 percent, which is based on the following assumptions:

- 35.2 percent of vehicle trips are short trips (2 mile or less, average of 1.29 miles) and thus could easily shift to walking (FHWA 2019).
- 64.8 percent of vehicle trips are longer trips that are unlikely to shift to walking (2 miles or more, average of 10.93 miles) (FHWA 2019).
- So $A_{max} = \frac{35.2\% \times 1.29 \text{ miles}}{64.8\% \times 10.93 \text{ miles}} = 6.4\%$

Subsector Maximum

($\sum A_{max_{T\text{-}18 \text{ through } T\text{-}22\text{-}C}} \leq 10\%$) This measure is in the Neighborhood Design subsector. This subcategory includes Measures T-18 through T-22-C. The VMT reduction from the combined implementation of all measures within this subsector is capped at 10 percent.

Example GHG Reduction Quantification

The user reduces household VMT by improving the pedestrian network in the study area. In this example, the existing sidewalk length (B) is 9 miles, and the sidewalk length with the measure (C) would be 10 miles. With these conditions, the user would reduce GHG emissions from household VMT within the study area by 0.6 percent.

$$A = \left(\frac{10 \text{ miles}}{9 \text{ miles}} - 1\right) \times -0.05 = -0.6\%$$

Quantified Co-Benefits

Improved Local Air Quality

The percent reduction in GHG emissions (A) would be the same as the percent reduction in NO_X, CO, NO_2, SO_2, and PM. Reductions in ROG emissions can be calculated by multiplying the percent reduction in GHG emissions (A) by an adjustment factor of 87 percent. See *Adjusting VMT Reductions to Emission Reductions* above for further discussion.

Energy and Fuel Savings

The percent reduction in vehicle fuel consumption would be the same as the percent reduction in GHG emissions (A).

VMT Reductions

The percent reduction in household VMT would be the same as the percent reduction in GHG emissions (A).

Improved Public Health

Users are directed to the Integrated Transport and Health Impact Model (ITHIM) (CARB et al. 2020). The ITHIM can quantify the annual change in health outcomes associated with active transportation, including deaths, years of life lost, years of living with disability, and incidence of community and individual disease.

Sources

- California Air Resources Board (CARB), California Department of Public Health (CDPH), and Nicholas Linesch Legacy Fund. 2020. Integrated Transport and Health Impact Model. Available: https://skylab.cdph.ca.gov/HealthyMobilityOptionTool-ITHIM/#Home. Accessed: September 17, 2021.
- Federal Highway Administration (FHWA). 2019. *2017 National Household Travel Survey Popular Vehicle Trip Statistics*. Available: https://nhts.ornl.gov/vehicle-trips. Accessed: January 2021.

Measure T-18: Extend Pedestrian Network

A=((C/B)-1)*D

A = Percent VMT reduction
B = Existing sidewalk length (9.33 miles)
C = Existing + Specific Plan sidewalk length (13.29 miles)
D = Elasticity of household VMT (-0.05)

VMT Reduction (A) = **-2.12%**

Existing Sidewalk Length

	North Side		South Side		Total	
Kern Street =	3,738	feet	3,928	feet	7,666	feet
North Street =	3,731	feet	3,287	feet	7,018	feet
Center Street =	4,340	feet	4,219	feet	8,559	feet
Main Street =	2,420	feet	1,926	feet	4,346	feet
Supply Row=	779	feet	454	feet	1,233	feet
Front Street=	222	feet	1,140	feet	1,362	feet
	15,230	feet	14,954	feet	30,184	feet
	2.88	miles	2.83	miles	5.72	miles

	West Side		East Side		Total	
10th Street=	1,815	feet	1,179	feet	2,994	feet
8th Street=	896	feet	1,008	feet	1,904	feet
7th Street=	928	feet	671	feet	1,599	feet
6th Street=	1,698	feet	1,363	feet	3,061	feet
5th Street=	973	feet	969	feet	1,942	feet
4th Street=	1,352	feet	1,145	feet	2,497	feet
3rd Street=	1,003	feet	1,008	feet	2,011	feet
2nd Street=	922	feet	1,069	feet	1,991	feet
1st Street=	692	feet	411	feet	1,103	feet
	10,279	feet	8,823	feet	19,102	feet
	1.95	miles	1.67	miles	3.62	miles

Existing Total= 9.33 miles

Existing + Specific Plan Sidewalk Length

	North Side		South Side		Total	
Kern Street =	3,738	feet	3,928	feet	7,666	feet
North Street =	3,731	feet	3,711	feet	7,442	feet
Center Street =	5,014	feet	5,109	feet	10,123	feet
Main Street =	5,074	feet	4,727	feet	9,801	feet
Supply Row=	3,573	feet	3,448	feet	7,021	feet
Front Street=	2,425	feet	2,161	feet	4,586	feet
Oak Street=	452	feet	420	feet	872	feet
	24,007	feet	23,504	feet	47,511	feet
	4.55	miles	4.45	miles	9.00	miles

	West Side		East Side		Total	
10th Street=	1,815	feet	1,595	feet	3,410	feet
8th Street=	1,039	feet	1,008	feet	2,047	feet
7th Street=	928	feet	956	feet	1,884	feet
6th Street=	1,698	feet	1,702	feet	3,400	feet
5th Street=	973	feet	969	feet	1,942	feet
4th Street=	1,708	feet	1,504	feet	3,212	feet
3rd Street=	1,003	feet	1,008	feet	2,011	feet
2nd Street/Olive Ave=	1,637	feet	1,706	feet	3,343	feet
1st Street=	692	feet	705	feet	1,397	feet
	11,493	feet	11,153	feet	22,646	feet
	2.18	miles	2.11	miles	4.29	miles

Existing + Specific Plan Total= 13.29 miles

T-20. Expand Bikeway Network

GHG Mitigation Potential

0.5%

Up to 0.5% of GHG emissions from vehicle travel in the plan/community

Co-Benefits (icon key on pg. 34)

Climate Resilience

Expanding bikeway networks can incentivize more bicycle use and decrease vehicle use, which have health benefits and can thus improve community resilience. This can also improve connectivity between residents and resources that may be needed in an extreme weather event.

Health and Equity Considerations

Prioritize low-income and underserved areas and communities with lower rates of vehicle ownership or fewer transit options. Make sure that destinations visited by low-income or underserved communities are served by the network.

Measure Description

This measure will increase the length of a city or community bikeway network. A bicycle network is an interconnected system of bike lanes, bike paths, bike routes, and cycle tracks. Providing bicycle infrastructure with markings and signage on appropriately sized roads with vehicle traffic traveling at safe speeds helps to improve biking conditions (e.g., safety and convenience). In addition, expanded bikeway networks can increase access to and from transit hubs, thereby expanding the "catchment area" of the transit stop or station and increasing ridership. This encourages a mode shift from vehicles to bicycles, displacing VMT and thus reducing GHG emissions. When expanding a bicycle network, a best practice is to consider bike lane width standards from local agencies, state agencies, or the National Association of City Transportation Officials' *Urban Bikeway Design Guide*.

Subsector

Neighborhood Design

Locational Context

Urban, suburban

Scale of Application

Plan/Community

Implementation Requirements

The bikeway network must consist of either Class I, II, or IV infrastructure.

Cost Considerations

Capital and infrastructure costs for expanding the bikeway network may be high. Construction of these facilities may also increase vehicle traffic, leading to more congestion and temporarily longer trip times for motorist. However, the local municipality may achieve cost savings through a reduction of cars on the road leading to lower infrastructure and roadway maintenance costs.

Expanded Mitigation Options

As networks expand, ensure safe, secure, and weather-protected bicycle parking facilities at origins and destinations. Also, implement alongside T-22-A, T-22-B, and/or T-22-C to ensure that micromobility options can ride safely along bicycle lane facilities and not have to ride along pedestrian infrastructure, which is a risk to pedestrian safety.

GHG Reduction Formula

$$A = -1 \times \frac{\left(\frac{C - B}{B}\right) \times D \times F \times H}{E \times G}$$

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from employee commute vehicle travel in plan/community	0–0.5	%	calculated
User Inputs				
B	Existing bikeway miles in plan/community	[ ]	miles	user input
C	Bikeway miles in plan/community with measure	[ ]	miles	user input
Constants, Assumptions, and Available Defaults				
D	Bicycle mode share in plan/community	Table T-20.1	%	FHWA 2017
E	Vehicle mode share in plan/community	Table T-3.1	%	FHWA 2017
F	Average one-way bicycle trip length in plan/community	Table T-10.1	miles per trip	FHWA 2017
G	Average one-way vehicle trip length in plan/community	Table T-10.1	miles per trip	FHWA 2017
H	Elasticity of bike commuters with respect to bikeway miles per 10,000 population	0.25	unitless	Pucher & Buehler 2011

Further explanation of key variables:

- (B) – The existing bikeway miles in a plan/community should be calculated by measuring the distance of all Class I, II, III, and IV bikeways within the plan/community. This information can sometimes be found in a city's bicycle master plan, if a plan has been prepared and is up to date.
- (D, E, F, and G) – Ideally, the user will calculate bicycle and auto mode share and trip length for a plan/community at the city scale. Potential data sources include the California Household Travel Survey (preferred) or local survey efforts. If the user is not able to provide a project-specific value using one of these data sources, they have the option to input the mode shares and trip lengths for bicycles and vehicles for one of the six most populated CBSAs in California, as presented in Table T-3.1, T-10.2, and T-20.1 in Appendix C. Trip lengths are likely to be longer for areas not covered by the listed CBSAs, which represent the denser areas of the state. Similarly, it is likely for areas outside of the area covered by the listed CBSAs to have vehicle mode shares higher and bicycle mode shares lower than the values provided in the tables.
- (H) – A multivariate analysis of the impacts of bike lanes on cycling levels in the 100 largest U.S. cities found that a 0.25 percent increase in commute cycling occurs for every 1 percent increase in bike lane distance (Pucher & Buehler 2011).

GHG Calculation Caps or Maximums

Measure Maximum

(A_{max}) For projects that use CBSA data from Tables T-3.1, T-10.2, and T-20.1 in Appendix C, the maximum percent reduction in GHG emissions (A) is 0.5 percent. This is based on a project within the CBSA of San Jose-Sunnyvale-Santa Clara that has no existing bike lane infrastructure. This maximum scenario is presented in the below example quantification.

($\frac{C-B}{B}_{max}$) The maximum percent increase in bike lane miles in the plan/community is conservatively capped at 1000 percent. If there is no existing bike lane infrastructure in the plan/community, (B) should be set to (1/11×C), resulting in a percentage change of 1000 percent.

Subsector Maximum

($\sum A_{max_{T\text{-}18\text{ through }T\text{-}22\text{-}C}} \leq 10\%$) This measure is in the Neighborhood Design subsector. This subcategory includes Measures T-18 through T-22-C. The VMT reduction from the combined implementation of all measures within this subsector is capped at 10 percent.

Example GHG Reduction Quantification

The user reduces employee commute VMT by increasing the length of a bicycle network within a plan/community, which displaces commute vehicle trips with bicycle trips. In this example, the existing bikeway length in the plan/community (B) is 0 miles and the length with the measure (C) is 11 miles. The project is within the San Jose-Sunnyvale-Santa Clara CBSA, yielding the following inputs from Tables T-3.1, T-10.2, and T-20.1 in Appendix C.

- Bicycle mode share (D) = 0.79 percent.
- Vehicle mode share (E) = 91.32 percent.
- Average one-way bicycle trip length (F) = 2.8 miles.
- Average one-way vehicle trip length (G) = 11.5 miles.

The user would displace GHG emissions from project study area employee commute VMT by 0.5 percent.

$$A = -1 \times \left(\frac{(1000\%) \times 0.79\% \times 2.8\text{ miles} \times 0.25}{91.32\% \times 11.5\text{ miles}}\right) = -0.5\%$$

Quantified Co-Benefits

Improved Local Air Quality

The percent reduction in GHG emissions (A) would be the same as the percent reduction in NO_X, CO, NO_2, SO_2, and PM. Reductions in ROG emissions can be calculated by multiplying the percent reduction in GHG emissions (A) by an adjustment factor of 87 percent. See *Adjusting VMT Reductions to Emission Reductions* above for further discussion.

Energy and Fuel Savings

The percent reduction in vehicle fuel consumption would be the same as the percent reduction in GHG emissions (A).

VMT Reductions

The percent reduction in employee commute VMT would be the same as the percent reduction in GHG emissions (A).

Improved Public Health

Users are directed to the ITHIM (CARB et al. 2020). The ITHIM can quantify the annual change in health outcomes associated with active transportation, including deaths, years of life lost, years of living with disability, and incidence of community and individual disease.

Sources

- California Air Resources Board (CARB), California Department of Public Health (CDPH), and Nicholas Linesch Legacy Fund. 2020. Integrated Transport and Health Impact Model. Available: https://skylab.cdph.ca.gov/HealthyMobilityOptionTool-ITHIM/#Home. Accessed: September 17, 2021.
- Federal Highway Administration (FHWA). 2017. *National Household Travel Survey – 2017 Table Designer*. Travel Day PMT by TRPTRANS by HH_CBSA. Available: https://nhts.ornl.gov/. Accessed: January 2021.
- Pucher, J., and Buehler, R. 2011. *Analysis of Bicycling Trends and Policies in Large North American Cities: Lessons for New York*. March. Available: http://www.utrc2.org/sites/default/files/pubs/analysis-bike-final_0.pdf. Accessed: January 2021.

Measure T-20: Extend Bikeway Network

A=-1*((((C-B)/B)*D*F*H)/(E*G))

A = Percent VMT reduction
B = Existing bikeway length (2.0 miles)
C = Existing + Specific Plan bikeway length (6.62 miles)
D = Bike mode share in plan/community (1.62%)
E = Vehicle mode share in plan/community (92.66%)
F = Average one-way bike trip length in plan/community (2.0 miles)
G = Average one-way vehicle trip length in plan/community (23.88 miles)
H = Elasticity of bike commuters (0.25)

VMT Reduction (A) = **-0.06%**

Existing Bikeway Length

Taft Bike Path=	2.0	miles

Existing + Specific Plan Bikeway Length

10th Street, Kern to Front=	0.37	miles
6th Street, Kern to Front=	0.38	miles
Kern, 10th to 1st=	0.79	miles
Westside Hwy, 1st to Main=	0.35	miles
1st Street, JNO Kern to Center=	0.17	miles
2nd Street, Kern to Supply Row=	0.26	miles
Center, 2nd to Westside Hwy=	0.33	miles
Main, 2nd to Westside Hwy=	0.40	miles
Existing + Specific Plan=	**5.05**	**miles**

T-23. Provide Community-Based Travel Planning

GHG Mitigation Potential

2.3%

Up to 2.3% of GHG emissions from vehicle travel in the plan/community

Co-Benefits (icon key on pg. 34)

Climate Resilience

CBTP can decrease vehicle use and thus improve air quality, resulting in health impacts that may increase the resilience of communities near freeways and roads. This can also increase the adaptive capacity of communities by informing them of travel alternatives if certain modes become disrupted due to extreme events.

Health and Equity Considerations

Outreach materials may need to be in multiple languages to address diverse linguistic communities.

Measure Description

This measure will target residences in the plan/community with community-based travel planning (CBTP). CBTP is a residential-based approach to outreach that provides households with customized information, incentives, and support to encourage the use of transportation alternatives in place of single occupancy vehicles, thereby reducing household VMT and associated GHG emissions.

Subsector

Trip Reduction Programs

Locational Context

Urban, suburban

Scale of Application

Plan/Community

Implementation Requirements

CBTP involves teams of trained travel advisors visiting all households within a targeted geographic area, having tailored conversations about residents' travel needs, and educating residents about the various transportation options available to them. Due to the personalized outreach method, communities are typically targeted in phases.

Cost Considerations

The main cost consideration for CBTP is labor costs for program managers and resident outreach staff plus material costs for development of educational material. The beneficiaries are the commuters who may be able to reduce vehicle usage or ownership. The local municipality may achieve cost savings through a reduction of cars on the road leading to lower infrastructure and roadway maintenance costs.

Expanded Mitigation Options

Pair with any of the Measures from T-17 through T-22-C to ensure that residents that are targeted by CBTP who want to use alternative transportation have the infrastructure and technology to do so.

GHG Reduction Formula

$$A = \frac{C}{B} \times D \times -E \times F$$

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from household vehicle travel in plan/community	0–2.3	%	calculated
User Inputs				
B	Residences in plan/community	[ ]	residences	user input
C	Residences in plan/community targeted with CBTP	[ ]	residences	user input
Constants, Assumptions, and Available Defaults				
D	Percent of targeted residences that participate	19	%	MTC 2021
E	Percent vehicle trip reduction by participating residences	12	%	MTC 2021
F	Adjustment factor from vehicle trips to VMT	1	unitless	assumed

Further explanation of key variables:

- (D) – Results from program evaluations of CBTP in several counties in Washington and Oregon across multiple years indicate that an average of 19 percent of residences targeted will participate (MTC 2021).
- (E) – Results from program evaluations of CBTP in several counties in Washington and Oregon across multiple years indicate that a 12 percent vehicle trip reduction will occur among participating residences (MTC 2021).
- (F) – The adjustment factor from vehicle trips to VMT is 1. This assumes that all vehicle trips will average out to typical trip length ("assumes all trip lengths are equal"). Thus, it can be assumed that a percentage reduction in vehicle trips will equal the same percentage reduction in VMT.

GHG Calculation Caps or Maximums

Measure Maximum

(A_{max}) The maximum percent reduction in GHG emissions (A) is 2.3 percent. This maximum scenario is presented in the below example quantification.

Subsector Maximum

Same as (A_{max}). Measure T-23 is the only measure at the Plan/Community scale within the Trip Reduction Programs subsector.

Example GHG Reduction Quantification

The user reduces household VMT by having residences in the plan/community participate in CBTP. In this example, all of the residences in a city of 5,000 are targeted (B and C), which would reduce GHG emissions from citywide household VMT by 2.3 percent.

$$A = \left(\frac{5{,}000\ \text{residences}}{5{,}000\ \text{residences}}\right) \times 19\% \times -12\% \times 1 = -2.3\%$$

Quantified Co-Benefits

Improved Local Air Quality

The percent reduction in GHG emissions (A) would be the same as the percent reduction in NO_X, CO, NO_2, SO_2, and PM. Reductions in ROG emissions can be calculated by multiplying the percent reduction in GHG emissions (A) by an adjustment factor of 87 percent. See *Adjusting VMT Reductions to Emission Reductions* above for further discussion.

Energy and Fuel Savings

The percent reduction in vehicle fuel consumption would be the same as the percent reduction in GHG emissions (A).

VMT Reductions

The percent reduction in household VMT would be the same as the percent reduction in GHG emissions (A).

Sources

- Metropolitan Transportation Commission (MTC). October 2021. *Plan Bay Area 2050, Forecasting and Modeling Report*. Available: https://www.planbayarea.org/sites/default/files/documents/Plan_Bay_Area_2050_Forecasting_Modeling_Report_October_2021.pdf. Accessed: November 2021.

Measure T-23: Provide Community-Based Travel Planning

A=(C/B)*D*-E*F

A = Percent VMT reduction
B = Residences in plan/community (12,015)
C = Residences in plan/community targeted with CBTP (3,120)
D = Percent of targeted residences that participate (19%)
E = Percent trip reduction by participating residences (12%)
F = Adjustment factor from vehicle trips to VMT (1.0)

VMT Reduction (A) = **-0.59%**

T-25. Extend Transit Network Coverage or Hours

GHG Mitigation Potential

4.6%

Up to 4.6% of GHG emissions from vehicle travel in the plan/community

Co-Benefits (icon key on pg. 34)

Climate Resilience

Increasing transit network coverage or hours improves the reliability of the transportation network and allows redundancy to exist even if an extreme event disrupts part of the system. They could also incentivize more people to use transit, resulting in less traffic and better allowing emergency responders to access a hazard site during an extreme weather event.

Health and Equity Considerations

This measure increases access to social, educational, and employment opportunities. Expansion of transit networks need to ensure equitable access by all communities to the transit system.

Measure Description

This measure will expand the local transit network by either adding or modifying existing transit service or extending the operation hours to enhance the service near the project site. Starting services earlier in the morning and/or extending services to late-night hours can accommodate the commuting times of alternative-shift workers. This will encourage the use of transit and therefore reduce VMT and associated GHG emissions.

Subsector

Transit

Locational Context

Urban, suburban

Scale of Application

Plan/Community

Implementation Requirements

There are two primary means of expanding the transit network: by increasing the frequency of service, thereby reducing average wait times and increasing convenience, or by extending service to cover new areas and times.

Cost Considerations

Infrastructure costs for extending the physical network coverage of a transit system can be significant. Costs to expand track-dependent transit, such as light rail and passenger rail, are high and can require resource- and time-intensive advanced planning. Costs to expand vehicle-dependent transit, such as busses, are likewise high but may be limited to procurement of additional vehicles. Any expansion of transit, including just service hours, would increase staffing and potentially maintenance costs. A portion of these costs may be offset by increased transit usage and associated income. Commuters who may more easily be able to travel without a car may also observe cost savings from reduce vehicle usage or ownership.

Expanded Mitigation Options

This measure is focused on providing additional transit network coverage, with no changes to transit frequency. This measure can be paired with Measure T-26, *Increase Transit Service Frequency*, which is focused on increasing transit service frequency, for increased reductions.

GHG Reduction Formula

$$A = -1 \times \frac{C - B}{B} \times D \times E \times F \times G$$

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from plan/community VMT	0–4.6	%	calculated
User Inputs				
B	Total transit service miles or service hours in plan/community before expansion	[ ]	miles	user input
C	Total transit service miles or service hours in plan/community after expansion	[ ]	miles	user input
D	Transit mode share in plan/community	Table T-3.1	%	user input
Constants, Assumptions, and Available Defaults				
E	Elasticity of transit demand with respect to service miles or service hours	0.7	unitless	Handy et al. 2013
F	Statewide mode shift factor	57.8	%	FHWA 2017
G	Ratio of vehicle trip reduction to VMT	1	unitless	assumption

Further explanation of key variables:

- (A) – This formula does not reflect any increase in transit vehicle travel and emissions, which can at least partially offset the reduction in GHG emissions from passenger vehicle travel. Inclusion of this component in the percent GHG reduction formula would require inputs that would not be available to most users.
- (B and C) – Transit service miles are defined as the total service mileage. Service hours represent the hours of operation. Either metric can be used in the GHG reduction formula so long as both B and C use the same metric.
- (D) – The transit mode share for the six most populated CBSAs in California are provided in Table T-3.1 in Appendix C (FHWA 2017). If the project study area is not within the listed CBSAs or the user is able to provide a project-specific value, the user should replace these regional defaults in the GHG reduction formula. It is likely for areas outside of the area covered by the listed CBSAs to have transit mode shares lower than the values provided in the table. Ideally, the user will calculate existing transit mode share for work trips or all trips at a scale no larger than a census tract. Potential data sources include the U.S. Census, California Household Travel Survey (preferred), or local survey efforts. Care should be taken to not present the reported commute mode share as retrieved from the ACS, unless the land use is office or employment based and the ACS tables are based on work location (rather than home location).
- (E) – A policy brief summarizing the results of transit service strategies concluded that a 0.7 percent increase in transit ridership occurs for every 1 percent increase in service miles or hours (Handy et al. 2013).

- (F) – Mode shift factor is an adjustment to reflect the reduction in vehicle trips associated with a reduction in person trips, since some vehicles carry more than one person. It is calculated as (1/average vehicle occupancy).
- (G) – The adjustment factor from vehicle trips to VMT is 1. This assumes that all vehicle trips will average out to typical trip length ("assumes all trip lengths are equal"). Thus, it can be assumed that a percentage reduction in vehicle trips will equal the same percentage reduction in VMT.

GHG Calculation Caps or Maximums

Measure Maximum

(A_{max}) The GHG reduction from expanding the transit network is capped at 4.6 percent, which is based on the following assumptions:

- $\left(\frac{C-B}{B} \leq 100\%\right)$ – The transit network increase is capped at a doubling in size, or 100 percent (twice as many revenue miles are provided, for a 100 percent increase).
- (D) – The CBSA is San Francisco-Oakland-Hayward, which has a default transit mode share for all trips of 11.38 percent.

This maximum scenario is presented in the below example quantification.

Subsector Maximum

$(\sum A_{max_{T\text{-}25 \text{ through } T\text{-}29}} \leq 15\%)$ This measure is in the Transit subsector. This subcategory includes Measures T-25 through T-29. The VMT reduction from the combined implementation of all measures within this subsector is capped at 15 percent.

Example GHG Reduction Quantification

The user reduces VMT by extending an existing transit route or lengthening the service hours. In this example, the project in a neighborhood of the San Francisco-Oakland-Hayward CBSA and would increase transit coverage in the area from 20 miles (B) to 40 miles (C). If the existing transit mode share in the study area is 11.38 percent (D), the user would reduce GHG emissions from VMT by 4.6 percent.

$$A = -1 \times \frac{(40 \text{ miles} - 20 \text{ miles})}{20 \text{ miles}} \times 11.38\% \times 0.7 \times 57.8\% \times 1 = -4.6\%$$

Quantified Co-Benefits

Improved Local Air Quality

The percent reduction in GHG emissions (A) would be the same as the percent reduction in NO_X, CO, NO_2, SO_2, and PM. Reductions in ROG emissions can be calculated by multiplying the percent reduction in GHG emissions (A) by an adjustment factor of 87 percent. See *Adjusting VMT Reductions to Emission Reductions* above for further discussion.

Energy and Fuel Savings

The percent reduction in vehicle fuel consumption would be the same as the percent reduction in GHG emissions (A).

VMT Reductions

The percent reduction in VMT would be the same as the percent reduction in GHG emissions (A).

Sources

- Federal Highway Administration (FHWA). 2017. *National Household Travel Survey–2017 Table Designer*. Average Vehicle Occupancy by HHSTFIPS. Available: https://nhts.ornl.gov/. Accessed: January 2021.
- Handy, S., K. Lovejoy, M. Boarnet, and S. Spears. 2013. *Impacts of Transit Service Strategies on Passenger Vehicle Use and Greenhouse Gas Emissions*. October. Available: https://ww2.arb.ca.gov/sites/default/files/2020-06/Impacts_of_Transit_Service_Strategies_on_Passenger_Vehicle_Use_and_Greenhouse_Gas_Emissions_Policy_Brief.pdf. Accessed: January 2021.

Measure T-25: Extend Transit Network (Based on Service Hours)

A=-1*((((C-B)/B)*D*E*F*G))

A = Percent VMT reduction
B = Existing total transit service hours per week (64.75 hours)
C = Existing + Specific Plan total transit service hours per week (148.27 hours)
D = Transit mode share in plan/community (1.12%)
E = Elasticity of transit demand (0.7)
F = Statewide mode shift factor (57.8%)
G = Ratio of vehicle trip reduction to VMT (1.0)

VMT Reduction (A) = -0.53%

Existing Transit Service Hours Per Week	Total Per Week		Morning	Afternoon	Evening	Total
Taft Area Transit Weekday Service Hours=	10.83	hours	0.5	0.82	0.85	2.17
Kern Transit Route 120 Weekday Service Hours=	53.50	hours	4.28	3.17	3.25	10.70
Kern Transit Route 120 Saturday Service Hours=	7.08	hours	2.82	2.82	1.45	7.08
Total Existing:	**71.42**	**hours**				

Existing + Specific Plan Transit Service Hours Per Week	Total Per Week		Morning	Afternoon	Evening	Total
Taft Area Transit Weekday Service Hours=	65.00	hours				13
Taft Area Transit Saturday Service Hours=	6.00	hours				6
Kern Transit Route 120 Weekday Service Hours=	71.08	hours	5.95	3.17	5.10	14.22
Kern Transit Route 120 Saturday Service Hours=	12.85	hours	4.65	2.82	5.38	12.85
Total Existing + Specific Plan:	**154.93**	**hours**				

T-26. Increase Transit Service Frequency

GHG Mitigation Potential

11.3%

Up to 11.3% of GHG emissions from vehicle travel in the plan/community

Co-Benefits (icon key on pg. 34)

Climate Resilience

Increasing transit service frequency improves the reliability of the transportation network and allows redundancy to exist even if an extreme event disrupts part of the system. It could also incentivize more people to use transit, resulting in less traffic and better allow emergency responders to access a hazard site during an extreme weather event.

Health and Equity Considerations

This measure increases access to social, educational, and employment opportunities. Expansion of transit service needs to ensure equitable access by all communities to the transit system.

Measure Description

This measure will increase transit frequency on one or more transit lines serving the plan/community. Increased transit frequency reduces waiting and overall travel times, which improves the user experience and increases the attractiveness of transit service. This results in a mode shift from single occupancy vehicles to transit, which reduces VMT and associated GHG emissions.

Subsector

Transit

Locational Context

Urban, suburban

Scale of Application

Plan/Community

Implementation Requirements

See measure description.

Cost Considerations

Increasing transit service frequency may require capital investment to purchase additional vehicles. Staff and maintenance costs may also increase. A portion of these costs may be offset by increased transit usage and associated income. Commuters who may more easily be able to travel without a car may also observe cost savings from reduce vehicle usage or ownership.

Expanded Mitigation Options

This measure is focused on providing increased transit frequency, with no changes to transit network coverage. This measure can be paired with Measure T-25, *Extend Transit Network Coverage or Hours*, which is focused on increasing transit network coverage, for increased reductions.

GHG Reduction Formula

$$A = -C \times \frac{B \times E \times D \times G}{F}$$

GHG Calculation Variables

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from vehicle travel in plan/community	0–11.3	%	calculated
User Inputs				
B	Percent increase in transit frequency	0–300	%	user input
C	Level of implementation	0–100	%	user input
Constants, Assumptions, and Available Defaults				
D	Elasticity of transit ridership with respect to frequency of service	0.5	unitless	Handy et al. 2013
E	Transit mode share in plan/community	Table T-3.1	%	FHWA 2017a
F	Vehicle mode share in plan/community	Table T-3.1	%	FHWA 2017a
G	Statewide mode shift factor	57.8	%	FHWA 2017b

Further explanation of key variables:

- (A) – This formula does not reflect any increase in transit vehicle travel and emissions, which can at least partially offset the reduction in GHG emissions from passenger vehicle travel. Inclusion of this component in the percent GHG reduction formula would require inputs that would not be available to most users. Users can calculate the absolute changes in passenger vehicle and bus VMT and emissions using the process described under *Co-Benefits*.
- (B) – Frequency is measured as the number of arrivals over a given time (e.g., buses per hour). Frequency is the inverse of transit headway, defined as the time between transit vehicle arrivals on a given route. This variable can be calculated as [transit frequency with measure minus existing transit frequency] divided by existing transit frequency.
- (C) – The level of implementation refers to the number of transit routes receiving the frequency improvement as a fraction of the total transit routes in the plan/community.
- (D) – A policy brief summarizing the results of transit service strategies concluded that a 0.5 percent increase in transit ridership occurs for every 1 percent increase in frequency (Handy et al. 2013).
- (E and F) – Ideally, the user will calculate transit and auto mode shares for a plan/community at the city scale (or larger). Potential data sources include the California Household Travel Survey (preferred) or local survey efforts. If the user is not able to provide a project-specific value using one of these data sources, they have the option to input the mode shares for transit and vehicles for one of the six most populated CBSAs in California, as presented in Table T-3.1 in Appendix C. It is likely for areas outside of

the area covered by the listed CBSAs to have vehicle mode shares higher and transit mode shares lower than the values provided in the table.

- (G) – Mode shift factor is an adjustment to reflect the reduction in vehicle trips associated with a reduction in person trips, since some vehicles carry more than one person. It is calculated as (1/average vehicle occupancy).

GHG Calculation Caps or Maximums

Measure Maximum

(A_{max}) For projects that use default CBSA data from Table T-3.1 and (B_{max}), the maximum percent reduction in GHG emissions (A) is 11.3 percent. This maximum scenario is presented in the below example quantification.

(B_{max}) The percent change in transit frequency is capped at 300 percent (SANDAG 2019).

Subsector Maximum

($\sum A_{max_{T\text{-}25 \text{ through } T\text{-}29}} \leq 15\%$) This measure is in the Transit subsector. This subcategory includes Measures T-25 through T-29. The VMT reduction from the combined implementation of all measures within this subsector is capped at 15 percent.

Mutually Exclusive Measures

If the user selects Measure T-28, *Provide Bus Rapid Transit*, and converts all transit routes in the plan/community to BRT, then the user cannot also take credit for this measure or Measure T-27, *Implement Transit-Supportive Roadway Treatments*. This is because Measure T-28 accounts for the VMT reduction associated with increased transit frequency and decreased transit travel time as well as the additional BRT-specific bonus. To combine the GHG reductions from Measure T-28 with Measure T-27 and/or Measure T-26 would be considered double counting. However, where BRT is proposed on less than all of the existing bus routes in the plan/community area, this measure and/or Measure T-27 could be applied to the remaining bus routes, and the measure reductions could be combined with Measure T-28 to determine the emissions reduction at the larger plan/community scale.

Example GHG Reduction Quantification

The user reduces plan/community GHGs by increasing transit frequency, thereby encouraging a mode shift from vehicles to transit and reducing VMT. In this example, the project is in the San Francisco-Oakland-Hayward CBSA where the transit and vehicle mode shares would be 11.38 percent and 86.96 percent, respectively (E and F). Assuming the maximum increase in transit frequency of 300 percent (B) and implementation for all transit routes (100 percent) in the plan/community (C), the user would reduce plan/community GHG emissions from VMT by 11.3 percent.

$$A = -100\% \times \frac{300\% \times 11.38\% \times 0.5 \times 57.8\%}{86.96\%} = -11.3\%$$

Quantified Co-Benefits

Improved Local Air Quality

The percent reduction in GHG emissions (A) would be the same as the percent reduction in NO_X, CO, NO_2, SO_2, and PM. Reductions in ROG emissions can be calculated by multiplying the percent reduction in GHG emissions (A) by an adjustment factor of 87 percent. See *Adjusting VMT Reductions to Emission Reductions* above for further discussion.

VMT Reductions

The decrease in passenger vehicle miles (H) and increase in bus miles (L) by the measure can be calculated as follows.

Passenger Vehicle VMT Reduction Formula

The percent reduction in passenger VMT would be the same as the percent reduction in GHG emissions (A). The absolute reduction in passenger VMT can be calculated using the following formula.

$$H = I \times E \times J \times B \times D \times G \times K$$

Passenger Vehicle VMT Reduction Calculation Variables

ID	Variable	Value	Unit	Source
Output				
H	Reduction in passenger vehicle miles in plan/community	[ ]	miles per year	calculated
User Inputs				
I	Total daily person trips in corridor(s)	[ ]	trips per day	user input
J	Vehicle trip length	[ ]	miles per trip	user input
Constants, Assumptions, and Available Defaults				
K	Days per year transit available	365	days per year	assumed

Further explanation of key variables:

- (I) – The total daily person trips in the corridor(s) represents the total daily trips by all modes between the bus route origin area and the bus route destination area. This may be obtained through travel demand modeling. If the strategy involves frequency improvements for more than one transit route, then the total person trips should reflect the sum of all the routes being improved.
- (J) – If the strategy involves frequency improvements for more than one transit route, then the trip length should reflect the average of all the routes being improved.
- Please refer to the GHG Calculation Variables table above for definitions of variables that have been previously defined.

Bus VMT Increase Formula

The absolute increase in bus VMT can be calculated using the formula below. As noted above, the formula for the percent GHG reduction (A) does not reflect any increase in bus VMT and bus emissions. Users that wish to capture these impacts should calculate absolute changes.

$$L = P \times (M_2 - M_1) \times N \times O \times K$$

Bus VMT Increase Calculation Variables

ID	Variable	Value	Unit	Source
Output				
L	Increase in annual bus miles in plan/community	[ ]	miles per year	calculated
User Inputs				
M_1	Bus frequency without measure	[ ]	transit vehicle roundtrips per hour	user input
M_2	Bus frequency with measure	[ ]	transit vehicle roundtrips per hour	user input
N	Bus hours of operation	0–24	hours per day	user input
O	Bus route one-way length	[ ]	miles per route	user input
Constants, Assumptions, and Available Defaults				
P	One-way trips in a roundtrip	2	one-way trips per roundtrip	conversion

Further explanation of key variables:

- (L) – If the strategy involves frequency improvements for more than one transit route, then the increase in bus miles should be calculated separately for each route.
- Please refer to the GHG Calculation Variables table above for definitions of variables that have been previously defined.

Energy and Fuel Savings

The decrease in passenger vehicle fuel consumption and increase in bus fuel consumption by the measure can be calculated as follows.

Passenger Vehicle Fuel Use Reduction Formula

Multiply the reduction in passenger vehicle miles (H) above by the fuel efficiency of the vehicle type (see Table T-30.2 in Appendix C) to output the change in fuel consumption.

Bus Fuel Use Increase Formula

The absolute increase in bus fuel consumption (Q) can be calculated using the formula below.

$$Q = L \times R$$

Bus Fuel Use Increase Calculation Variables

ID	Variable	Value	Unit	Source
Output				
Q	Increase in annual bus fuel consumption in plan/community	[ ]	gal per year	calculated
User Inputs				
	None			
Constants, Assumptions, and Available Defaults				
R	Fuel economy of a transit bus, by fuel type	Table T-26.1	gal or kilowatt hour per mile	CARB 2020; U.S. DOE 2021

Further explanation of key variables:

- (R) – The average fuel economy for gasoline, diesel, and natural gas transit buses was calculated using EMFAC2017 (v1.0.3). The model was run for a 2020 statewide average of UBUS vehicles, disaggregated by fuel type (CARB 2020). The efficiency of electric buses was calculated based on the gasoline equivalent value (U.S. DOE 2021). The user should reference Table T-26.1 for the fuel economy of the appropriate fuel type for their location's transit system. If the user can provide a project-specific value (i.e., for a future year and project location), the user should run EMFAC to replace the default in the fuel use increase formula.
- Please refer to the Bus VMT Increase Calculation Variables table above for definitions of variables that have been previously defined.

Sources

- California Air Resources Board (CARB). 2020. *EMFAC2017 v1.0.3*. August. Available: https://arb.ca.gov/emfac/emissions-inventory. Accessed: January 2021.
- Federal Highway Administration (FHWA). 2017a. *National Household Travel Survey–2017 Table Designer*. Travel Day PMT by TRPTRANS by HH_CBSA. Available: https://nhts.ornl.gov/. Accessed: January 2021.
- Federal Highway Administration (FHWA). 2017b. *National Household Travel Survey–2017 Table Designer*. Average Vehicle Occupancy by HHSTFIPS. Available: https://nhts.ornl.gov/. Accessed: January 2021.
- Handy, S., K. Lovejoy, M. Boarnet, S. Spears. 2013. *Impacts of Transit Service Strategies on Passenger Vehicle Use and Greenhouse Gas Emissions*. October. Available: https://ww2.arb.ca.gov/sites/default/files/2020-06/Impacts_of_Transit_Service_Strategies_on_Passenger_Vehicle_Use_and_Greenhouse_Gas_Emissions_Policy_Brief.pdf. Accessed: January 2021.
- San Diego Association of Governments (SANDAG). 2019. *Mobility Management VMT Reduction Calculator Tool–Design Document*. June. Available: https://www.icommutesd.com/docs/default-source/planning/tool-design-document_final_7-17-19.pdf?sfvrsn=ec39eb3b_2. Accessed: January 2021.
- U.S. Department of Energy (U.S. DOE). 2021. *Fuel Economy Datasets for All Model Years (1984-2021)*. January. Available: https://www.fueleconomy.gov. Accessed: January 2021.

Measure T-26: Increase Transit Service Frequency

A=-C*((B*E*D*G)/F)

A = Percent VMT reduction
B = Percent increase in transit frequency (275%)
C = Level of implementation (100%)
D = Elasticity of transit ridership (0.5)
E = Transit mode share in plan/community (1.12%)
F = Vehicle mode share in plan/community (92.66%)
G = Statewide mode shift factor (57.8%)

VMT Reduction (A) = -0.96%

Existing Transit Frequency			Hours of Operation
Taft Area Transit Weekday Frequency=	1.38	per hour	2.17
Kern Transit Route 120 Weekday Frequency=	0.37	per hour	10.70
Kern Transit Route 120 Saturday Frequency=	0.42	per hour	7.08
Average Existing Transit Frequency:	**0.73**	**per hour**	

Existing + Specific Plan Transit Frequency			Hours of Operation
Taft Area Transit Weekday Frequency=	2.00	per hour	13.0
Taft Area Transit Saturday Frequency=	2.00	per hour	6.0
Kern Transit Route 120 Weekday Frequency=	2.00	per hour	14.22
Kern Transit Route 120 Saturday Frequency=	2.00	per hour	12.85
Average Existing + Specific Plan Transit Frequency:	**2.00**	**per hour**	

Percent Increase in Transit Frequency: 275%