Caltrans SB 743 Program

Mitigation Playbook

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DRAFT

SUSTAINABILITY
People, planet, prosperity

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF EQUATIONS

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INTRODUCTION

Caltrans seeks to avoid inducing new traffic, as measured in VMT, as it manages and evolves the State Highway System. This commitment arises out of the department's implementation of CEQA as amended by SB 743 (2013) and the resultant OPR Technical Advisory (2018). It also responds to research findings that induced traffic from highway expansions tends to undermine the purpose of many of those expansions, congestion relief.

This guide describes mitigation methods for VMT induced by highway capacity projects. It should be noted, however, that mitigation is not the first option for addressing induced VMT. The primary method is to plan and develop projects in a way that does not induce VMT in the first place. Where induced VMT is unavoidable, design and lane-management strategies may minimize it. Mitigation is required when significant induced VMT remains after exhausting these options. Formally, mitigation is memorialized in an environmental document, where it must meet CEQA standards for additionality[1] – the need for mitigation must be caused by the project – and be enforceable – the mitigation must be firmly committed to by the relevant parties. The mitigation must also be additional to any other VMT reduction required by law, or which would occur otherwise. And, most relevant to this guide, it must be quantifiable and effective at reducing VMT.

For transportation agencies, mitigation is a familiar concept with respect to other types of environmental impacts. Mitigation for induced VMT is less familiar for most of those agencies, but it has a long history in other settings. Local and regional governments and Transportation Management Associations, for example, have run programs aimed at reducing SOV transportation demand for many years.[2] More recently, since passage of SB 743, many local governments in California have established VMT

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[1] For more on additionality, see this Aug. 26, 2021, bulletin from the SB 743 Program.

[2] Note that many of these programs are aimed at reducing peak-period congestion, rather than VMT. Often, but not always, measures aimed at peak period congestion also reduce VMT. See "Modernizing Mitigation: A Demand-Centered Approach" (SSTI, 2018) for more details.

calculators or other tools, which describe a menu of quantifiable VMT-reduction measures that land-use developers can use for VMT mitigation.

That history means that there is a substantial body of work on which to base mitigation decisions. In California, a particularly authoritative compilation of VMT-reducing measures was published in 2010 and recently updated in December 2021 by the California Air Pollution Control Officers Association. "Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity" is, as the title suggests, aimed at GHG impacts. However, in many instances described in the handbook, GHG reductions are accomplished through VMT reductions, and so the measure descriptions and quantification are useful in considering VMT mitigation for roadway expansions. The CAPCOA handbook is referred to frequently in the discussion on mitigation measures in this document, but we have not exhausted it as a source of mitigation ideas, so it is a recommended resource for anyone charged with the development and analysis of VMT mitigation.

Related, many local governments have developed VMT calculators, based on CAPCOA or the same body of literature used by CAPCOA. In this guide we use the Alameda County VMT calculator[3] as an example and list others in Appendix B. These calculators, like CAPCOA, can provide ways of assessing many potential VMT-reduction measures. Direct use is quite convenient because the calculators come pre-loaded with default data. Where such custom calculators do not exist, the formulas for making assessments can be useful, though the burden on the analyst to find data is greater.

With CAPCOA, the calculators, and other sources, we are able assess many mitigation measures for effectiveness. But not all. In this guide we include measures that are well-defined and quantified, and those that are conceptually effective but do not yet

[3] The Alameda County calculator referenced in this playbook uses 2010 CAPCOA data.

have standard metrics associated with them. We hope to develop some of these measures further both through ongoing Caltrans-funded research and through the efforts of the many stakeholders in the state and elsewhere. As development occurs, we will update and extend this guide.

Even though substantial and growing research to evaluate VMT mitigation measures exits, this does not mean mitigating VMT is easy. On the contrary, it is likely to be difficult, as highway capacity projects may generate VMT in the millions per year and creating offsetting reductions can be a significant undertaking. That is one reason the preferred route to VMT neutrality is to avoid VMT-inducing projects whenever possible. Best practices for considering VMT impacts early on in the project development process can be found in the SB 743 Environmental Essentials in Project Development and Delivery document, published by Caltrans.[4]

Caltrans and many stakeholders are interested in organizing mitigation efforts through banks or exchanges. If such efforts succeed, an entity would collect and validate VMT mitigation opportunities – from land-use developers, transit agencies, TMAs,[5] local active transportation programs and others – and make them available to transportation agencies whose projects are in need of mitigation. At the moment no such arrangement has emerged, so project development teams must either develop VMT-reduction measures, e.g. pedestrian facilities, or connect with mitigation providers themselves. Sharing this guide with likely providers in the area is one way to help surface possible mitigation options.

The rest of this guide summarizes mitigation measures, providing factors to consider, methods for measuring, and some examples of assessing measure efficacy.

[4] https://dot.ca.gov/-/media/dot-media/programs/sustainability/documents/sb-743-environmental-essentials-for-project-development-and-delivery-a11y.pdf

[5] See Appendix A for a list of TMAs in California.

HOW TO USE THIS PLAYBOOK

Though this playbook lays out various quantifiable approaches to mitigating VMT, it is not comprehensive. In some cases, entities may wish to use mitigations which are not in this playbook, are not readily available in other sources such as CAPCOA and may be difficult to quantify.

For example, take the case of transit facility comfort improvements such as benches and shade. These are both relatively low-cost system improvements, which—in theory—should have a positive effect on ridership, especially in places with higher temperatures and sun exposure. However, little research has been done on this question and no widely accepted quantification measures exist. If an entity wishes to use such improvements as VMT mitigation measures, more analysis would need to be done to develop a reasonable estimate. The analyst could review the existing literature on the topic—which is fairly scarce—to find any applicable evidence (either quantitative or qualitative) that would help build a case. Moreover, the analyst could rely on internal data, if such data showed an increase in transit ridership corresponding to the installation of shade facilities. Regardless of the specific methodology used, VMT reductions should be reasonable. In the shade facility installation case, it wouldn't be reasonable to expect a drastic ridership increase due to the installation of shade facilities and thus the VMT reduction would likely be fairly small in most cases.

This playbook includes other mitigation measures, such as park and ride lots, without given quantification approach. While various methodologies exist to calculate the VMT reductions from these mitigations, they are much more context sensitive and likely vary on a case-by-case basis. Additional research is likely needed in order to successfully quantify the effects of these mitigations. As Caltrans develops more guidance on these measures, this playbook will be updated.

Lastly, it is important to acknowledge that this playbook is not comprehensive and that the field and practice of VMT quantification and mitigation is rapidly evolving. Caltrans is currently funding a research project focused on assessing the effectiveness of potential VMT mitigation measures, the outcome of which may supersede this playbook.

MITIGATION MEASURES

Table 1 summarizes many mitigation measures that could be applied to a project to offset induced travel. "Ease of implementation" is higher when costs are lower and fewer parties are involved. "Efficacy" is higher for measures that have the potential to reduce more VMT in most common situations. "On-System" or "Off-System" refers to whether the measure applies directly to the SHS or not. The ratings are general and actual conditions will vary with particular projects. Note that while these measures could constitute mitigation, they could alternatively serve as projects or elements of projects, reducing or eliminating the need for mitigation. For example, added highway capacity may induce 1 million VMT annually, while transit improvements that are part of the same project may reduce VMT by 500,000 annually, leaving 500,000 VMT in need of mitigation (per CEQA). Alternatively, the transit improvements may be funded as mitigation.

Mitigation measures may be combined. However, in most cases a combination would reduce the effectiveness of each individual measure. Consider a combination of new transit service and dense affordable housing, aimed at reducing 1 million VMT. By themselves we calculate transit would offset 10 percent or 100,000 of the VMT from a project, while the dense affordable housing would offset 20 percent or 200,000. However, if transit reduces VMT to 900,000, then the dense affordable housing effect would be 20 percent of that figure, or 180,000. Thus, the total reduction would be 280,000 VMT. CAPCOA p. 38 and in introductions to measure descriptions provides guidance for combining measures.

Table 1. VMT mitigation measures summarized. Note that this list is not exhaustive, and other measures that satisfy CEQA requirements could be developed.

Measure	Ease of implementation	Efficacy	On- or Off-System	Key considerations
Active transportation	High	Low[6]	Both (Note: for the SHS, may be most effective when integrated with conventional "main-street" highways)	Must provide access to destinations, not simply recreational opportunities.
Land use – residential	Low	High	Off	Requires partnership agreements with land use jurisdictions housing authorities, and private developers. VMT benefits come from density, affordability and location.
Land use – employment	Low	High	Off	Requires partnership agreements with land use jurisdictions housing authorities, and private developers. VMT benefits come from density and location.
TDM	High	Medium	Off	Services can be tailored to meet specific user needs. Must be supported with long term maintenance of effort.
Transit service improvement	Low to high	Low to high	Both	Usually requires partnership agreements with transit operators.
Local road networks/ connectivity	Low to high	Low to high	Off	Can relieve pressures on SHS and provide more direct, multimodal access to destinations.

[6] This is not to imply that Active Transportation projects are not a high priority for Caltrans and worth doing for their own sake. While Active Transportation projects do have a downward VMT effect, the amount of VMT that can be reduced by these projects is often much smaller than the VMT induced by highway projects. This scale is important to consider when developing mitigations.

Measure	Ease of implementation	Efficacy	On- or Off-System	Key considerations
Micro-mobility	High	Low	Both	Requires partnership agreements with transit operators and/or transportation network companies.
Telecommuting	High	Minimal	NA	Telecommuting tends to shift trip-making, but not reduce VMT. Any claim here would need careful, specific support.
Schedule-shifting	NA	None	NA	Reschedules rather than reduces trips. Likely increases VMT.
Road diets	High	High	Both	Lane removals can be considered roughly equivalent to lane additions for similar facilities.
Pricing	Low to high	High	Both	Operational details and market analysis needed during PA&ED.
Lane management	Low to high	Low	On	VMT effect depends on specific management strategy such as transit/HOV priority.
Parking pricing/ restrictions	High	High	Off (On in some limited cases)	Potentially powerful tool for specific land uses in a highway corridor.
Park and ride lots	High	Low	Both	Removes commute trips. Effect on total VMT needs to be addressed in mitigation plan.
Land preservation	High	Unclear	Off	Could work in theory but measurement is difficult. May be best combined with transfer of development rights to spur infill TOD.

Active transportation

Providing complete streets or dedicated active transportation facilities is an integral part of achieving Caltrans' goals. Safe and convenient walking and biking environments should be provided regardless of the need for VMT mitigation. When mitigation funds are used for active transportation, the active transportation improvement must reduce motor vehicle use. For example, a new or improved AT facility that garners only recreational use would not serve as mitigation (though it may be worthwhile for other reasons).

Factors to consider:

- Proximity: Most transportation-related use of AT facilities is for short trips – less than 20 minutes, or about a mile walking or 3 miles cycling. Demand curves are steep; an additional minute or two can reduce AT demand significantly. Therefore transportation-generating facilities must link land uses that are fairly close, with as few traffic stops or diversions (including lengthy stairs or ramp for overcrossings) as possible (see Figure 1). Therefore, projects that reduce travel time between relatively proximate land uses are good candidates for VMT reduction. For example, a pedestrian overpass connecting two relatively dense residential and commercial areas that are separated by a highway would be an ideal VMT-reducing active transportation project

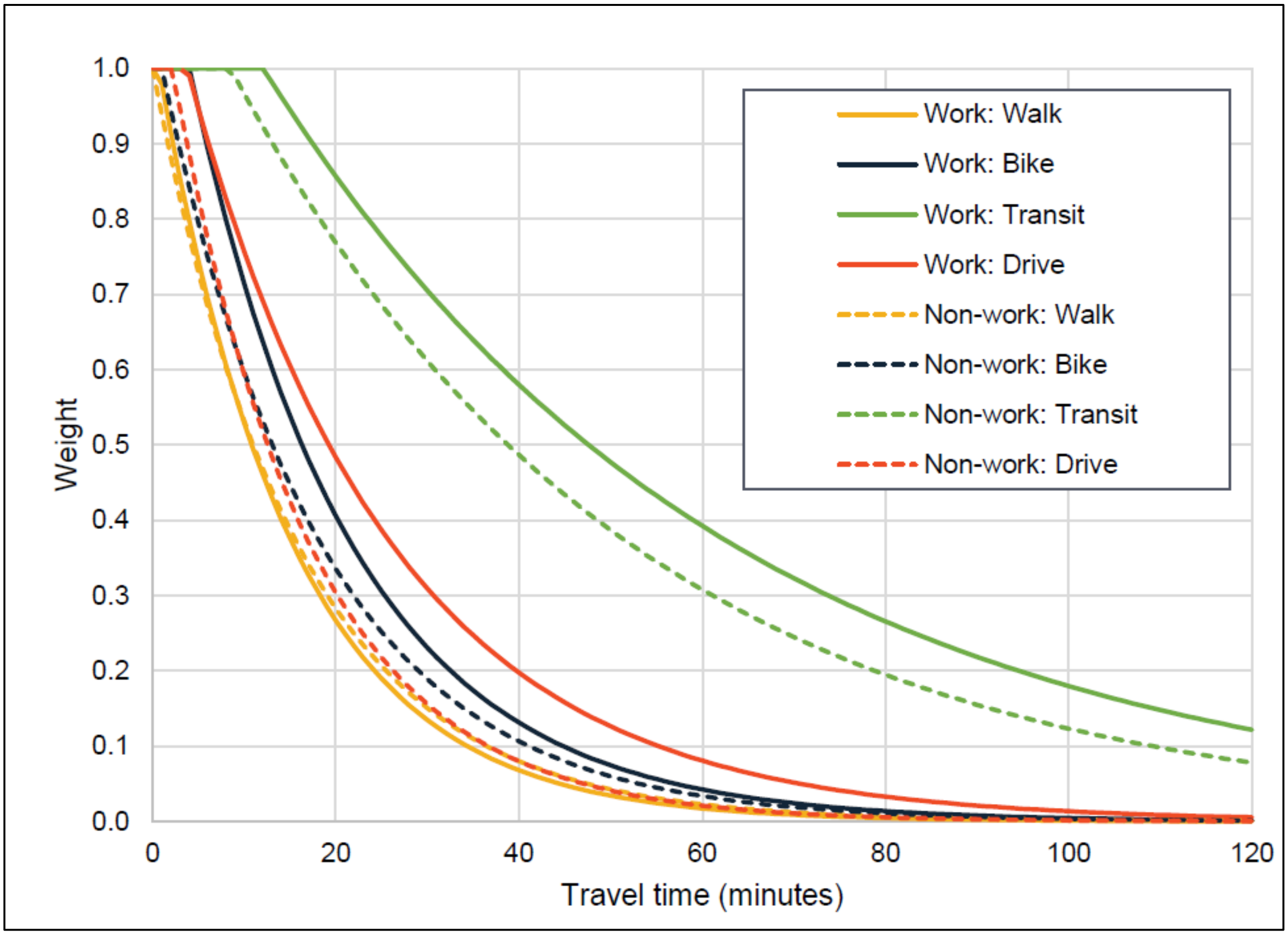


Figure 1. AT usage drops rapidly as time and distance increases. Source: SSTI.

- Level of traffic stress: Even if the network for AT appears robust on a map, with destinations in close proximity, travelers will not use it if it is perceived to be unsafe. Therefore, projects that reduce level of traffic stress, for example by providing buffered or separated cycling lanes, are good candidates for VMT reduction.
- Scale: Large highway projects generally have large impacts as they can affect auto accessibility across a region. AT projects are almost always more modest in scope, affecting in a narrower area, and in terms of VMT impact. In general AT improvements will offset a small percentage of induced VMT from a highway project.

<u>Ways to measure VMT reduction:</u>

- Most demand models are unable to measure effects from AT projects, due to lack of granularity. Should a region invest in a parcel-based model, it could be so employed. For a very large new AT facility, such as a river or freeway crossing that links two transportation analysis zones, a conventional demand model might be employed.
- Various data/software packages are available to measure outputs from small network and land use changes. Urban Footprint is a commonly used package, and it could estimate effects from AT network changes. Caltrans' local partners may have access to this tool.
- Some local governments have adopted VMT estimation tools for use in evaluating land-use and transportation projects. These tools often include AT facility improvements as measures, giving VMT outcomes. An example is the Alameda CTC tool. Where these tools are available online or as macro-enabled spreadsheets, they can be of use in assessing VMT impacts from AT facilities. It may also be possible to use one of these tools where it exits in a neighborhood similar to one where the project will be, if there is no tool there. Alternatively, the underlying formulas may be of use with project-area data; the Alameda formulas are cited below.
- For new pedestrian facilities, several formulas exist, including[7]:
    - "Alternative Quantification Method" prepared for CARB in 2019. See pp. 26-30.
    - "Pedestrian Facility Improvement" prepared for Alameda County (similar to formulas used by other local governments). See pp. 34-35.

[7] Note that the changes in VMT indicated will be for a relatively small project area, compared to the area affected by highway VMT.

- For new bike facilities, several formulas exist, including[1]:
    - "Alternative Quantification Method" prepared for CARB in 2019. See pp. 5-7.
    - "Bikeway Network Expansion" and "Bike Facility Improvement" prepared for Alameda County (similar to formulas used by other local governments). See pp. 37-40.
- For improvements in level of traffic stress, formulas also exist. These may be applied along with the new-facility formulas; for example, if a facility may be considered utility-constrained by LTS, with improvements counting toward additional utility and VMT reduction:
    - "Low-Stress Bicycling and Network Connectivity" by the Mineta Transportation Institute in 2012. See pp. 17-22 for segments, pp. 23-26 for intersection approaches, pp. 27-30 for crossings.
    - "Level of Traffic Stress" by the State Smart Transportation Initiative in 2021. See pp. 27-29.
    - The Alameda County provides adjustment factors for various bike improvements. If a new Class II bike lane is the base, a new Class 1 bike path or Class IV bikeway will be 1.54 times as impactful, while a Class II to Class IV conversion will be 0.54 times as impactful. See pp. 38-9.
- Sometimes a more ad hoc or qualitative case can be made. This might be the case if new or improved AT facilities were designed to serve a particular, perhaps new, activity center. If trip lengths can be determined, the Auto Substitution rates in the CARB formulas may help estimate the VMT displaced. As well, facilities that clearly improve AT connectivity and/or traffic stress in relatively dense areas with a variety of land uses can be assumed to have beneficial VMT impacts. In the Sacramento region, SACOG's Project Performance Assessment tool provides density and land-use mix data for project areas, which can be easily inputted.

Examples:

- New AT elements: Consider an expansion of bikeways. The Alameda County calculator, or similar calculators in other cities, are a convenient way to determine VMT impacts. Figure 2 below shows the calculator estimate, using built-in default values and a handful of user inputs to show the location and extent of the bikeway improvements. The result is in terms of percentage of VMT, so a final step would be to apply that percentage to total VMT in the affected area, which could be obtained from the MPO or other planning entity, or from a big-data tool. Caltrans also tracks VMT at the municipal and county levels, though most active transportation improvements would affect much smaller geographies. Where calculators are not available, the formulas above or in the calculator may be used, but data burden will be higher.
- Improved AT elements: Consider an improvement to a facility, rather than new facilities. The analyst needs to make a finding about the improved utility. If the improvement is very significant, e.g. there was a pedestrian route but it was very difficult to use, not ADA compliant, and/or clearly unsafe, and the improved route addresses such issues, it might be considered to have as much impact as a new facility. More typically, an improved facility will get "partial credit." For example, the Alameda calculator documentation cited above would provide 54 percent of the VMT reduction for a Class II to Class IV conversion, compared to a new facility.

4C. Bikeway Network Expansion

Level of application: **Neighborhood/City**
Type of VMT affected: **All neighborhood/city trips**
Max VMT reduction: **0.5%**

Return to Main
Results Summary

This strategy will increase the length of a city or neighborhood bikeway network. A bicycle network is an interconnected system of bike lanes, bike paths, and cycle tracks. Providing bicycle infrastructure with markings and signage 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 local or state bike lane width standards.

Would the project expand a network of bikeways or add a single bikeway?	Network of bikeways	user input
Default bicycle mode share in neighborhood/city	#N/A	Alameda CTC model, overridden
User override of bicycle mode share in neighborhood/city	2.6%	user input, optional
Bicycle mode share used for calculation	2.6%	calculated
Default vehicle mode share in neighborhood/city	#N/A	Alameda CTC model, overridden
User override of vehicle mode share in neighborhood/city	85.8%	user input, optional
Vehicle mode share used for calculation	85.8%	calculated
Are any of the current or proposed bikeways in neighborhood/city classified as Class III?		user input — Info on facility types
Existing bikeway miles (only Class I, II, and IV) in neighborhood/city	25.0	user input
Bikeway miles (only Class, I, II, and IV) in neighborhood/city with strategy	50.0	user input
% change in bikeway miles (only Class I, II, and IV)	100%	calculated
Default average one-way bicycle trip length in neighborhood/city (miles)	#N/A	Alameda CTC model, overridden
User override of one-way bicycle trip length in neighborhood/city (miles)	3.0	user input, optional
One-way bicycle trip length used for calculation (miles)	3.0	calculated
Default average one-way vehicle trip length in neighborhood/city (miles)	#N/A	Alameda CTC model, overridden
User override of one-way vehicle trip length in neighborhood/city (miles)	8.5	user input, optional
One-way vehicle trip length in neighborhood/city used for calculation (miles)	8.5	calculated
Elasticity of bike commuters with respect to bikeway miles per 10,000 population	0.25	constant, source (2)
Change in VMT	-0.3%	Exclude from Results — Active

Formula: % Change in VMT = -1*(((Bikeway miles (only Class, I, II, and IV) in neighborhood/city with strategy - Existing bikeway miles (only Class I, II, and IV) in neighborhood/city)/ Existing bikeway miles (only Class I, II, and IV) in neighborhood/city)* Bicycle mode share * One-way bicycle trip length (miles) * Elasticity of bike commuters with respect to bikeway miles per 10,000 population)/(Vehicle mode share * One-way vehicle trip length in neighborhood/city (miles)))

% change in bikeway miles is capped at 1000%.

Sources:

(1) 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.

(2) Pucher, J., 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.

Figure 2. Alameda County VMT calculator, an Excel tool. Addition of 25 miles of bikeway results in a 0.3 percent reduction in VMT.

Land use – residential (density and affordability)

Compact housing can reduce VMT compared to housing that is lower density. Affordable housing produces less VMT compared to market-rate housing. To the extent a project contributes to such housing, it can take credit for the VMT reduction compared to business as usual. Compared to other options, denser, more affordable housing is a powerful VMT-reduction tool.

Factors to consider:

- Density of housing relative to typical or existing
- Affordability of new housing
- Current household VMT
- The level of contribution committed by the mitigation
- Location of the housing project

Ways to measure VMT reduction:

- For projects that provide density, CAPCOA provides an elasticity of -.22. That is, for every percentage increase in density, VMT decreases by -.22 percent. Additionally, there is a starting point; density must by higher than typical in order to qualify as a VMT reducer. CAPCOA sets that starting point at 9.1 units/acre. Lower density developments would not reduce VMT. And CAPCOA caps the reduction at 30 percent. For more details, see CAPCOA, pp. 70-72. Table A-3.1 shows VMT reductions in percentages and per household (assuming typical VMT), for various densities.

Equation 1: Increase Residential Density

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

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from project VMT in study area	0–30.0	%	calculated
User Inputs				
B	Residential density of project development	[]	du/acre	user input
Constants, Assumptions, and Available Defaults				
C	Residential density of typical development	9.1	du/acre	Ewing et al. 2007
D	Elasticity of VMT with respect to residential density	-0.22	unitless	Stevens 2016

See table A-3.1 in Appendix 3 for comprehensive VMT reduction values for increased residential density.

- For projects that include affordable multifamily housing[8], VMT for units dedicated as affordable can be estimated at 28.6 percent reduced from market. For more details, see CAPCOA, pp. 80-83.
- Note that the source material from CAPCOA considers density at the project level. However, if a very large housing project increases density in a larger

[8] CAPCOA defines affordable housing: "Multifamily residential units must be permanently dedicated as affordable for lower income families. The California Department of Housing and Community Development (2021) defines lower income as 80 percent of area median income or below, and affordable housing as costing 30 percent of gross household income or less."

geography, such as a TAZ or Census block group, it would be fair to consider the increase across the full geography, adding a VMT reduction for the existing homes to the calculation for the project itself.

- CAPCOA cautions that "This measure is most accurately quantified when applied to larger developments and/or developments where the density is somewhat similar to the surrounding neighborhood." It is unlikely that a small project would be attractive as mitigation for a highway project. However the second caution is important. A dense housing project in a very disconnected, low-density area will be unlikely to provide the VMT benefits desired. In other words, infill rather than edge development is the goal.
- If a project contributes half of the backing (funding, land, infrastructure, etc.) needed to deliver the housing units that reduce VMT by 10,000 miles/day, it could claim 5,000 miles/day as VMT reduction.
- Caltrans is working to acquire an accessibility tool to help quantify the effect of a project that is located with high destination activity – where residents and visitors can access many destinations with short auto trips, or by other modes. For now, this aspect can be cited directionally, e.g. to add more support to claims of reduced VMT for a dense housing project. See CAPCOA, p. 52.

Examples:

- New density: CAPCOA assumes a typical density of 9.1 dwelling units/acre. Housing provided at greater than 9.1 units/acre can be assessed for VMT reduction as follows: A new project will provide 1,000 housing units at a density of 10 units/acre, a 10 percent increase over BAU. Per the elasticity cited in CAPCOA, we should expect VMT to be reduced by 2.2 percent, or 427 miles annually for a typical household. For 1,000 units, the development will reduce VMT by 427,371 per year.

In addition, the project raises the density of the neighborhood (TAZ, block group or similar geography) by 5 percent, to 9.6 du/acre (above the 9.1 threshold). There are 2,000 existing households in the geography. The 5 percent increase in density equates to 1.2 percent reduction in VMT, or 237 miles/year/household. For 2,000 households, this produces another reduction of 474,857 VMT per year.

- Affordability: For the example above, if a project proposed 1,000 affordable housing units at the standard 9.1 units/acre, it could assume an annual VMT reduction of 5,618 per household based on the 28.6 percent reduction from the typical 19,641.8 per year. Based on this reduction, 1,000 units could claim a reduction of 5,617,555 VMT per year. If the project was also denser than 9.1 units/acre, it could claim both reductions from affordability and density, subject to the rules of combining measures in CAPCOA (discussed on page 6).
- Proportion of impact: Consider the affordability example. The project costs $20 million. Caltrans, in mitigating a highway mitigation project, provides surplus land valued at $3 million, in-kind infrastructure work valued at $4 million, and $3 million in funding, covering half the project cost. Caltrans could claim 2,808,777 annual VMT in mitigation.

Land use – employment (density)

As with residential density, job density can shorten trips and reduce VMT. If a transportation project contributes to development of dense employment facilities, it could claim some VMT reduction as mitigation.

Factors to consider:

- Density of prospective employment center.
- Typical VMT for employment in the area.
- Proportion of backing for the employment center from the mitigation effort.
- Per CAPCOA guidance, this measure is most effectively quantified when used in the context of either a large new development and/or a new development with similar surrounding densities.

Ways to measure impacts:

- CAPCOA (pp. 73-5) provides a density-to-VMT elasticity of -0.07. It sets 145 jobs/acre as a floor for seeing VMT benefits, and a cap of 30 percent on VMT reductions from density. Reductions are shown in Table A-3.2. These must be applied to typical commute VMT for the development, a number that may be developed during the traffic and parking study or may be available from the MPO or other planning entity. Local VMT calculators may also provide estimates. If typical commute VMT is not available, it could be calculated by referring to the ITE Trip Generation Manual and multiply the trips by trip lengths from a big-data tool.

Equation 2: Increase Job Density

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

ID	Variable	Value	Unit	Source
Output				
A	Percent reduction in GHG emissions from project VMT in study area	0–30.0	%	calculated
User Inputs				
B	Job density of project development	[]	jobs per acre	user input
Constants, Assumptions, and Available Defaults				
C	Job density of typical development	145	jobs per acre	ITE 2020
D	Elasticity of VMT with respect to job density	-0.07	unitless	Stevens 2016

See table A-3.2 in Appendix 3 for comprehensive VMT reduction values for increased job density.

- Local VMT calculators may also provide estimates of outcomes from employment density. The Alameda County calculator does so, requiring the user to input location and density information.

<u>Example:</u>

- New job center: In order to mitigate VMT from a transportation project, funds are made available to an office developer that is planning a new activity center. The activity center will cost $20 million, and mitigation supplies $10 million in order to capture half the VMT reduction benefit as mitigation. The facility will house 2,000 workers at 400 employees per acre. From the table, this level of density implies a 12.3 percent reduction in commute VMT compared to typical conditions. A traffic study for the project indicates typical commute VMT in the area is 75 miles per week per employee. The denser development will reduce commuting by 9.2 miles per week for 2,000 workers, or 18,466 per week, or 960,207 per year assuming a 52-week year, for the workforce. Because the project provided half the support to develop the employment center, it can claim 480,103 in reduced annual VMT as mitigation.

Transportation Demand Management (TDM)

Transportation Demand Management (TDM) is a longstanding practice most often aimed at getting workers to their jobs while reducing peak-hour vehicle travel. However, TDM can also be focused on other groups, such as students or tourists, or at a general community level. While TDM was developed as a response to peak-hour congestion, most of the measures commonly employed also tend to reduce VMT. Exceptions, discussed elsewhere in this guide, are telecommuting and schedule-shifting, which have peak-hour benefits but minimal or no VMT benefits. Measures that are more useful to consider include transit and micro-mobility pass discounts, carpool matching and incentives, parking pricing (discussed separately in this guide), bike facilities at workplaces, vanpools, emergency-ride-home service for non-driving employees, education and information on non-SOV travel, and more. "Modernizing Mitigation" (2018) from the State Smart Transportation Initiative, describes VMT-focused TDM in more detail.

Factors to consider:

- SB 743-relevant TDM measures may replace car trips with other modes or by increasing vehicle occupancy in motor vehicle trips (e.g. carpooling). As well, TDM measures could work in tandem with workplace and residential density measures to reduce distances traveled.
- TDM may be supported with capital mitigation funds as new highway capacity opens – resources would need to provide VMT reductions for the project's lifecycle – or it could be funded on an ongoing basis out of tolls from the project itself.
- TDM may be accomplished by requirements from local units of government. The various local VMT calculators in Appendix B are largely aimed at reducing VMT from new development through TDM and other measures. TDM is also offered by Transportation Management Associations (TMA), listed in Appendix A, and by Congestion Management Associations (CMA). TMAs are typically public-private partnerships, or entirely private organizations, frequently formed as voluntary

non-profit organizations by partnering jurisdictions and large employers. CMAs are typically governmental agencies, frequently incorporated under state and federal law by Regional Transportation Planning Agencies as a part of their planning, programming, and service delivery portfolios. Other providers include local governments, employers, college campuses, transit systems (e.g. with free or discounted transit passes), and residential landlords (e.g. with priced parking).

Ways to measure impacts:

- The large number of TDM measures available, combined with variable effects by setting, make it impossible to summarize measurement methods in this short guide. However, TDM providers may be able to calculate VMT effects of their services, based on the CAPCOA guide or similar literature, or their own analysis of their programming. Some of the local VMT calculators capture this effect; the Alameda County calculator calculates effects for employee and residential transit subsidies and vanpools for specific sites. (Note that the calculator does show reductions for telecommuting for employment sites, but it does not address effects other driving, so it would not be useful for VMT mitigation of a highway project.) If a TMA or other entity has ready evidence of program effectiveness, purchasing VMT reduction may be fairly straightforward. In other cases, project teams will have to work with the literature, local VMT calculators, or other sources to estimate VMT effects.

Example:

- Transit-pass subsidies: Consider a highway project that adds HOT lanes. The city through which the highway passes has piloted a mobility wallet program, which provides free passes for transit and bike- and scooter-share. The program costs $50 per participant per month, and surveys of pilot participants showed that on average each reduced their VMT by 50 miles per month while in the program. As part of its mitigation package, the highway project commits toll revenues of

$50,000 per month to support 1,000 users, claiming 50,000 miles of reduced VMT per month.

Transit service improvement

Transit can be an important VMT reduction strategy. Not only may it replace auto trips, but over time it can foster transit-oriented development (TOD), which provides low-VMT housing, employment, retail, and other land uses. TOD may be developed intentionally around transit service, or it may occur organically as land uses adapt with features such as higher densities (accomplished in part by parking reductions), walkability and public-area amenities, and a mixture of land uses in close proximity. Note that even community members who never ride transit will enjoy shorter trips via this effect. VMT reduction though the land use effect is sometimes referred to as a "transit multiplier."

<u>Factors to consider:</u>

- Mitigation should be based on actual transit service improvements. It is not enough to say that congestion reduction on a facility might allow for better service. It would be more compelling to work with a transit provider to determine the actual effect on travel times, headways and potential increased service would result from highway improvements, such as transit-signal priority, lane management and others. Direct support for transit that increases service would, of course, be an even more compelling case for mitigation.

<u>Ways to measure impacts:</u>

- Determining the VMT effect from increased transit service can be done with two calculations:
    - Ridership. For major transit projects, the provider will estimate ridership for New Starts, Small Starts or state capital funding. Such applications could provide the needed estimate, which should be in the form of passenger-miles-traveled. If such an application is not being made, the transit provider would need to make an estimate using similar methods.
    - VMT. Converting ridership into VMT is thoroughly discussed in "An Update on Public Transportation's Impacts on Greenhouse Gas Emissions" (TCRP, 2021). In summary, a passenger-mile on transit directly replaces .329 VMT

(not all transit trips would have been taken by car). Adding the powerful land-use multiplier effect, which reduces travel for transit users and non-users alike, the overall savings in VMT is 2 miles for every 1 passenger-mile.

- Alternatively, local VMT calculators may provide VMT reduction estimates. The Alameda County calculator provides estimates both for transit network expansions and for transit frequency improvements.

Example:

- Lane-management: A freeway expansion includes transit-priority at ramps and lane-management that gives buses markedly improved travel times and reliability[9]. The transit provider is able to improve headways as well, because buses are no longer stuck in traffic. As a result of these improvements, the transit provider estimates a ridership increase of 100,000 passenger-miles per year. With the TCRP formula discussed above, such ridership should reduce VMT by 200,000 per year. If the transit priority and lane-management strategies are committed for the project lifecycle, the 200,000 VMT reduction could be used to offset the VMT increase from the highway project (as part of the project's estimated net VMT or as a mitigation measure).
- Light-rail extension. A transit provider has a planned but unfunded light-rail extension in a corridor where Caltrans is adding an HOV lane, which will be converted to HOT, for $400 million. Capital cost of the transit project is $200 million. The freeway contributes $100 million in mitigation, and the transit provider raises the other $100 million for the project. The transit provider estimates the extension will grow ridership by 2 million passenger-miles per year. Employing the mode-shift factor and transit multiplier from TCRP, this ridership would imply a reduction of 4 million VMT per year. Project mitigation

[9] Bus on Shoulder (BOS) projects are another important type of transit service improvement on state highway facilities.

paid half the capital cost and could claim 2 million VMT in mitigation, assuming it also covers half the ongoing operating cost from toll revenues.

Local road networks/connectivity

Though highways were originally conceived as intercity or rural-serving facilities, today in most places they facilitate mostly local and intraregional travel. The large volume of short-distance traffic is both a problem – it undercuts highways' original purpose, for example by delaying intercity or farm-to-market freight in traffic – and an opportunity. In many cases local travelers use the state highway system (SHS) for short trips because local networks are incomplete or disconnected. Creating better-connected, multimodal networks off the SHS offers options for travelers to make more direct trips, sometimes by non-auto modes, reducing not only VMT but pressures to add expensive highway capacity. The planning literature cites "intersection density" as a measure of connectivity, and one that indicates lower VMT. Assisting owner-operators of local networks could thus reduce the need for highway capacity and mitigation and may provide mitigation opportunities where needed as well.

Factors to consider:

- Origins and destinations of travelers in a corridor or on a facility.
- Gaps and other identified needs in the local modal networks.

Ways to measure impacts:

- Needs and gaps can be demonstrated through the use of big data, to examine origins and destinations of travelers, and circuity of routing. Where travelers are diverting significantly from direct routes, or where they are nearly all driving despite origins and destination that are close by, improvements in the auto and active transportation networks are worth considering. See Figure 5 as an example.
- Accessibility tools can measure gaps in the multimodal systems as well, comparing existing accessibility to ideal accessibility where origins and destinations are linked directly.
- If local network improvements are sufficient to avoid capacity on the SHS, and they are screened as unlikely to induce VMT, mitigation is a moot issue. If new capacity on the SHS is still pursued, local network improvements may be applied

to mitigate some of the resulting induced VMT. Quantification of new active transportation facilities and improved transit service are discussed in a separate section. A more robust street network would likely require analysis with a travel demand model or a similar tool, e.g. Urban Footprint, to demonstrate it was not adding VMT-inducing capacity and to assess VMT reductions from greater connectivity.

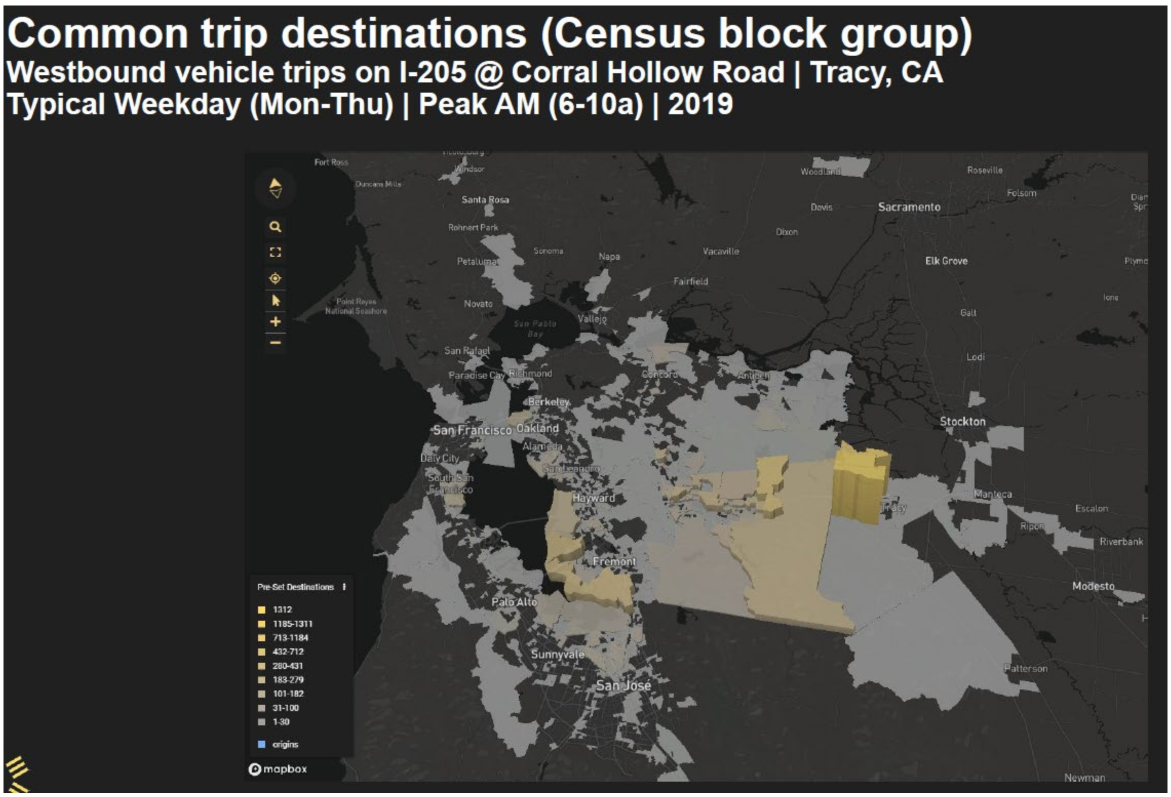


Figure 3. Big data indicates destinations of travelers passing through a select link in Tracy. While some travel long distances, a large number are making local trips, suggesting local network improvements might relieve pressures on the Interstate.

Example:

- Critical added link: A freeway serving a major activity center is experiencing congestion, and widening is under consideration. Some of the heaviest traffic occurs on a bridge connecting the activity center to medium-density neighborhoods and smaller activity centers. There is no nearby surface facility paralleling the freeway bridge, but the locality has been studying such an option, potentially carrying autos, bikes, pedestrians, and extended light-rail service. Origin-destination studies show significant circuitous auto travel in the corridor, which might divert to the more direct route afforded by a new bridge. While the bridge is not screened as categorically unlikely to induce travel, travel-demand analysis suggest it will provide meaningful route-shortening, and a delphi panel determines that as a slow-speed, local-serving surface facility connecting likely infill areas, it is unlikely to induce low-VMT land use. Transit and active transportation provide additional VMT reductions. A decision is made to table the freeway widening and to support the local government in pursuit of the VMT-reducing reliever bridge.

Micro-mobility

Micro-mobility programs can reduce VMT and provide other benefits such as enhanced mobility. However, widescale deployment of micro-mobility programs is ongoing, and the VMT-reducing effects of such programs are not well-understood and vary greatly by context.

Factors to consider:

- For its cost, micro-mobility delivers fewer benefits than other potential mitigations.

Ways to measure impact:

- CARB recommends a simple approach to quantify VMT reductions from Micro-mobility implementation. Using default assumptions on bike and scooter share trip lengths and induced trips, VMT reductions can be derived given an expected number of micro-mobility trips. Equation 3 below can be used to estimate VMT reduction given an expected number of trips.

Equation 3: Implement micro-mobility

$$\boldsymbol{R} = (\boldsymbol{T}) \times (\boldsymbol{A}) \times (\boldsymbol{L})$$

ID	Variable	Value	Unit	Source
Output				
R	Reduction in auto VMT	[]	VMT	calculated
User Inputs				
T	Number of annual trips expected in the first year	[]	trips	user input
Constants, Assumptions, and Available Defaults				
A	Adjustment factor to account for induced trips and recreational bike share use	0.5 (bike and scooter)	unitless	CARB 2019
L	Average length of micro-mobility trip	1.5 (bike), 1 (scooter)	miles	CARB 2019

Examples:

- At mitigation for a large highway widening project, Caltrans funds the rollout and operations of a dock-less bikeshare program for a one-year period in a mid-sized city where the widening will occur. Based on previous dock-less bikeshare rollouts in similar-sized cities, it is expected that approximately 500,000 trips will occur during the first year. Using the assumptions for bikes, the bike-share program is expected to reduce VMT by 375,000 annually, or by 1,027 per day. Since Caltrans funded the program, the full 375,000 annual VMT reduction can be claimed as mitigation for one year.

Telecommuting

Telecommuting is a tool that has been used to reduce peak-hour congestion, and one that has been popular as workplaces shut down during the COVID pandemic. It may appear attractive as a VMT-reduction measure, but caution is warranted.

Factors to consider:

- Telecommuting's effect in reducing VMT is doubtful, and it may actually generate more VMT. CAPCOA (p. 54) cautions that "While this measure [telework] certainly reduces commute-related VMT, recent research has shown that total VMT from telecommuters can exceed VMT from non-telecommuters (Goulias et al. 2020)." Pandemic-era VMT patterns documented in big data suggest "WFH didn't necessarily mean all workers were driving less. Many just may have been driving differently. Our analysis found a shift in peak driving hours, with a dip in morning driving but a slight rise and wider peak time for afternoon driving. Also, essential workers still commuted, and Census data showed a large increase in online retail, which created more delivery vehicle miles." More evidence of telecommuting's poor performance in reducing VMT is here and here.

Ways to measure impacts:

- Measuring reduction in commute VMT is straightforward if motor-vehicle-based commute volumes and distances are known, and the effect of a telecommuting program were also predictable. However, any claim for reduced VMT from telecommuting would need careful, specific support to show how it would address non-work travel, or longer work-travel distances created when workers who frequently telecommute move further from the workplace.

Examples:

- NA

Schedule-shifting

Alternative work schedules, encouraging workers to commute during non-peak hours, is a congestion-reduction strategy, but probably not a VMT-reduction strategy. Some alternative work schedule arrangements eliminate some workdays and thus some work trips. However, the impacts of such a policy may be limited and the removal of work trips doesn't necessarily reduce overall VMT (as discussed in the previous Telecommuting section).

Factors to consider:

- Because it shifts travel times rather than eliminating or shortening them, there is no rationale for considering it as a VMT-reduction measure. Schedule-shifting may actually increase VMT if it allows commuting during periods of faster traffic and/or involves off-peak work travel when transit service is less robust.

Ways to measure impacts:

- NA

Examples:

- NA

Road diets

Caltrans determines VMT impacts by considering highway capacity, essentially as a proxy for reduced travel times that spur additional driving. Because additional lane-miles are a critical factor in calculating increases in VMT, it may be useful to think about lane reductions, aka road diets, as a VMT-reduction measure. Road diets have become popular in recent years, as reduced road widths can improve safety at intersections or along the roadway due to speed reductions, and they can accommodate bike lanes and/or wider sidewalks, as well as parking for local destinations. They are screened as unlikely to induce VMT (TAF, p. 14). Where lane reductions can offset lane additions, the reduction can be used to offset VMT predicted to occur from the additions.

Factors to consider:

- Reducing lanes to offset added lanes can avoid burdens around calculating VMT outcomes. The showing of net-zero lane additions would be sufficient for full mitigation.
- The offsetting reductions must be reasonably equivalent to the lanes being added. A freeway lane-mile could not be offset by reducing a lane-mile on a collector street. In general, induced VMT decreases with functional classification. Therefore, it would be appropriate to cite lane reductions for a facility equal to or higher in functional classification of the facility receiving the additional lanes.
- Any multimodal benefits from the lane reduction such as added bikeways or sidewalks, or safer crossings or operating speeds, should be cited to provide extra evidence for the VMT-reducing effects of the road diet.
- The road diet does not need to be within the project boundaries of the capacity project, or in the same corridor. However, if the widening project adds VMT in a distressed community and the road diet benefits a different community, particularly one that is not distressed, equity would be a policy concern.

Ways to measure impacts:

- Show that lane reductions are equal or greater to lane additions both in terms of length of travel lanes affected and functional classification. Cite multimodal improvements as additional support.
- Where lane reductions do not fully mitigate a project's lane additions, they can be used in combination with other mitigation measures.
- It may be possible to show a mitigation benefit where functional classifications or project types are not easily comparable, e.g. where the road diet on a minor arterial is part of a mitigation package for a freeway addition or for an interchange. As of now there is no simple formula for this instance, and it would require substantial specific analysis by a project team and/or a consultant.

Example:

- Road diet offset: A project to add two lane-miles to a principal arterial in an industrial neighborhood (functional class 3) will generate 500,000 VMT annually. A mile away in a residential/commercial neighborhood, the locality is considering reducing a four-lane principal arterial to two travel lanes, a turn lane, and bike lanes. That project would reduce travel lanes by 2.5 miles. Conditioning the widening project on funding and construction of the road diet would lead to a net reduction of travel lanes and would satisfy the VMT mitigation requirement for the widening project.

Pricing

(Under development)

Pricing literally raises the cost of travel, which would seem to discourage driving and reduce VMT. However, when lanes are priced to improve flows, travelers may find it advantageous to pay the dollar cost in exchange for time-cost savings. In addition, some studies have shown that HOV-to-HOT conversions result in travelers paying to avoid carpooling, lowering vehicle occupancy and raising VMT. Determining when pricing reduces VMT, and by how much, remains under investigation.

Lane management

(Under development)

Lane management strategies vary and with them VMT outcomes. Caltrans guidance, for example, treats the addition of an HOV2+ lane as the equivalent in most cases as the addition of a general-purpose lane, because HOV2s on the facility simply sort themselves into the new lane. HOV3+ holds more promise for raising vehicle occupancy and reducing VMT compared to general purpose lanes. We are investigating ways to quantify outcomes from such strategies.

Parking

Parking management is one of the more powerful measures that either spurs driving or reduces it. Typically, these measures are applied at multifamily residential or employment land uses, in the form of parking charges or capacity limitations. As such, these measures could work in tandem, subject to the rules of combining measures, of denser housing or employment. There could be ways to achieve VMT benefits from parking management outside of specific land uses, though the calculations would be more complex. Note that some localities enforce parking minimums and would require exceptions for major capacity limitations.

Factors to consider:

- Standard parking-demand rates (based on unlimited free parking).
- Type and degree of parking management (extent of capacity limitation, amount of fees).

Ways to measure impacts:

- For capacity limits at residential land uses, CAPCOA calls for calculating the standard parking demand from the "ITE Parking Generation Manual," finding the difference between that figure and the proposed lower figure, and applying constants. The result is a percentage decrease in VMT compared to typical conditions; that percentage could be applied to an average household VMT figure to get the predicted reduction in VMT per household. The reduction is capped at 15.7 percent. An important caveat is that this measure will not work if free parking is readily available on the street or elsewhere near the housing project. For more details, see CAPCOA pp. 122-5.
- For parking charges at residential land uses, CAPCOA provides a formula that only requires the amount of the fee. Results are shown in Table A-3.3, based on the household VMT average from the 2017 NHTS. The percentage reduction would be applied to an average household VMT figure to get the predicted reduction in VMT per household. The reduction is capped at 15.7 percent. For more details, see CAPCOA, pp. 126-9.

Equation 4: Unbundle Residential Parking Costs from Property Cost

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

ID	Variable	Value	Unit	Source
		Output		
A	Percent reduction in GHG emissions from project VMT in study area	0-15.7	%	calculated
		User Inputs		
B	Annual parking cost per space	[]	$ per year	user input
		Constants, Assumptions, and Available Defaults		
C	Average annual vehicle cost	$ 9,282	$ per year	AAA 2019
D	Elasticity of vehicle ownership with respect to total vehicle cost	-0.4	unitless	Litman 2020
E	Adjustment factor from vehicle ownership to VMT	1.01	unitless	FHWA 2017

See table A-3.3 in Appendix 3 for comprehensive VMT reduction values for unbundled parking costs.

- For parking charges at employment land uses, CAPCOA offers a variation on the residential formula. See CAPCOA, pp. 109-112. It produces percentage decreases in commute VMT associated with the land use, which would need to be separately calculated. It caps the reduction at 20 percent.
- Some local VMT calculators provide easy ways to calculate VMT reductions from parking policies. The Alameda County calculator, for example, has options for pricing residential and employee parking, as well as "parking cash-out" (another form of pricing), and for limiting parking supply.

<u>Example:</u>

- Unbundled residential parking: A highway expansion is mitigating induced VMT by supporting a new housing development (see Land Use – residential). The development will produce 1,000 housing units, and the project is providing half the backing to build the project. The development is located in an area where street parking requires residential permits, which are not available to residents of the new buildings. It will charge $200 per month for parking in addition to rent. Per Table 2, the $2,400 annual parking cost implies a reduction of 10.4 percent in VMT, or 2,051.8 in lowered VMT compared to typical households. The development as a whole produces 2,051,800 less VMT than typical in a year. Because mitigation is responsible for half the backing of the project, it amounts to 1,025,900 per year. If the housing is denser than 9.1 units per acre, it could also claim VMT reductions for density, subject to the rules of combining measures in CAPCOA.

Park-and-ride lots

(Under development)

Park-and-ride lots, when serving transit, can be important means of reducing commute travel. If they serve a well-defined activity center, calculating the VMT reduction is straightforward. If they serve carpooling or less-well-defined activity centers, the math becomes more complicated. Moreover, any rebound effects – do park-and-ride lots encourage employees to live further from work, in high VMT neighborhoods – are not clear.

Land preservation

(Under development)

Generally speaking, open space lands in regional hinterlands that are feasible to convert into residential uses, regional service centers, or large-scale, stand-alone employment centers can lead to sprawling development patterns that drive increases in VMT. There are several tools available to acquire and preserve or otherwise enter into agreements that place permanent conservation easements on developable open space and channel future growth toward VMT efficient development patterns. For example, Transfer of Development Rights (TDR) is a zoning technique used to permanently protect land with conservation value (such as farmland, community open space, or other natural or cultural resources) by redirecting development that would otherwise occur on this land (the sending area) to an area planned to accommodate growth and development (the receiving area). TDR programs financially compensate landowners for choosing not to develop some or all of their land. These landowners are given an option under municipal zoning to legally sever the development rights from their land and sell these rights to another landowner or a real estate developer for use at a different location. The land from which the development rights have been severed is permanently protected through a conservation easement or a restrictive covenant. The development value of the land where the transferred development rights are applied is enhanced by allowing for new or special uses; greater density or intensity; or other regulatory flexibility that zoning without the TDR option would not have permitted. Other land use planning tools such as the Density Bonus can also be paired with TDRs as a larger package of incentives intended to help make affordable, location efficient housing more economically enticing to develop. Density bonus tools include reduced parking requirements and concessions such as reduced setback and minimum square footage requirements. And a local government can purchase open space outright.

By establishing partnerships with local land use authorities and interested developers, Districts could engage and influence strategic TDRs and even directly participate in the creation of Development Agreements that steer future development to where it is adequately supported by active transportation, transit, intercity passenger rail, and similar non-auto mobility options. This might be a particularly valuable strategy where there is interest by local or regional governments (or even non-governmental conservation organizations) to employ land preservation strategies or where there is interest by individual developers to swap development rights for locations or increased densities that might be more lucrative or less expensive to develop.

The VMT effect of land preservation will be context-specific. It is even possible to increase VMT by creating more dispersed development. Caltrans is not aware of a simple way to measure the effect.

Appendix A: Congestion Management Authorities and Transportation Management Associations

Two potentially valuable sources of VMT mitigation partnerships are Congestion Management Authorities (CMAs) and Transportation Management Associations (TMAs). CMAs are governmental agencies incorporated under state law that typically provide TDM services as a part of their regional planning, programming, and service delivery portfolios. TMAs are typically private or public-private partnerships, frequently formed as voluntary non-profit organizations involving large employers.

These organizations each provide different services to different user groups in different travel sheds. They also have differing levels of data collection capabilities needed to document VMT reduction for use toward SB 743 mitigation purposes. Practitioners are advised contact the CMAs and TMAs in their areas and proactively participate in data collection and/or program development activities as needed. This could range from simply requesting available data from existing TDM measures to working collaboratively with relevant partners in order to identify expanded TDM services that could specifically serve as VMT mitigation measures for SHS projects. Given that Caltrans will likely not be the primary implementer of most regional TMD strategies, creating strong working relationships and mitigation agreements with CMAs and TMAs could also prove valuable when it comes to the long-term maintenance-of-effort that will likely be needed for them to be successful in reducing VMT.

CMAs

In order to identify a variety of potential mitigation measures for SHS projects, Caltrans practitioners can review relevant planning documents produced by CMAs, such as the Regional Transportation Plan or Short-Range or Long-Range Transit Development Plans. These types of regional planning documents outline specific mobility services, TDM measures, and in-fill development opportunity areas have been planned but are not fully funded and they provide valuable data such as service-specific ridership forecasts that could be used as the basis for estimating related VMT reductions if the services were to be funded as mitigation. Other good sources for identifying potential TDM measures and acquiring important data on potential VMT reduction is active participation on regional Transit Coordinating Committee and Social Services Transportation Advisory Councils, engaging in the annual Unmet Transit Needs Hearing process. In such venues, Caltrans staff may identify pilot services that are being planned for a test period to measure actual ridership against forecast ridership or to determine if farebox recovery requirements can be meet. Transit operators and CMAs may have also developed grant applications for new start or expansion services based on projected ridership. To attract and support this projected ridership, they may also have Transit Asset Management Plans that outline fleet needs, capital investments, or supporting infrastructure such as shelters or modal-transfer stations that could also be used as mitigation.

In essence, the planning processes that CMAs and RTPAs manage can provide valuable data on the potential for specific TDM services to reduce VMT. The most direct way to explore the potential mitigation partnerships and acquire related data is for relevant district staff, including District Transit Representatives, to schedule meetings with their transit operators and CMA counterparts to discuss it with them directly.

Below is a list of regional agencies that Districts can contact regarding information about California's CMAs and their VMT reduction efforts:

Table A-A.1: List of Congestion Management Authorities (CMAs)

Congestion Management Authorities (CMAs)
Alameda County Transportation Commission
City/County Association of Governments of San Mateo County
Contra Costa Transportation Authority
Fresno Council of Governments
Kern Council of Governments
Los Angeles County Metropolitan Transportation Authority
Napa Valley Transportation Authority
Orange County Transportation Authority
Placer County Transportation Planning Agency
Riverside County Transportation Commission
Sacramento Area Council of Governments
San Bernardino County Transportation Authority
San Diego Association of Governments
San Francisco County Transportation Authority
San Joaquin Council of Governments
Santa Barbara County Association of Governments
Santa Clara Valley Transportation Authority
Santa Cruz County Regional Transportation Commission
Shasta County Regional Transportation Planning Agency
Solano Transportation Authority
Sonoma County Transportation Authority
Stanislaus Council of Governments
Transportation Agency for Monterey County
Transportation Authority of Marin
Tulare County Association of Governments
Valley Transportation Authority (VTA)
Ventura County Transportation Commission
Yolo County Transportation District

TMAs

Although TMAs are typically non-governmental organizations and they do not carry out the same comprehensive regional transportation planning functions, they are similar to CMAs in that they may have identified TDM measures that they would like to implement but are not fully funded and could be used as potential mitigation measures. However, one significant difference between TMAs and CMAs that practitioners should be aware of is the differing levels of sophistication and capacity with regard to data collection and analysis. Specifically, while most all TMAs collect data on their service users in terms of "auto-trips avoided," additional data such as user trip lengths may need to calculate VMT reduction.

This is another example of the need for District Transit Representatives or similar staff members to proactively contact potential mitigation partners and discuss available options with them directly. Similar to identifying mitigation options and measuring effectiveness through the regional transit planning process, there are limitation on using existing VMT reduction methodologies based on current research, as TDM efficacy will vary based on context-specific market factors and travel-shed characteristics. Further, Districts will ultimately need to form long range relationships or even programmatic agreements to address and resolve issues such as monitoring, reporting, and maintenance-of-effort (i.e. the mitigation "performance period").

A partial list of TMAs in California is shown below:[10]

[10] https://www.apse.org/wp-content/uploads/docs/TMAs%20-%20National%20Directory.pdf

Table A-A.2: List of Transportation Management Associations (TMAs)

Transportation Management Associations (TMAs)	Location
50 Corridor Transportation Management Association	Sacramento
Altrans TMA	San Jose
Anaheim Transportation Network	Anaheim
Burbank Transportation Management Organization	Burbank
City of Santa Monica Transportation Management Association	Santa Monica
Emeryville Transportation Management Association	Emeryville
Glendale Transportation Management Association	Glendale
Hacienda Business Park	Pleasanton
McClellan Park TMA	McClellan
Moffett Park & Business Transportation Association	Sunnyvale
North Natomas TMA	Sacramento
Pajaro Valley TMA	Watsonville
Placer County Transportation Management Association	Auburn
Point West Area TMA	Sacramento
Ride-on TMA	San Luis Obispo
Sacramento TMA	Sacramento
San Francisco International Airport Commission	San Francisco
South Natomos TMA	Sacramento
Spectrumotion TMA	Irvine
The Presidio Trust	San Francisco
TMA of San Francisco	San Francisco
Traffic Solutions	Santa Barbara
Truckee North Lake Tahoe TMS	Truckee
Warner Center TMO	Woodland Hills
Yolo TMA	Woodland

A comprehensive list of local/regional transit operators, specialized transportation service providers, and Consolidated Transportation Services Agencies that has been assembled by the American Public Transportation Association can be found here.

For further information on opportunities to connect with mobility service providers, Districts can contact the California Association for Coordinated Transportation, or CalAct.

Appendix B: Local VMT calculators

Performance Assessment Tools and VMT Calculators: Several local planning jurisdictions and regional planning agencies such as SACOG have launched performance assessment tools to analyze anticipated outcomes from transportation investments at the project level. The goal of the Project Performance Assessment tool is to align with federal and state emphasis on outcome-based performance measurement and to prioritize cost-effective transportation projects with desired performance benefits, such as increased travel reliability and reducing VMT per capita. In light of the fact that these tools typically result from extensive development and data-collection efforts, development reports may be valuable references to cite the methodologies used, explain the variable considered, understand how to add user inputs, and how to extract VMT reduction figures from the tool's indicators output table. Caltrans practitioners are encouraged to contact their RTPA/MPO counterparts to identify the availability of any such tools for their collective use. For example, Appendix 3 of the tool's Development report, Supplemental Indicator Methodology, gives a detailed technical description of several complex data sources and indicators. Given that potential mitigation measures are similar in many respects to planned mobility improvements, performance indicators from these types of tools can be applied to assess their impact on VMT reduction. For VMT, the SACOG tool looks at the number of transit trips and average vehicle occupancy that a freeway project would add, the number of jobs and dwelling units, mixed uses, and neighborhood services that a complete-street project would provide access to, and the change in jobs, dwelling unit, mixed uses and neighborhood services that a transit or local network expansion would result in.

Similarly the City of Los Angeles Department of Transportation Vehicle Miles Traveled (VMT) Calculator uses an MXD methodology and was originally developed by the U.S. Environmental Protection Agency to better estimate trip generation in urban areas considering a number of factors including the relative numbers of residents and jobs, the density of development, the connectivity for walking or driving among different activities, the availability of transit, the number of convenient trip destinations within the immediate area, vehicle ownership, and household size. The calculator's assumptions were validated and are explained in the calculator's development report for practitioners to cite in their analysis on the potential VMT reductions available from 22 different types of TDM site modifications, system improvements, and operational changes. The calculator follows CAPCOA guidance by either directly applying the CAPCOA methodology, applying the alternative literature methodology, or adjusting the methodology offered by CAPCOA to account for local needs. A methodology is specified for each TDM strategy, with individual levels of anticipated effectiveness identified. The calculator uses four place-types, or travel behavior zones, (Urban, Compact Infill, Suburban Center, and Suburban) and allows TDM strategies to be combined with a maximum VMT reduction result of 75% for measures in urban locations, 40% compact infill locations, 20% for suburban center locations, and 15% for suburban locations.

The calculator's TDM measures and maximum VMT reduction rates are show below and specific methodologies are provided here:

1. Reduce Parking Supply: 12.5%
2. Unbundle Parking: 26% of residential-based VMT
3. Parking Cash-Out: 7.7% of commute VMT
4. Price Workplace Parking: 19.7% of commute VMT
5. Residential Area Parking Permits: 0.25%
6. Reduce Transit Headways: 2.5%
7. Implement Neighborhood Shuttle: 13.4%
8. Transit Subsidies: 20%
9. Voluntary Travel Behavior Change Program: 8%
10. Promotions & Marketing: 4%

11. Required Commute Trip Reduction Program: 21% of commute VMT
12. Alternative Work Schedules and Telecommute Program: 5.5% of commute VMT
13. Employer Sponsored Vanpool or Shuttle: 13.4% of commute VMT
14. Ride Share Program: 15% of commute VMT
15. Car Share: 0.7%
16. Bike Share: 0.25%
17. School Carpool Program: 15.8% of school VMT, or 0.9% of overall VMT
18. Implement/Improve On-Street Bicycle Facility: 0.625%
19. Include Bike Parking: 0.625%
20. Include Secure Bike Parking and Showers: 0.625%
21. Traffic Calming Improvements: 1%
22. Pedestrian Network Improvements: 2%

A variety of similar VMT calculators have been developed for local and regional agencies across the state that Districts could explore for mitigation purposes. The following are among other VMT calculators and TDM assessment tools that have been developed by some of Caltrans external partners:

- Fresno Council of Governments
  - https://www.fresnocog.org/project/vmt-tool/
- San Gabriel Valley Council of Governments
  - https://www.sgvcog.org/vmt-analysis-tool
- Valley Transportation Authority
  - https://www.vta.org/projects/level-service-los-vehicle-miles-traveled-vmt-transition
- County of Santa Barbara
  - https://www.countyofsb.org/plndev/projects/SB743.sbc
- City of San Jose
  - https://www.sanjoseca.gov/your-government/departments-offices/transportation/planning-policies/vehicle-miles-traveled-metric

- San Diego Association of Governments
  - https://www.icommutesd.com/planners/tdm-local-governments
- San Diego Association of Governments
  - https://www.sandag.org/index.asp?classid=13&subclassid=97&projectid=592&fuseaction=projects.detail
- Alameda County Transportation Commission
  - AlamedaCTC_VMT_Final_Tool_20210826.xlsx (live.com)

Further, some local jurisdictions have already completed updates to their local impact assessment guidelines that include specific methodologies for estimating VMT reductions from various TDM mitigation measures that Caltrans District staff could adapt for use on transportation projects. For example, below are just a few examples from across the state that District staff could refer to:

- See Appendix H of the Escondido Transportation Impact Analysis Guidelines : https://www.escondido.org/Data/Sites/1/media/Engineering/TIACRAIG/EscondidoTransportationImpactAnalysisGuidelines2021.pdf
- See Appendix H of the City of Long Beach Transportation Impact Analysis Guidelines:

  https://www.longbeach.gov/globalassets/city-manager/media-library/documents/memos-to-the-mayor-tabbed-file-list-folders/2020/june-30--2020---vehicle-miles-traveled--vmt--standards-for-development-review

- See Appendices A-C of the City of Fremont's Transportation Impact Analysis Handbook:

  https://www.fremont.gov/DocumentCenter/View/48317/TIA-Handbook_Final_June2020?bidId=

- See Appendix C of the City of Carlsbad's VMT Analysis Guidelines: https://www.carlsbadca.gov/home/showpublisheddocument/312/637425981341500000

Appendix C: VMT Reduction Tables for Select Mitigation Measures

Table A-C.1: VMT effects from dense residential development following the CACOA formula. Household figures assume an adjusted typical household annual VMT of 19,641.8, from the [2017 NHTS](#).

Density (DU/acre)	Change in VMT from typical	Change in annual VMT for typical household
9.1	0.0%	0.00
9.2	-0.2%	-47.49
9.3	-0.5%	-94.97
9.4	-0.7%	-142.46
9.5	-1.0%	-189.94
9.6	-1.2%	-237.43
9.7	-1.5%	-284.91
9.8	-1.7%	-332.40
9.9	-1.9%	-379.89
10.0	-2.2%	-427.37
10.1	-2.4%	-474.86
10.2	-2.7%	-522.34
10.3	-2.9%	-569.83
10.4	-3.1%	-617.31
10.5	-3.4%	-664.80
10.6	-3.6%	-712.29
10.7	-3.9%	-759.77
10.8	-4.1%	-807.26
10.9	-4.4%	-854.74
11.0	-4.6%	-902.23
11.1	-4.8%	-949.71
11.2	-5.1%	-997.20
11.3	-5.3%	-1,044.68
11.4	-5.6%	-1,092.17
11.5	-5.8%	-1,139.66
11.6	-6.0%	-1,187.14
11.7	-6.3%	-1,234.63

Density (DU/acre)	Change in VMT from typical	Change in annual VMT for typical household
11.8	-6.5%	-1,282.11
11.9	-6.8%	-1,329.60
12.0	-7.0%	-1,377.08
12.1	-7.3%	-1,424.57
12.2	-7.5%	-1,472.06
12.3	-7.7%	-1,519.54
12.4	-8.0%	-1,567.03
12.5	-8.2%	-1,614.51
12.6	-8.5%	-1,662.00
12.7	-8.7%	-1,709.48
12.8	-8.9%	-1,756.97
12.9	-9.2%	-1,804.46
13.0	-9.4%	-1,851.94
13.1	-9.7%	-1,899.43
13.2	-9.9%	-1,946.91
13.3	-10.2%	-1,994.40
13.4	-10.4%	-2,041.88
13.5	-10.6%	-2,089.37
13.6	-10.9%	-2,136.86
13.7	-11.1%	-2,184.34
13.8	-11.4%	-2,231.83
13.9	-11.6%	-2,279.31
14.0	-11.8%	-2,326.80
14.1	-12.1%	-2,374.28
14.2	-12.3%	-2,421.77
14.3	-12.6%	-2,469.25
14.4	-12.8%	-2,516.74
14.5	-13.1%	-2,564.23
14.6	-13.3%	-2,611.71
14.7	-13.5%	-2,659.20
14.8	-13.8%	-2,706.68
14.9	-14.0%	-2,754.17
15.0	-14.3%	-2,801.65
15.1	-14.5%	-2,849.14
15.2	-14.7%	-2,896.63

Density (DU/acre)	Change in VMT from typical	Change in annual VMT for typical household
15.3	-15.0%	-2,944.11
15.4	-15.2%	-2,991.60
15.5	-15.5%	-3,039.08
15.6	-15.7%	-3,086.57
15.7	-16.0%	-3,134.05
15.8	-16.2%	-3,181.54
15.9	-16.4%	-3,229.03
16.0	-16.7%	-3,276.51
16.1	-16.9%	-3,324.00
16.2	-17.2%	-3,371.48
16.3	-17.4%	-3,418.97
16.4	-17.6%	-3,466.45
16.5	-17.9%	-3,513.94
16.6	-18.1%	-3,561.43
16.7	-18.4%	-3,608.91
16.8	-18.6%	-3,656.40
16.9	-18.9%	-3,703.88
17.0	-19.1%	-3,751.37
17.1	-19.3%	-3,798.85
17.2	-19.6%	-3,846.34
17.3	-19.8%	-3,893.82
17.4	-20.1%	-3,941.31
17.5	-20.3%	-3,988.80
17.6	-20.5%	-4,036.28
17.7	-20.8%	-4,083.77
17.8	-21.0%	-4,131.25
17.9	-21.3%	-4,178.74
18.0	-21.5%	-4,226.22
18.1	-21.8%	-4,273.71
18.2	-22.0%	-4,321.20
18.3	-22.2%	-4,368.68
18.4	-22.5%	-4,416.17
18.5	-22.7%	-4,463.65
18.6	-23.0%	-4,511.14
18.7	-23.2%	-4,558.62

Density (DU/acre)	Change in VMT from typical	Change in annual VMT for typical household
18.8	-23.5%	-4,606.11
18.9	-23.7%	-4,653.60
19.0	-23.9%	-4,701.08
19.1	-24.2%	-4,748.57
19.2	-24.4%	-4,796.05
19.3	-24.7%	-4,843.54
19.4	-24.9%	-4,891.02
19.5	-25.1%	-4,938.51
19.6	-25.4%	-4,986.00
19.7	-25.6%	-5,033.48
19.8	-25.9%	-5,080.97
19.9	-26.1%	-5,128.45
20.0	-26.4%	-5,175.94
20.1	-26.6%	-5,223.42
20.2	-26.8%	-5,270.91
20.3	-27.1%	-5,318.40
20.4	-27.3%	-5,365.88
20.5	-27.6%	-5,413.37
20.6	-27.8%	-5,460.85
20.7	-28.0%	-5,508.34
20.8	-28.3%	-5,555.82
20.9	-28.5%	-5,603.31
21.0	-28.8%	-5,650.79
21.1	-29.0%	-5,698.28
21.2	-29.3%	-5,745.77
21.3	-29.5%	-5,793.25
21.4	-29.7%	-5,840.74
21.5	-30.0%	-5,888.22

Table A-C.2: VMT reductions from increased job density, following the formula in CAPCOA.

Density (jobs per acre)	Percent VMT reduction from typical
145	0.0%
150	-0.2%
155	-0.5%
160	-0.7%
165	-1.0%
170	-1.2%
175	-1.4%
180	-1.7%
185	-1.9%
190	-2.2%
195	-2.4%
200	-2.7%
205	-2.9%
210	-3.1%
215	-3.4%
220	-3.6%
225	-3.9%
230	-4.1%
235	-4.3%
240	-4.6%
245	-4.8%
250	-5.1%
255	-5.3%
260	-5.6%
265	-5.8%
270	-6.0%
275	-6.3%
280	-6.5%
285	-6.8%
290	-7.0%
295	-7.2%
300	-7.5%
305	-7.7%

Density (jobs per acre)	Percent VMT reduction from typical
310	-8.0%
315	-8.2%
320	-8.4%
325	-8.7%
330	-8.9%
335	-9.2%
340	-9.4%
345	-9.7%
350	-9.9%
355	-10.1%
360	-10.4%
365	-10.6%
370	-10.9%
375	-11.1%
380	-11.3%
385	-11.6%
390	-11.8%
395	-12.1%
400	-12.3%
405	-12.6%
410	-12.8%
415	-13.0%
420	-13.3%
425	-13.5%
430	-13.8%
435	-14.0%
440	-14.2%
445	-14.5%
450	-14.7%
455	-15.0%
460	-15.2%
465	-15.4%
470	-15.7%
475	-15.9%
480	-16.2%

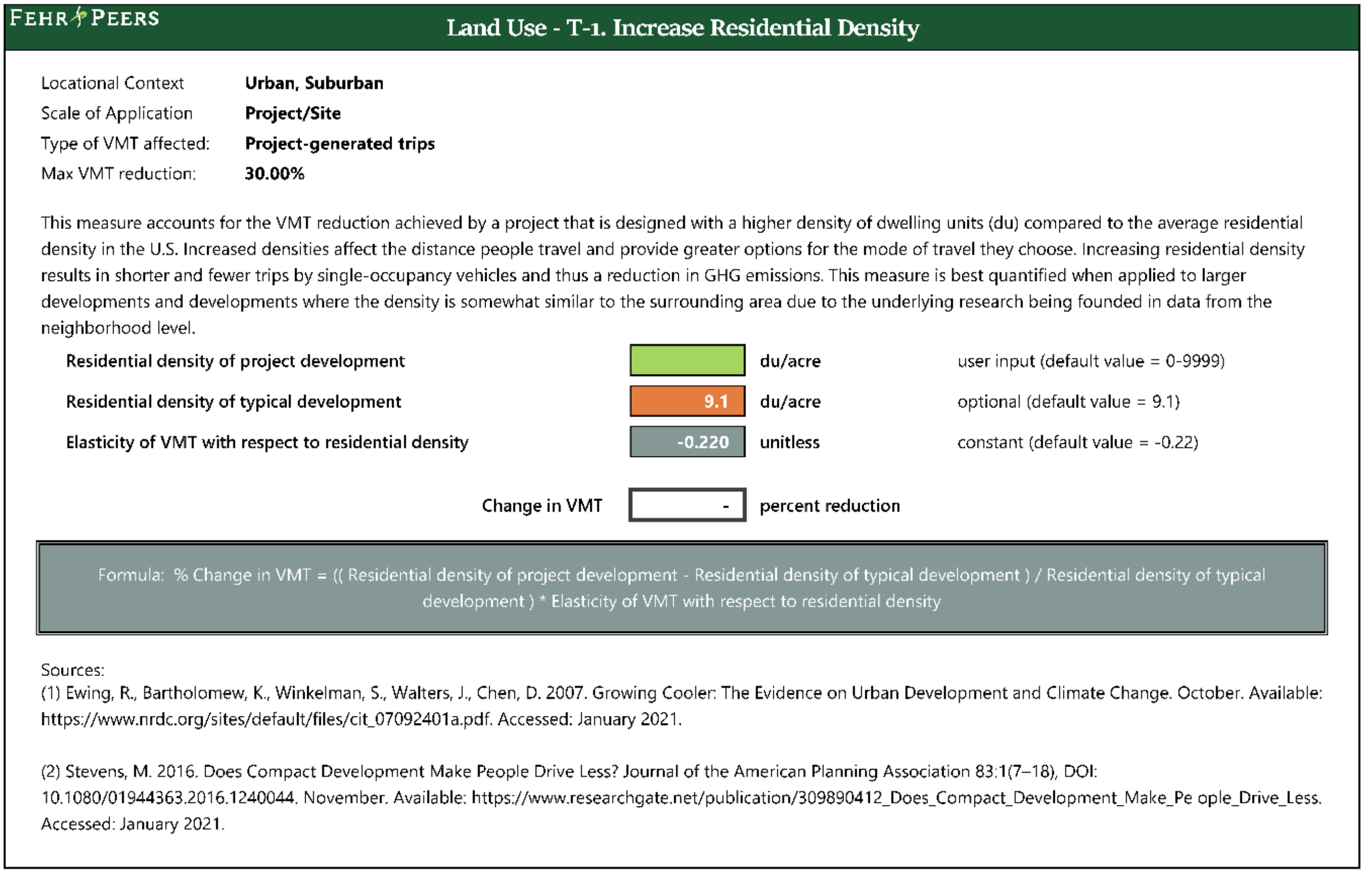
Density (jobs per acre)	Percent VMT reduction from typical
485	-16.4%
490	-16.7%
495	-16.9%
500	-17.1%
505	-17.4%
510	-17.6%
515	-17.9%
520	-18.1%
525	-18.3%
530	-18.6%
535	-18.8%
540	-19.1%
545	-19.3%
550	-19.6%
555	-19.8%
560	-20.0%
565	-20.3%
570	-20.5%
575	-20.8%
580	-21.0%
585	-21.2%
590	-21.5%
595	-21.7%
600	-22.0%
605	-22.2%
610	-22.4%
615	-22.7%
620	-22.9%
625	-23.2%
630	-23.4%
635	-23.7%
640	-23.9%
645	-24.1%
650	-24.4%
655	-24.6%

Density (jobs per acre)	Percent VMT reduction from typical
660	-24.9%
665	-25.1%
670	-25.3%
675	-25.6%
680	-25.8%
685	-26.1%
690	-26.3%
695	-26.6%
700	-26.8%
705	-27.0%
710	-27.3%
715	-27.5%
720	-27.8%
725	-28.0%
730	-28.2%
735	-28.5%
740	-28.7%
745	-29.0%
750	-29.2%
755	-29.4%
760	-29.7%
765	-29.9%

Table A-C.3. Calculated values for VMT reduction from CAPCOA formula.

Annual parking price	% VMT change	Absolute VMT change per household
$200	-0.9%	-171.0
$300	-1.3%	-256.5
$400	-1.7%	-342.0
$500	-2.2%	-427.5
$600	-2.6%	-512.9
$700	-3.0%	-598.4
$800	-3.5%	-683.9
$900	-3.9%	-769.4
$1,000	-4.4%	-854.9
$1,100	-4.8%	-940.4
$1,200	-5.2%	-1,025.9
$1,300	-5.7%	-1,111.4
$1,400	-6.1%	-1,196.9
$1,500	-6.5%	-1,282.4
$1,600	-7.0%	-1,367.9
$1,700	-7.4%	-1,453.3
$1,800	-7.8%	-1,538.8
$1,900	-8.3%	-1,624.3
$2,000	-8.7%	-1,709.8
$2,100	-9.1%	-1,795.3
$2,200	-9.6%	-1,880.8
$2,300	-10.0%	-1,966.3
$2,400	-10.4%	-2,051.8
$2,500	-10.9%	-2,137.3
$2,600	-11.3%	-2,222.8
$2,700	-11.8%	-2,308.3
$2,800	-12.2%	-2,393.8
$2,900	-12.6%	-2,479.2
$3,000	-13.1%	-2,564.7
$3,100	-13.5%	-2,650.2
$3,200	-13.9%	-2,735.7
$3,300	-14.4%	-2,821.2
$3,400	-14.8%	-2,906.7
$3,500	-15.2%	-2,992.2

Appendix D: TDM+ VMT Reduction Quantification Tool



FEHR & PEERS

Land Use - T-1. Increase Residential Density

Locational Context	**Urban, Suburban**
Scale of Application	**Project/Site**
Type of VMT affected:	**Project-generated trips**
Max VMT reduction:	**30.00%**

This measure accounts for the VMT reduction achieved by a project that is designed with a higher density of dwelling units (du) compared to the average residential density in the U.S. Increased densities affect the distance people travel and provide greater options for the mode of travel they choose. Increasing residential density results in shorter and fewer trips by single-occupancy vehicles and thus a reduction in GHG emissions. This measure is best quantified when applied to larger developments and developments where the density is somewhat similar to the surrounding area due to the underlying research being founded in data from the neighborhood level.

Residential density of project development		**du/acre**	user input (default value = 0-9999)
Residential density of typical development	9.1	**du/acre**	optional (default value = 9.1)
Elasticity of VMT with respect to residential density	-0.220	**unitless**	constant (default value = -0.22)

Change in VMT | - | **percent reduction**

Formula: % Change in VMT = ((Residential density of project development - Residential density of typical development) / Residential density of typical development) * Elasticity of VMT with respect to residential density

Sources:

(1) Ewing, R., Bartholomew, K., Winkelman, S., Walters, J., Chen, D. 2007. Growing Cooler: The Evidence on Urban Development and Climate Change. October. Available: https://www.nrdc.org/sites/default/files/cit_07092401a.pdf. Accessed: January 2021.

(2) Stevens, M. 2016. Does Compact Development Make People Drive Less? Journal of the American Planning Association 83:1(7–18), DOI: 10.1080/01944363.2016.1240044. November. Available: https://www.researchgate.net/publication/309890412_Does_Compact_Development_Make_Pe ople_Drive_Less. Accessed: January 2021.

Figure 4. TDM+ Excel tool interface.

The TDM+ tool is a spreadsheet-based tool that calculates VMT reductions based on strategies presented in the 2021 CAPCOA handbook. Many of the strategies discussed in this playbook are included in the tool, which provides a simple interface to input project information and perform analysis.

Detailed instructions on how to use the tool are provided on the "START HERE" tab. Basic input data is required such as the mitigation type, geographic location and place type, and amount of mitigation being provided. The tool can automatically detect conflicting measures and flags them on the 'Conflicts' tab. For measures that can be combined (discussed earlier in this playbook on page 6), the tool automatically applies multiplicative dampening to make these adjustments.

The "Results" tab shows the combined VMT reduction (as a percentage) by the strategy type. For example, VMT reduction is reported for 'Land Use: Project Site', which includes four strategies within it. With this information, the analyst can apply these percent reductions (once conflicts have been resolved) to a VMT estimate to estimate a VMT reduction in absolute terms.

This tool is currently a beta, and only includes six core-based statistical areas as available parameters. Future iterations of the tool will include expanded drop-down options. For each mitigation strategy, orange cells indicate default values, sometimes based on the selected core-based statistical area. These default values can be overridden if more accurate data is available. The TDM+ tool can be accessed here.