TECHNICAL EVALUATION OF THE GREENHOUSE GAS EMISSION REDUCTION QUANTIFICATION FOR THE SACRAMENTO AREA COUNCIL OF GOVERNMENTS' SB 375 SUSTAINABLE COMMUNITIES STRATEGY

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California Environmental Protection Agency
Air Resources Board

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EXECUTIVE SUMMARY

The Sustainable Communities and Climate Protection Act of 2008 (SB 375) calls for the California Air Resources Board (ARB or Board) to accept or reject the determination of each metropolitan planning organization (MPO), that their Sustainable Communities Strategy (SCS) would, if implemented, achieve the greenhouse gas (GHG) emission reduction targets for 2020 and 2035, set by the Board in 2010.

On April 19, 2012, the Sacramento Area Council of Governments (SACOG) adopted a Metropolitan Transportation Plan/Sustainable Communities Strategy for 2035 (MTP/SCS), which includes the region's first SCS.

This technical report supports ARB's action on SACOG's MTP/SCS. It describes both the method used to review SACOG's SCS GHG quantification and the results of the technical evaluation.

The results ARB staff's technical review were presented to the Board at a public meeting on March 22, 2012, and were based on review of SACOG's draft MTP/SCS published in November 2011. The MTP/SCS that SACOG adopted in April 2012 contains minor modifications. However, these modifications do not affect the plan's greenhouse gas reduction results.

This report documents ARB staff's technical review of the draft plan together with its subsequent review of the adopted MTP/SCS, as modified. This review affirms that SACOG's adopted SCS demonstrates that, if implemented, the region will achieve a 9 percent per capita greenhouse gas reduction in 2020, and a 16 percent reduction in 2035. These reductions meet the targets established for SACOG of 7 percent and 16 percent GHG per capita reduction from 2005 for the years 2020 and 2035, respectively.

I. TRANSPORTATION PLANNING IN THE SACRAMENTO REGION

The Sacramento Area Council of Governments (SACOG) adopted its long-range regional transportation plan (RTP), known as the Metropolitan Transportation Plan/Sustainable Communities Strategy for 2035 (MTP/SCS), on April 19, 2012. While it is the region's first MTP to be prepared under Senate Bill 375 (SB 375), it is the region's second long-range transportation plan to integrate land use strategies with future transportation investments.

This chapter provides an overview of the Sacramento region's transportation planning context, and summarizes the major policies and planning initiatives that have influenced development of SACOG's MTP/SCS plan.

A. Sacramento Area Council of Governments (SACOG)

SACOG is a voluntary association of Sacramento area governments formed by the region's six counties: El Dorado, Placer, Sacramento, Sutter, Yolo, and Yuba, as well as the 22 cities within them.[1] The agency delivers a variety of federal, State, and local programs to its member local governments and serves as a forum for the study and resolution of regional issues. Some of its key work efforts include regional forecasting and monitoring, the Regional Housing Needs Assessment, and coordination of land use, transportation, and air quality plans and programs.

Under federal transportation law, SACOG is the designated Metropolitan Planning Organization (MPO) for the six-county Sacramento region. In this capacity, SACOG's Board of Directors serve as the transportation policy-making body that is responsible for developing the RTP every four years.

Under State regional transportation planning law, the Sacramento region is represented by three regional transportation planning agencies (RTPAs): SACOG is responsible for four of the region's counties (Sacramento, Sutter, Yolo, and Yuba counties), while the El Dorado County Transportation Commission and the Placer County Transportation Planning Agency serve El Dorado and Placer counties, respectively. In their capacities as RTPAs, each agency is responsible for adopting and implementing an RTP for their respective counties, overseeing some planning, programming, and administrative functions related to transportation projects, and coordinating directly with local agencies in their portion of the region. Under memoranda of understanding with the other RTPAs, SACOG has responsibility for incorporating each agency's transportation planning into one RTP.

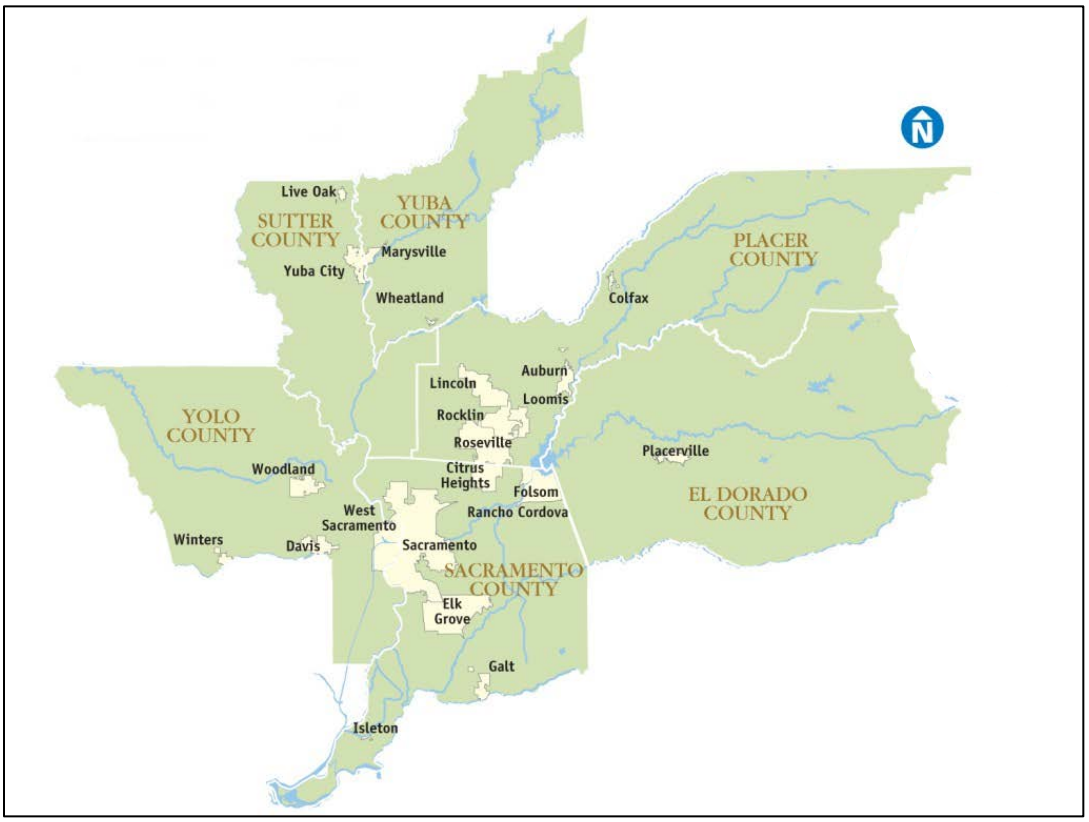
[1] Excluding the Tahoe Basin.

With passage of SB 375 into law in 2008, SACOG's RTPs must now include a Sustainable Communities Strategy (SCS). The purpose of the SCS is to demonstrate how the SACOG region would reduce greenhouse gas (GHG) emissions from automobiles and light trucks in accordance with targets set by the California Air Resources Board (ARB or Board).

Planning Area

The regional planning area covered by SACOG is shown in Figure 1. The area spans a diverse geography, which includes productive agricultural lands, urban and foothill communities, as well as sparsely populated forest lands of the western Sierra Nevada.

Figure 1. SACOG regional planning area

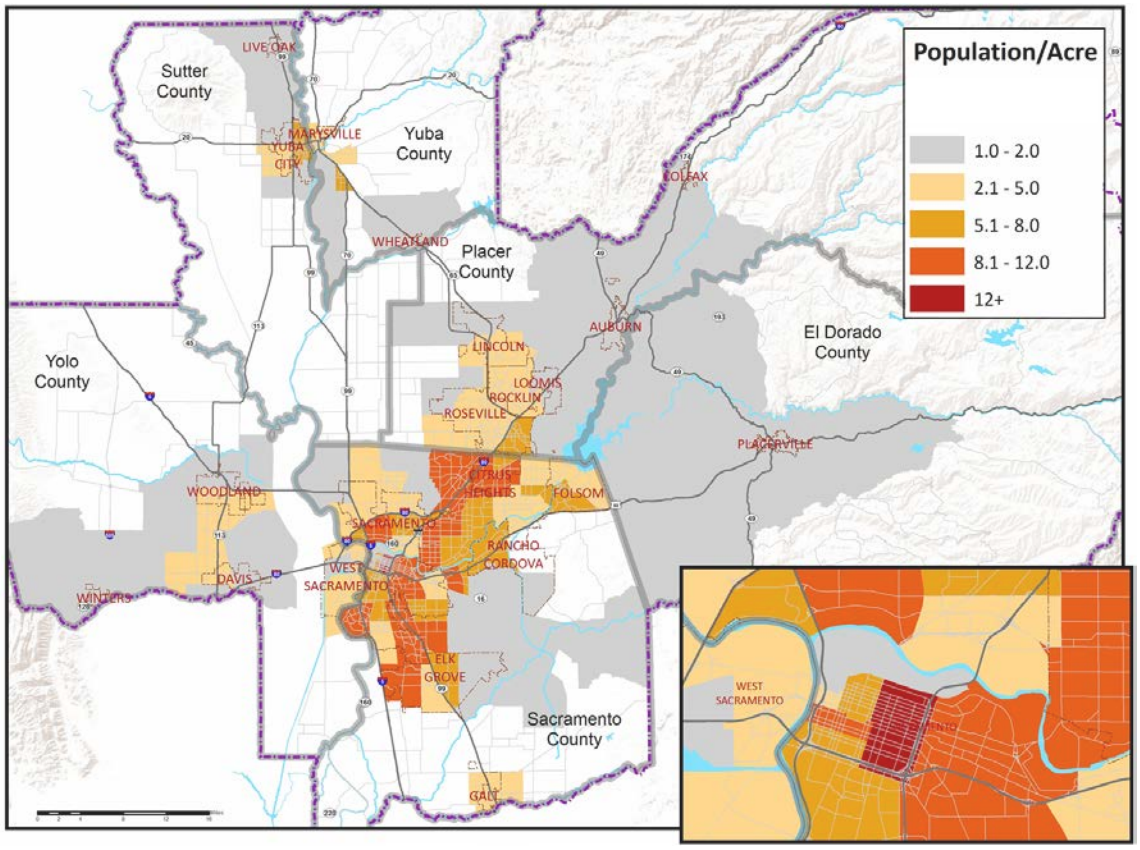


The current urbanized areas of the region, with the largest shares of the population, housing, and employment, are located primarily within the counties of Sacramento, Placer, and Yolo.

Figure 2 illustrates the population centers within SACOG's planning area in 2008. Today, the region houses approximately 2.3 million people. Sacramento County sits at the geographic center of the region and includes some of the region's

most urbanized land uses, and about 60% of the region's population. Placer and Yolo counties contain some medium-to-high density development, as well as rural and agricultural lands. The remaining areas of the region, covered by Sutter, Yuba, and El Dorado counties are home to about 14 percent of the region's population, and predominantly characterized by rural and agricultural land uses.

Figure 2. Sacramento area population centers (2008)



Regional Transportation Network

The current transportation system serving the SACOG planning area is multimodal, including an interconnected system of roads, transit, rail, and non-motorized facilities and infrastructure.

Currently, the region's roadway system consists of nearly 4,800 lane miles of existing collector and local streets, over 2,000 lane miles of freeway, high-occupancy vehicle, auxiliary lanes, expressways, and arterials, and numerous small and large bridges. Major regional roadway facilities serving the plan area include Interstates 5 and 80, US Highway 50 and State Route 99. Interstate 5 is the largest of the major regional facilities in the area, running from north to south

through the western portion of the region. State Route 99 is the second largest regional facility in the plan area. It passes through the central portion of the region through Sacramento and Sutter counties, connecting to a number of the state's urbanized and agricultural areas, making it an important commercial corridor in the Central Valley.

The region's public transit system encompasses a wide array of services, including urban light rail and bus service, suburban and rural local and commuter bus service, rural lifeline services, and dial-a-ride/paratransit services. Local public transit service in the region is currently provided by 13 public operators and two private non-profit agencies. These operators range from very large systems, such as the Sacramento Regional Transit District that operates over 200 buses, 90 light-rail cars and 40 miles of track, to very small systems with fleets of five or fewer vehicles. In addition, the region also has access to interregional rail and bus services through Amtrak, the Capitol Corridor Joint Powers Authority, and Greyhound. These services facilitate longer distance trips into and out of the region to destinations such as the Bay Area, Bakersfield, and beyond.

Non-motorized transportation facilities in the region include bicycle routes, walkways, and associated infrastructure. Of the over 1,400 miles of bicycle routes in the region, 56 percent are located in urban areas, with the rest located outside of urbanized boundaries in small urban or rural areas. With regard to walkways, about 40 to 50 percent of existing roads in the region's urbanized area have sidewalks. These bicycle and pedestrian facilities are often built by local agencies as part of other capital projects. Developers, in cooperation with cities and counties, are expected to fully fund bicycle and pedestrian facilities in new developments.

In addition, SACOG has run a bicycle and pedestrian funding program since September 2003. Specific investments for this program are identified in the Regional Bicycle, Pedestrian, and Trails Master Plan, which was recently amended and adopted in June 2011. This plan represents the efforts of SACOG staff, the Regional Bicycle and Pedestrian Advisory Committee, local public agencies, and advocacy groups in the Sacramento region, and is focused on utilitarian trips and improving the region's connectivity with these modes, especially in their connections to the regional transit system.

Several agencies are responsible for planning, programming, and administrative functions related to transportation projects and transportation services in the region. In addition to the region's three RTPAs, the region's transportation network is influenced by decisions of local and regional transportation authorities, as well as adopted local agency general plans, which typically address roadway operating standards, public transit, bicycle, and pedestrian facilities.

B. Policies, Laws, and Initiatives Influencing the Regional Planning Area

In updating the region's long-range regional transportation plan, SACOG works to accommodate various related policies, laws, and initiatives at the federal, State, and local levels. A brief summary of the major planning initiatives, laws, and local plans influencing the MTP update follows.

Blueprint Growth Strategy

The Blueprint Growth Strategy is a SACOG Board-adopted, voluntary growth strategy that the region's 28 local jurisdictions are actively encouraged to use as they make local land use decisions. The strategy was created through a two-year scenario planning process that began in 2002. The process was originally initiated by SACOG's Board of Directors to explore use of growth management strategies for helping to address the region's congestion and air quality challenges.

The process for developing the Blueprint was based on two basic strategies: 1) making scientific, objective information available about the cause-and-effect relationships among land use patterns, travel behavior, and external effects such as air quality; and 2) engaging a broad base of stakeholders with this information and seeking their opinions about how to shape future growth in the region's neighborhoods and communities. Much of the analysis and public discussion during the Blueprint process focused on preferred types of housing stock, as well as the perceived impacts of integrating, rather than segregating, different kinds of land uses (e.g., locating housing near job centers, schools, shopping, and recreation).

To support this process, SACOG built several project modeling and analysis tools, and assembled the first parcel-level Geographic Information System database for the region. The analysis resulting from this process demonstrated that when paired with supportive transportation investments, new land use patterns would significantly reduce the length of automobile trips, increase alternative mode trips, reduce conversion of agricultural and sensitive lands to urban development, and create fewer air pollution emissions than historical growth patterns.

Based on thie information, SACOG's Board of Directors adopted a Blueprint map that showed an alternative to historic growth patterns, and identified areas for future housing and employment growth in the region through 2050. In addition, the SACOG Board adopted seven Blueprint principles to guide future growth in the region:

- Provide a variety of transportation choices;
- Offer housing choices and opportunities;
- Use existing assets;
- Take advantage of compact development;
- Preserve open space, farmland, natural beauty, through natural resources conservation;
- Encourage distinctive, attractive communities with quality design; and
- Encourage mixed land uses.

2008 MTP and State Implementation Plan

The 2008 MTP was the region's first plan to link regional growth patterns and smart growth land use principles to the region's transportation system investments through the planning horizon of 2035. Using the adopted and locally-supported Blueprint map as the land use foundation for the region, SACOG developed multiple transportation scenarios to test which investments would perform best with the Blueprint-based future land use pattern.

As a result of this work, the 2008 MTP invested a far greater share of the region's transportation resources to alternative modes of travel and trip reduction methods than any previous MTP. In addition, it provided for high occupancy vehicle lanes on freeways, construction of bridges that shorten distances for motorists and bicyclists, and installation of complete streets that safely accommodate vehicles, transit, bicyclists, and pedestrians.

When developing the 2008 MTP, SACOG was also involved in updating the State Implementation Plan for air quality, which provided opportunities for closer collaboration with the region's air quality management districts in the development of the MTP. As a result, the MTP contains several transportation control measures that commit SACOG to future actions to reduce transportation-related air pollutants, including development of a rural sustainability strategy (Rural-Urban Connections Strategy), and analysis and development of parking and congestion pricing policies.

Rural-Urban Connections Strategy

While the Blueprint growth strategy focused the region's dialog about growth, economic development, and quality of life in urban areas, another key interest of the SACOG region has been to address economic and environmental sustainability for rural areas. Given that approximately 85 percent of the lands in the SACOG region are agricultural, forest, or other open space, a key goal of the region is to maintain a balance between the need to urbanize with the need to conserve rural lands and their uses. In response, SACOG created the Rural-Urban Connections Strategy (RUCS) project.

The intended result of this ongoing project is to develop a comprehensive toolkit of ideas, best practices, and technical tools for SACOG member jurisdictions to consider in their local and regional planning of rural areas. Thus far, a number of innovative ideas have been documented that focus on promoting land use practices in rural areas that are both economically viable and environmentally sustainable for land owners and local governments. Some of issues the project has been working to address include: natural resource protection, development practices that support agricultural and natural resource values, infrastructure needs in rural areas, reducing vehicle miles traveled and greenhouse gases, and methods to promote jobs-housing balance.

Sustainable Communities and Climate Protection Act of 2008 (SB 375)

SB 375 was passed into law shortly after SACOG adopted its 2008 MTP. In conjunction with AB 32, the California Global Warming Solutions Act, SB 375 affects how regional transportation plans in the State can reduce GHG emissions that contribute to climate change, and affect the sustainability of future growth. SB 375 requires that MPO transportation plans now include a Sustainable Communities Strategy (SCS) that integrates the plan's land use assumptions with transportation investments and Regional Housing Needs Allocations, while showing the effects of these actions on GHG emissions.

Local Plans and Initiatives

State law requires cities and counties to adopt general plans to include land use and transportation (or circulation) elements. A general plan's land use element functions as a guide to planners, the general public, and decision makers on the ultimate pattern of development for the city or county at build-out and addresses the distribution of housing, businesses, industry, open space, and other categories of public and private uses. Transportation elements in local general plans typically address roads, highways, public transit, bicycle, and pedestrian facilities, in the context of stated transportation-related goals and policies of the city or county. In addition, many of SACOG's local member jurisdictions and partner agencies have developed or are in the process of developing climate action plans, GHG emissions reduction plans, and/or local sustainability plans. Ultimately, these plans, as well as city and county government decisions on individual project applications, influence the regional growth assumptions SACOG incorporates in its regional transportation plans, and consequently the transportation-related GHG impacts of these plans.

In developing the MTP/SCS, SACOG worked with each of its local jurisdictions to develop future land use allocations and transportation investments based on these local factors and related local development decisions that have been taken since the adoption of the 2008 MTP.

The 28 jurisdictions in the Sacramento region are at various stages of updating or augmenting their local plans. Future development patterns in these plans reflect a combination of market forces, as well as local policies; many have been influenced by the region's Blueprint principles. The cities of Citrus Heights, Rancho Cordova, Rocklin, Galt, Lincoln, Live Oak, Sacramento, Wheatland, West Sacramento, and Yuba, as well as El Dorado, Sacramento, Yolo, Yuba, and Sutter counties have recently adopted or are currently undergoing general plan updates. In addition, the cities of Davis, Elk Grove, Roseville, Placerville, and Folsom, as well as Placer County have recently adopted or are currently developing area-specific, community-level land use plans. Collectively, these areas cover 97 percent of the region's anticipated growth during the MTP/SCS's planning period.

II. SACOG'S SUSTAINABLE COMMUNITIES STRATEGY

Development of SACOG's MTP/SCS began in 2009. SACOG's plan development efforts started with gathering data on current and future regional population, housing, and employment. Using this information as a foundation, local agencies, stakeholders, and the general public were consulted on different options for accommodating the region's anticipated future growth through 2035. Using the input received, SACOG developed alternative plan scenarios, each with a different package of land use patterns and transportation investments. They also used technical modeling tools and methods to test and compare each scenario's performance relative to the agency's long-term goals. An extensive public process was then used to weigh the results and help SACOG's Board of Directors select a preferred regional land use and transportation scenario as the basis of their MTP/SCS.

This chapter summarizes the key land use and transportation assumptions, GHG emissions reduction performance results, and plan development features of SACOG's adopted MTP/SCS.

A. Land Use

In developing the land use assumptions for the MTP/SCS, SACOG initiated an extensive consultation process with each of its member cities and counties to identify existing development policies and discuss local growth projections. During this process, SACOG gathered information about local sustainable development efforts that have been ongoing since the adoption of its previous MTP in 2008. As a result, SACOG's MTP/SCS includes updates to and development of many more local plans, many of which now promote Blueprint-style development.

The MTP/SCS also shows a more compact land use pattern that is able to accommodate a 40 percent increase in the region's population by 2035 that is largely within the region's current development footprint. This is achieved through the region's focus on providing more small-lot and attached housing and maximizing infill and redevelopment opportunities. Tables 2 and 3 show SACOG's assumptions related to these two points.

The region's focus on providing a greater mix of housing types is shown in Table 2. Between 2008 and 2035, SACOG assumes housing growth will focus on more attached and small-lot products, with over 70 percent of new housing built as attached or small-lot projects, and just 30 percent built as large-lot or rural residential products.

Table 2. Summary of MTP/SCS housing product mix assumptions

Housing Product Type	2008	Housing Growth (2008-2035)
Single-Family Large-Lot and Rural Residential (%)	65	29
Single-Family Small-Lot and Attached (%)	35	71

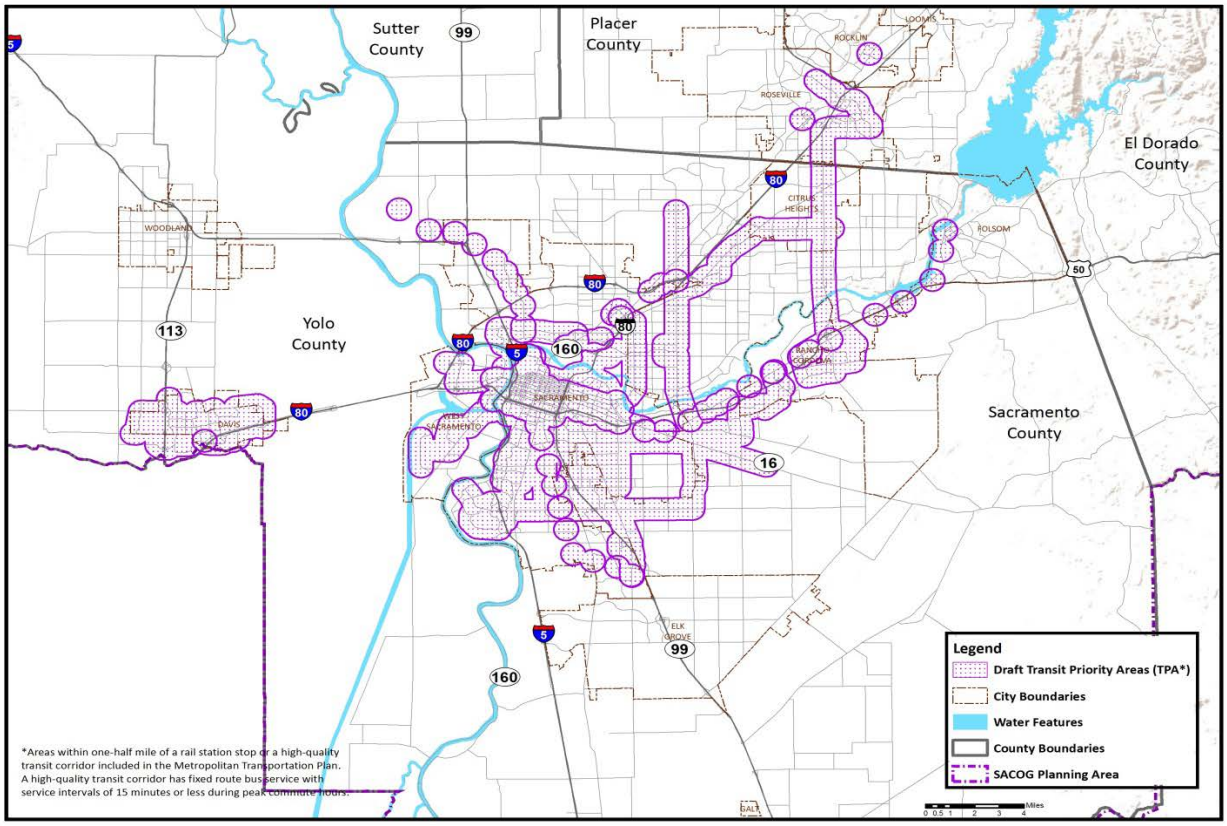
One way of looking at SACOG's use of infill and redevelopment opportunities is through their allocation of housing and employment growth into the region's established urbanized areas. Table 3 shows that nearly 80 percent of the region's new housing and business growth over the next 25 years is planned to occur within Placer and Sacramento counties. These counties are the most urbanized in the region today and provide the most opportunity for development on infill lands, intensification of underutilized parcels, and redevelopment.

Table 3. Expected housing and employment growth allocation

County	2008		2008-2035		2035	
	Existing Dwelling Units	Existing Employees	New Dwelling Units	New Employees	Total Dwelling Units	Total Employees
	% of Regional Total		% of Regional Total		% of Regional Total	
Sacramento	63	64	59	59	62	63
Placer	15	15	18	19	16	16
Yolo	8	11	10	11	9	11
El Dorado	7	5	4	5	6	5
Yuba	3	2	4	3	3	3
Sutter	4	3	4	3	4	3

A subset of the housing and employment growth in the MTP/SCS falls within Transit Priority Areas (TPAs). SACOG defines TPAs as areas of the region within a half mile of a major transit stop with a service frequency of 15 minutes or less during peak commute hours. Locating more new homes and jobs near these areas helps to make transit more accessible and efficient. Figure 3 shows the TPAs identified in the SACOG region for 2035.

Figure 3. SACOG Transit Priority Areas in 2035



In 2008, 14 percent of housing units and 27 percent of employees were within TPAs. By 2035, the MTP/SCS land use distribution would increase the number of people, both residents and employees, with access to high quality transit, such that 38 percent of new housing units and 39 percent of new employees in the region would be within Transit Priority Areas. Additionally, high-quality transit would service over 150,000 existing housing units and over 240,000 existing employees. As a result, by 2035 nearly 34 percent of total housing units and 48 percent of total employees would be within TPAs.

B. Transportation

SACOG also worked with its local member jurisdictions to update the transportation system investments that had been included in the 2008 MTP, accounting for a nearly 13 percent reduction in revenues from slower growth anticipated over the next 25 years.

One of the most significant changes to the investment strategy of the MTP/SCS from the 2008 MTP is its emphasis on operational improvements over new roadway capacity projects. Furthermore, the MTP/SCS reduces the number of road widening projects that were previously included in the 2008 MTP, as well as defers some of the roadway

projects slated for construction. At the same time, “complete streets” projects have replaced new roadway investments along existing urban corridors, balancing the needs of all travel modes and potential users of a road. Over 30 percent of projects in the MTP/SCS contain complete streets elements.

Another significant change in the MTP/SCS is its increased investment in bus service frequency in the region. The MTP/SCS increases bus service with 15-minute-or-better service in the region from 14 percent in 2008 to 45 percent in 2035, compared to 38 percent in 2035 under the 2008 MTP. This will result in transit productivity increases (i.e., how many passengers board per unit of service provided) of 27 percent over levels in the 2008 MTP. The MTP/SCS indicates that higher productivity will lead to a significantly higher percentage of transit operating costs in the region that can be recovered through user fares, allowing transit investments in the MTP/SCS to go further and have a larger impact.

Figure 4 summarizes distribution of the MTP/SCS’s investments across general transportation project categories through year 2035. In total, the MTP/SCS will invest $35.2 billion to improve the regional transportation system, with maintenance/rehabilitation and transit project categories receiving the largest, and nearly equal, shares of the region’s transportation dollars.

Figure 4. MTP/SCS investments 2011-2035 (billions $)

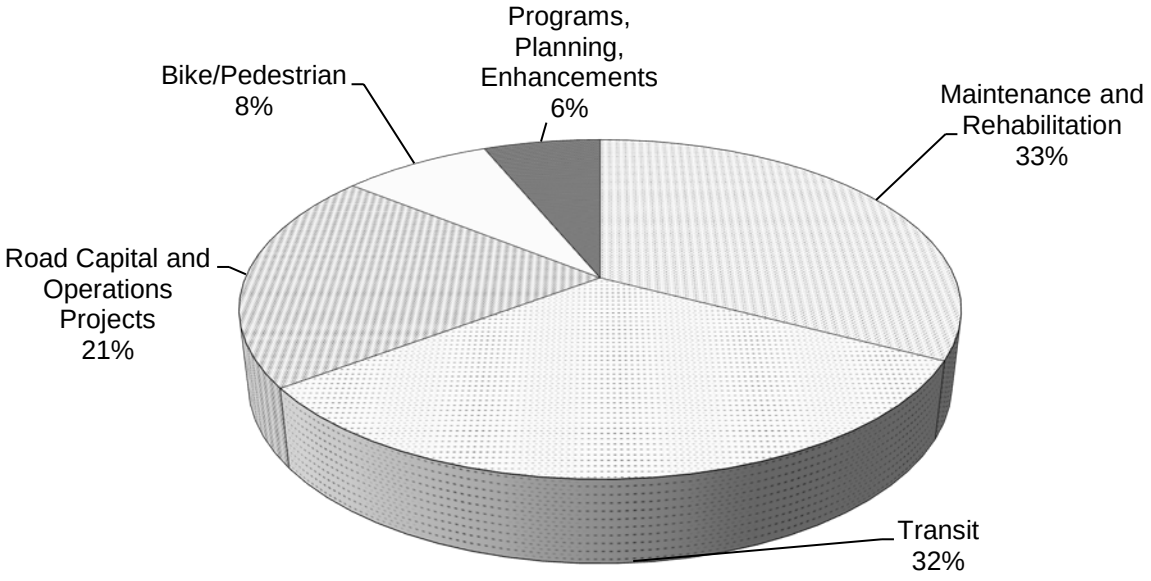


Table 4 shows how the programs and projects the plan funds are expected to improve both service and infrastructure across the different travel modes in the region. By 2035, transit service hours and bike and pedestrian facility miles are expected to nearly double. Over the same time period freeway lane miles also increase, with a focus on growing the region's high occupancy vehicle mobility options in the region and minimizing growth of general purpose freeway lanes.

Table 4. MTP/SCS transportation system investments by travel mode

		2008 Total	2035 Total	% Change (2008-2035)
Transit	Transit Total Daily Vehicle Service Hours	4,074	8,062	98%
	Rail Route Miles	258	458	78%
	Bus Route Miles	3,816	6,702	76%
Roadway	Freeway HOV Lane Miles	64	182	184%
	Arterial/Expressway Lane Miles	3,609	5,095	41%
	Freeway Auxiliary Lane Miles	196	262	34%
	Collector and Local Street Lane Miles	22,000	28,000	27%
	General Purpose Freeway Lane Miles	1,462	1,522	4%
Bike and Pedestrian	Bicycle/Pedestrian Class I Miles	397	793	100%
	Bicycle Class II Miles	1,059	1,781	68%

The general level, type, and extent of investments covered by the MTP/SCS are described in more detail below.

Maintenance and Rehabilitation Program

Thirty-three percent of total revenues for the planning period, or $11.5 billion, are budgeted to road and highway maintenance and rehabilitation, including routine maintenance, major reconstructions, and various safety improvements.
Five percent of these revenues, or approximately $600 million, will be spent on maintenance and rehabilitation of bike and pedestrian facilities. In addition, 20-30 percent of roadway investments on the region's project list includes bike and pedestrian improvement components (striping, signage, sidewalk gap closures, ADA retrofits and intersection improvements).

Transit Program

Thirty-two percent of total revenues for the planning period, or $11.3 billion, will go to transit investments. Investment in this category focuses on increasing transit operational efficiencies by continuing funding for existing transit services and focusing new transit investments on corridors with more compact and mixed land uses. The plan calls for 53 percent of all transit services (bus and rail) to

operate at 15 minute or better service frequency by 2035, versus 24 percent of services today. In addition, the plan provides increased transit coverage across the region along focused corridors. By 2035, it increases the number of miles covered by bus transit by 19 percent and increases daily bus service hours by 95 percent. Rail transit coverage increases by 54 percent with local light rail expansion projects. New services including: nine bus rapid transit (BRT) lines with 15-30 minute service connecting major employment centers, new neighborhood shuttles, and streetcar services, are also planned.

Road Capital and Operations Projects

Twenty-one percent of total plan revenues, or $7.4 billion, will go to road and highway capital improvements, including intersection improvements, safety projects, signal timing, road widening in growth areas, and new connections for local access. The focus of these funds is on operational improvements and strategic capacity projects. Road operational improvement projects include local and state highway projects that provide interchange and intersection bottleneck relief, streetscape improvements to support improved transit access, investments to support BRT corridors, and improved access to transit oriented development areas (TODs). Of the new capacity projects the MTP/SCS invests in, 89 percent of the new lane miles are on surface streets to primarily serve emerging activity centers (Rancho Cordova, Folsom, West Sacramento and southern Placer County). These areas are expected to shoulder significant shares of projected housing and employment growth by year 2035. Of the projects included that increase freeway lane miles, over 75 percent are carpool lanes, auxiliary lanes, new or widened ramps. Most of these additions occur in urbanized parts of the region and are directed at closing gaps that relieve congestion along major commute corridors during peak commute periods.

Bike and Pedestrian Projects

Eight percent of plan revenues, or $2.8 billion, go to bicycle and pedestrian improvements, including bicycle trails, sidewalks, ADA retrofits, and supporting facilities. In addition, an estimated 20 to 30 percent of roadway investments in the plan have a bicycle or pedestrian feature.

Programs, Planning, Enhancements

Six percent of total revenues, or $2.2 billion, are budgeted for other types of improvements important to achieving regional goals, including project development and analysis, community design incentives, travel demand management (including the regional rideshare program), and other enhancement programs. This category includes seed funding for SACOG's Community Design program which provides seed funding to encourage smart growth development

projects that complement the MTP/SCS, allowing greater regional coverage and support for planning through implementation.

C. Greenhouse Gas Emissions

SACOG's MTP/SCS includes an SB 375 GHG reduction calculation and analysis. As part of this analysis, SACOG documents its use of an updated transportation analysis tool to analyze the GHG performance of the MTP/SCS. Using the updated tool, SACOG projects a 9 percent per capita GHG emissions reduction from the region's 2005 level by 2020 and a 16 percent reduction by 2035.

SACOG considers several explanatory factors for the decline in per capita passenger vehicle-related GHG emissions. Some are external, such as increases in auto operating costs, driven by higher fuel prices, and aging of the population. Others are tied to land use and transportation factors such as how connected areas of the region are to existing development, how walkable areas of the region are, the distances from residences to their nearest transit station or stop, to name a few. ARB's evaluation of SACOG's analysis is discussed in Section 3 of this report.

D. Plan Implementation

SACOG's MTP/SCS includes a set of policies and supportive strategies that are intended to support plan implementation. SACOG has augmented the policies and strategies in their previous 2008 MTP to reflect new projects, research, and circumstances since the last MTP, including SB 375.

In particular, a new strategy in the MTP/SCS supports SACOG's development of social equity analysis methods and performance measures to help inform future plan updates and local discussions on development patterns. Another new strategy in the MTP/SCS calls for additional modeling enhancements, including the development of an economic land use model to better inform future plan updates on the effects of jobs-housing fit, infill incentives, congestion and parking pricing, and transportation project phasing.

E. Public Outreach Process

SACOG conducted an extensive public outreach process as part of their MTP/SCS development. Starting in October 2010, SACOG held a series of nine general-audience public workshops and eight focus group meetings with environmental justice populations around the region on three alternative MTP/SCS scenarios. Participants were presented with information on the scenarios and asked to discuss benefits and drawbacks of each at both the regional and county scales. At the end of the discussion, participants voted to choose a preferred scenario for both the region and counties. Input from the public workshops and environmental justice focus groups was summarized and presented to the SACOG Board of Directors.

Based on input received, as well as multiple rounds of local and partner agency input and review, in November 2011, the SACOG Board of Directors released a draft MTP/SCS. Three public hearings were held on the draft plan and the associated draft Environmental Impact Report (EIR) in December 2011 and January 2012. SACOG also held informational meetings for the region's city and county elected officials to present and discuss the draft MTP/SCS, including key land use and planning assumptions, and to solicit additional comments.

SACOG made responsive modifications to both documents based on public comments received on the draft MTP/SCS and the draft EIR. The proposed final MTP/SCS was presented at public meetings of SACOG's Transportation and Land Use and Air Quality Committees on March 1 and April 5, 2012. On April 19, 2012, SACOG's Board of Directors conducted a final public meeting, where it adopted the MTP/SCS by unanimous vote.

III. ARB STAFF REVIEW

The Sustainable Communities and Climate Protection Act of 2008 calls for ARB's "acceptance or rejection of the MPO's determination that the Sustainable Communities Strategy would, if implemented, achieve the greenhouse gas emission reduction targets" in 2020 and 2035. SACOG's quantification of GHG emissions reductions in the SCS is central to its determination that the SCS would meet the targets ARB established in September 2010.

As required by Government Code section 65080(b)(2)(j)(ii), SACOG submitted a quantification methodology to ARB on October 14, 2010. For the technical foundation of the MTP/SCS GHG quantification, the methodology identifies SACOG's travel modeling system, growth and land use forecast, and transportation project assumptions. Using this methodology, SACOG estimated that its MTP/SCS would achieve a 9 percent per capita reduction in GHG emissions from passenger vehicles by 2020, and a 16 percent per capita reduction by 2035.

ARB staff prepared the following analyses based on SACOG's draft MTP/SCS and GHG quantification, released in November 2011. Staff's analyses show that if implemented, SACOG's SCS would achieve the GHG emissions reductions claimed and meet the targets set by the Board for 2020 and 2035. SACOG followed advanced modeling practices for an activity-based model and used reasonable model inputs and assumptions. The sensitivity analysis of the model demonstrates adequate sensitivity to land use and transportation strategies utilized in the plan. Plan performance indicators are also supportive of estimated GHG reductions. ARB staff presented these results to the Board on March 22, 2012.

On April 19, 2012, SACOG adopted an MTP/SCS containing minor modifications to the November draft reviewed by ARB staff. ARB staff have since reviewed the adopted modifications and affirm that they do not change the underlying technical land use and transportation assumptions of the plan, SACOG's greenhouse gas quantification method, nor the greenhouse gas results presented by ARB staff to the Board in March 2012.

A. Application of ARB Staff Review Methodology

Review of SACOG's SCS focused on the technical aspects of regional modeling that underlie the quantification of GHG reductions. The review is structured to examine SACOG's modeling tools, model inputs, application of the model, and modeling results, following the general method described in its July 2011 document entitled "Description of Methodology for ARB Staff Review of Greenhouse Gas Reductions from Sustainable Communities Strategies Pursuant to SB 375". To address the unique characteristics of the SACOG region and modeling system, ARB staff tailored and expanded the general methodology to be applicable for SACOG's SCS.

ARB staff evaluated how SACOG's models operate and perform in estimating travel demand, land use impacts, and future growth, and how well they provide for quantification of GHG emissions reductions associated with the SCS. In evaluating whether SACOG's model is reasonably sensitive for this purpose, ARB staff examined issues such as:

- How the growth forecast reflected the economic recession
- The basis for allocating land use changes
- How well SACOG's activity-based model replicated observed results
- How SACOG applied off-model tools
- Cost assumptions (fuel price and vehicle operation cost) used in the model
- How sensitive SACOG's model is to changes in key land use and transportation variables as compared with the empirical literature

To help answer these and other questions, ARB staff used publicly available information in SACOG's MTP/SCS and accompanying documentation including MTP technical appendices and the model validation and peer review reports. SACOG also provided additional clarifying information, and a data table, as shown in Appendix A.

In order to assess technical soundness and general accuracy of SACOG's GHG quantification four central components of SACOG's GHG analyses were evaluated, including: modeling tools, data inputs and assumptions for modeling tools, model sensitivity analyses, and performance indicators.

Modeling Tools

SACOG's model and off-model documentation and peer review report were reviewed to assess how well SACOG's travel demand model replicates observed results based on both the latest socioeconomic, land use, and travel data inputs and assumptions used to model the SCS. SACOG's off-model adjustment documentation and results were reviewed to assess whether an appropriate methodology was used to quantify the expected reduction in GHG emissions from its SCS. SACOG's modeling practices were also reviewed in light of the California Transportation Commission's (CTC) "2010 California Regional Transportation Plan Guidelines," the Federal Highway Administration's (FHWA) "Model Validation and Reasonableness Checking Manual," and other key modeling guidance and reference documents.

Data Inputs and Assumptions for Modeling Tools

SACOG's key model inputs with underlying data sources and assumptions were evaluated to confirm they represent current and reliable data for use in their model. This involved using publicly available, authoritative sources of information, such as national and statewide survey data on socioeconomic and

travel factors. A subset of the most relevant model inputs for GHG quantification, which includes: 1) regional socioeconomic characteristics, 2) the region's transportation network, 3) travel inputs, and 4) cost assumptions. The documentation of region-specific forecasting processes and approaches (especially where applicable to the evaluation of the region's land use forecast assumptions) were also evaluated.

Model Sensitivity Analysis

Sensitivity testing is often used to assess whether a model is reasonably responsive to changes in key inputs, including changes to land use and transportation factors. These tests often involve systematically changing model input variables and measuring variations in output variables. They can also be performed by examining variations in independent and dependent variables across a dataset, and evaluating the correlations between the variables. SACOG conducted sensitivity tests of its travel model to support its GHG emissions quantification analyses as part of its MTP/SCS.

The results of SACOG's sensitivity tests were compared to those found in the available empirical literature. As part of the sensitivity analysis review, responsiveness of SACOG's travel demand model to changes in the following input variables were examined:

- Auto Operating Cost
- Transit Fares
- Household Income
- Highway Capacity
- Regional Accessibility
- Mix Use
- Proximity to Transit
- Street Pattern
- Residential Density

Regional Performance Indicators

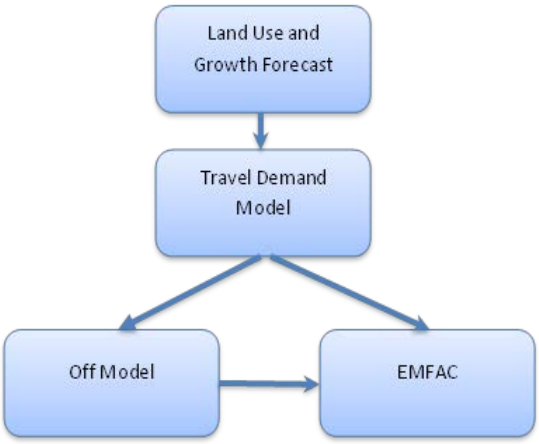
Performance indicators help explain changes in VMT and related GHG emissions that are expected to occur, whether through changes in travel modes, vehicle trip distances, or through some other means. SACOG developed several performance indicators to evaluate the effect of implementing the MTP/SCS. A qualitative evaluation was done to determine if increases or decreases in these individual indicators are directionally consistent with SACOG's modeled GHG emissions reductions. In particular, the following performance indicators were evaluated: land consumption, jobs/housing balance, distance of housing and

employment from transit stations, passenger VMT, mode share, congested VMT, change in average trip length by purpose, and number of non-motorized trips.

B. Modeling Tools

SACOG uses several models to quantify GHG emissions that would result from implementation of the MTP/SCS (Figure 5). SACOG is one of the first MPOs in California to develop an activity-based travel demand model to calculate changes in travel demand based on a number of different modeling inputs, such as base year population, employment, and planning assumptions about future year land use, housing, and the transportation network. Based on these and other inputs, the travel demand model produces vehicle activity outputs (performance indicators) such as VMT, vehicle hours traveled, number of vehicle trips, and average speed.

Figure 5. Modeling tools



Using the VMT outputs from its travel demand model, SACOG then estimates the reduction in GHG emissions from implementation of its MTP/SCS for 2020 and 2035. SACOG converted VMT outputs to GHG emissions by running ARB's vehicle emissions model, EMFAC 2007. SACOG also made use of off-model adjustments to account for changes in GHG emissions and other model outputs due to plan elements to which their travel demand model is not responsive, or was insufficiently sensitive. The section below describes the various models used to develop the MTP/SCS, as well as planned model improvements that SACOG is developing for its next MTP update.

1. I-PLACE3S

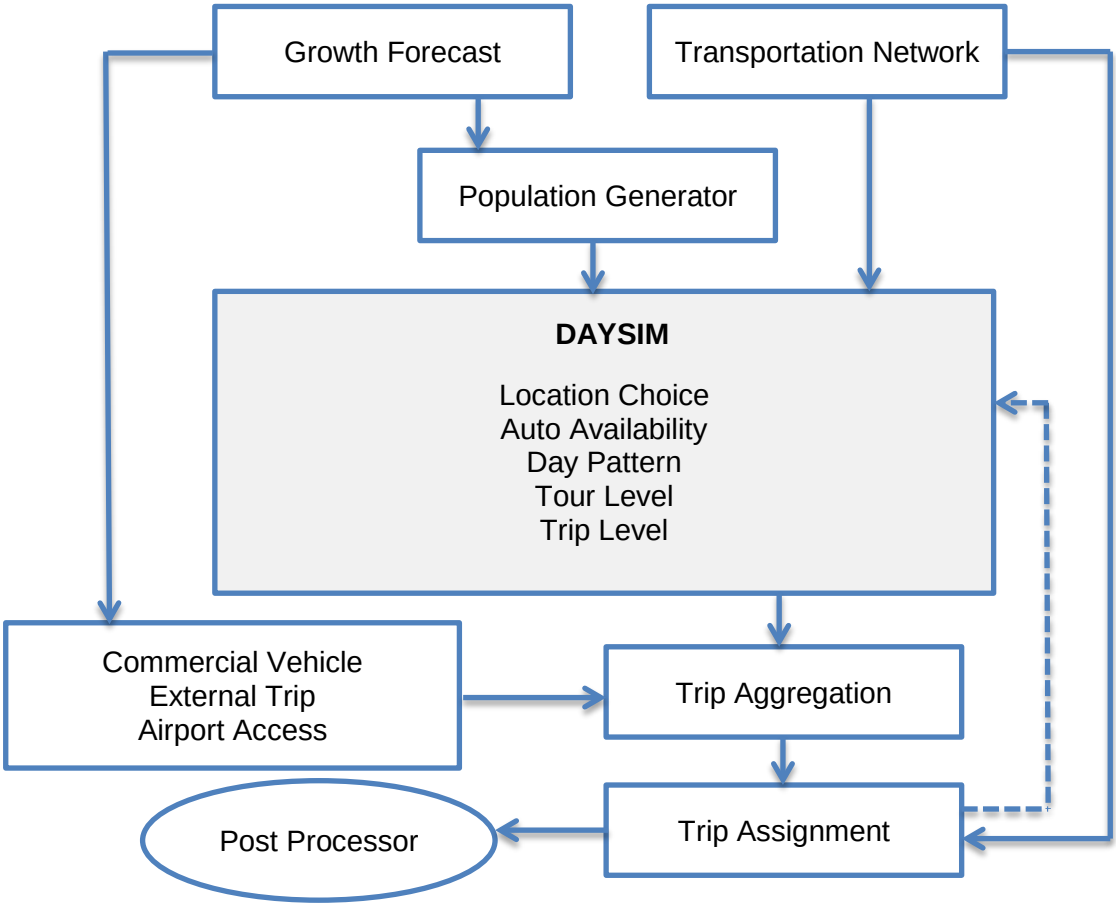
SACOG uses I-PLACE3S as a tool for developing and comparing land use scenarios or assumptions prior to input into their travel demand model. This tool is used to spatially allocate development to jurisdictions within the region, in a way that meets growth forecast control totals as determined by SACOG and its local member agencies. The allocation process is an iterative process with the goal of achieving a land use forecast that spatially accounts for growth forecasted in the region. Once the forecast is modeled in I-PLACE3S, it can be visually displayed, tallied, and summarized by different geographies. The primary reasons for modeling land use in I-PLACE3S are to: 1) be able to account spatially for the region's estimated growth, which makes it possible to make further refinements, if needed, and 2) provide the ability to check preliminary assumptions with local jurisdictions in an easily understandable format.

2. Activity-Based Travel Demand Model

The travel demand model SACOG used for its MTP/SCS is the Sacramento Activity-Based Travel Simulation Model (SACSIM). As part of its plan development process, SACOG used SACSIM to assess the long-term needs of the region's transportation system such as roadways, transit planning, and goods movement. SACOG also used SACSIM to perform federally required air quality conformity analyses and the technical analysis for determining if GHG emissions reduction targets will be achieved through implementation of the MTP/SCS.

SACSIM is an activity-based travel demand model. This type of model allocates households and jobs to the parcel level, allowing the model to capture smaller-scale land use changes. Similar to other travel demand model types, it is an aggregation of a number of different sub-models (Figure 6). This section reviews the key components of SACSIM: population generator, day-pattern activity simulator (DAYSIM), trip aggregation, and trip assignment. This section also discusses the model validation process SACOG performed to establish the credibility of the model's outputs.

Figure 6. SACOG's activity-based travel demand model



Population Generator

As displayed in Figure 6, the growth forecast is an input into SACSIM's population generator to create a synthetic population, which matches household-level and person level characteristics in the region. To develop the synthetic population, Public Use Micro-data Samples (PUMS)[2] were randomly matched to parcel level information using control variables such as household size, number of workers per household, income, and age. Once the data is matched, all other attributes are included for the year 2008 from American Community Survey (ACS) data. For future year demographics, SACOG relies on forecasts developed by the Center for Continuing Study of the California Economy (CCSCE)[3]. The output from the population generator is then input into DAYSIM.

Characteristics of SACSIM's representative population such as household size distribution, number of workers in household, income distribution, and householders' age distribution at the county level was compared with ACS 5-year data. Population at the census tract level from SACSIM was also compared with 2010 Census data.

At the county level, comparisons among all variables were matched with less than one percent difference. In addition, the correlation coefficient at the census tract level was 0.99, indicating that the SACSIM's base year and the 2010-census population are consistent. As shown in Table 6, the average household size between 2010 census and SACSIM are similar. Based on these analyses, the synthetic populations from the population generator are reasonable for use in the model.

Table 6. Average household size (persons per hh)

County	SACSIM (2008)	Census (2010)
El Dorado (partial)	2.7	2.6
Placer (partial)	2.7	2.6
Sacramento	2.7	2.7
Sutter	2.9	3.0
Yolo	2.7	2.7
Yuba	2.9	2.9
Regional total	2.7	2.7

[2] A sample of population and housing unit records from the American Community Survey.

[3] The detailed descriptions of future year projections are discussed in the data input and assumption section.

Day-Pattern Activity Simulator (DAYSIM)

The DAYSIM sub-model simulates the full day activity and travel schedule of each person per household in the Sacramento region. DAYSIM captures the complex aspects of travel decisions such as mode, location, and time, and represents the individual decision-making process of their travel choices. This simulation provides more accurate travel demand forecasts. DAYSIM is implemented by replacing and extending a certain portion of a typical four-step model (trip generation, trip distribution, and mode choice) into several distinct routines or sub-models: the location choice, the auto ownership, the day pattern, the tour model, and the trip level model. This section describes and evaluates each sub-model in detail.

DAYSIM Location Choice Model

DAYSIM treats work/school location and auto ownership as long-term decisions since they do not change for months or sometimes for years. It uses a multinomial logit model structure with the constraints of travel distance, mode choice, and destination choices to identify work and school location choices. The number of jobs available and school enrollment were used as constraints. SACOG calibrated the model for the year 2000 using census data and household travel surveys and concluded that about 6 percent of workers work at home and more than 50 percent travel less than 10 miles to work locations.

To evaluate the location choice model, model structure and variables used in the model were reviewed. Average distance distribution between home-to-work and school locations was also evaluated.

The location choice model showed a good fit with the adjusted rho-squared[4] value ranging from 0.122 to 0.239. The location choice model uses land use density and mixed use variables, accessibility to various modes, employment, number of parking available, and street connectivity. Table 7 shows a comparison of the average distance between home-to-work and school/college predicted by the location choice model and the observed data. The distance distributions for work and school trips matched very closely with less than 3 percent difference, whereas the distance to college did not match well, which SACOG attributes to under-reporting of student residents.

[4] Adjusted rho-squared is a modification of rho-squared that adjusts for the number of explanatory variables in the model.

Table 7. Average distance between home and work/school

	Model (miles)	Observed data (miles)
Average distance to work (one-way)	11.5	11.8
Average distance to school, (one-way)	3.1	3.1
Average distance to college, (one-way)	9.0	7.8

DAYSIM Auto Availability Model

The auto availability model is applied at the household level and is disaggregated into five ownership choices: zero car, one car, two cars, three cars and four or more cars. It also utilizes multinomial logit model structure with variables such as number of drivers in household, accessibility to work and school location, nearest transit stations/stops, and proximity of services within a half mile from the residence. SACOG calibrated the model at the regional level using the census data.

To evaluate the auto availability model, the structure and variables used in the model and the region-wide distribution of auto-ownership were reviewed. The auto availability model, showed a strong relationship between the number of drivers in a household and auto ownership. The number of vehicles available per household decreased when the distance to the nearest transit stop is less than a half mile. The auto availability model was also sensitive to accessibility from home to non-work activities, and parking prices. The model followed the recommendations in CTC's 2010 California Regional Transportation Plan Guidelines (CTC Guidelines) that it should have an auto ownership model and be sensitive to land use and transit accessibility. Table 8 compares the auto-ownership distribution for the model and the observed data in the Sacramento region. Overall, the modeled results tracked the observed data very closely.

Table 8. Auto-ownership distribution

Auto-ownership	Model (% hh)	Observed Data (% hh)
Zero vehicle	7.7	7.7
1 vehicle	34.7	34.4
2 vehicles	39.6	39.7
3 vehicles	13.2	13.3
4 or more vehicles	4.9	4.9

DAYSIM Day Pattern Model

The day pattern model is similar to the trip generation step in the four-step model, while providing detailed activity for the entire day of an individual's travel activity. This model predicts the number of home based tours[5] and extra stops a person might make for seven activity purposes: work, school, carpool, personal business, shopping, meal, and social/recreational. It also includes work-at-home as an alternative activity. The day pattern model is a function of household, personal characteristics, land use, and accessibility at the residence. It estimates a 30-minute temporal resolution with a spatial resolution at the parcel level. This model does not explicitly account for interactions with other members of the household, but is indirectly represented using other household variables. The day pattern model is calibrated using SACOG's 2000 household travel survey at the individual level.

The day pattern model of the SACOG regional travel demand model was evaluated by through review of variables used in the model and the signs (±) of each variable. Estimated tour frequency for various tour types as indicated in the SACSIM model reference report were also reviewed.

In the day pattern model, the personal and household characteristics strongly influence the number and purpose of tours. Significant variables include employment status, car availability, income, age, and the presence of children. It was observed that an increase in mixed use density in residential areas increased the number of shopping tours. Table 9 provides a comparison of model and observed number of tours per day by person type. Overall, day pattern model results track closely and are consistent with the observed data.

[5] A tour is a unit of analysis that measures the sequence of trips, originating from a single location, such as home or work. This unit of analysis helps to better account for the influence connections between trips have on travel behavior.

Table 9. Tours by person type per day

Person Type	Model	Observed
Full time worker	0.91	0.92
Part-Time Worker	0.63	0.66
K-12 students	0.86	0.85
University students	0.64	0.70
Non-working adult	1.46	1.41

DAYSIM Tour-Level Model

A tour-level model is developed to predict the primary destination, mode, and time-of-day for all tours determined in the activity generator step. Therefore, once the day pattern has been estimated for each person, the model schedules the tours that he or she would take. If work or school is involved in a tour, then it becomes the primary destination. A work tour is developed as a nested logit model with alternate locations of work. Places of travel for non-work/non-school tours are determined at the tour-level destinations. A multinomial logit model uses purpose of tours, mode choices, distances, parking at destinations, street patterns, density, and commercial employment.

The tour-level mode choices include drive alone, shared ride (2 persons and 3 or more persons), drive-to-transit, walk-to-transit, school bus, bike and walk, with some of these modes available for specific purpose only. SACOG used multinomial logit model to forecast the main tour mode, from the tour origin to the primary destination, and back to the origin. SACOG then further divided the tour mode choice model into four sub-models based on the tour purpose: work tour, school tour, non-mandatory tour (shopping, meals, personal business, and social/recreational) and work-based sub-tours.

The work-based tour sub-model includes level of service variables such as cost, in-vehicle time, wait time, walk/bike time, number of persons in household, and mixed use density. The school tour mode is similar to the work tour mode, except here, the school bus is constrained by the age of students. Work-based-sub-tours are the only non-home based tours, which start and end at the same location and are conditioned on the mode used for the work tour. The non-mandatory tour mode choice model uses similar variables to the other models with land use density and street pattern variables as significant contributors.

DAYSIM includes two types of tour-level time-of-day models, which is applied after primary destination and mode choice models: tour primary destination arrival and departure time, and intermediate stop arrival and departure time. The time-of-day sub-model uses 48 half-hour periods in the day and provides an approximate duration of the activity at each activity location. A multinomial logit model structure predicts the time that the person arrives at the primary tour destination and the time that the person leaves that destination to begin the return half-tour. For intermediate stops, this sub-model predicts either the time that the person arrives at the stop location or else the time that the person departs from the stop location. The time-of-day sub-model uses variables like person type, income, and time pressure, and is conditioned on what other activities have already been scheduled or remain to be scheduled for the day.

In evaluating the tour-level sub-models, the model structure and variables used, as well as observed and surveyed data SACOG used to develop and calibrate the model were reviewed. The estimated distance distribution and mode share by tour purpose was also compared against the observed data. Tour length frequency distributions were also checked using coincidence ratios for different tour purposes.

In the estimated multinomial logit model, the adjusted rho-squared value is a measure of fit of the model, depends on the tour purposes, and ranges from 0.169 to 0.479. Based on the available literature, this range shows a good model fit. The coefficients of key variables SACOG used in the model street pattern, mix use, density, and accessibility all fell within the acceptable range with significant t-values[6]. Tour-level models were calibrated using census journey-to-work (for work tours only) and SACOG's 2000 household travel survey.

Table 10 provides a comparison of modeled and observed average tour lengths for each tour purpose. The differences between the model estimated and observed tour length miles ranged between 2 percent to 33 percent, which is probably due to underreporting of certain tour types: meals, shopping, and escort passenger trips. According to FHWA guidelines, coincidence ratios for each tour purpose should be at least 0.7. In SACOG's model, the ratios ranged from 0.82 to 0.95, indicating a close match between the modeled and observed data.

Table 10. Tour length by purpose

[6] A t-value statistic is the ratio of the coefficient to its standard error, measuring how many standard errors the coefficient is away from zero.

Tour Purpose	Model (miles)	Observed (miles)
Work	12.0	11.8
School	3.5	3.8
Shop	6.0	5.6
Meal	7.1	8.2
Personal business	6.7	6.4
Social/recreational	7.0	6.6
Escort passenger	4.8	3.6
All non-work/non-school	6.2	5.9

The mode choice model captured key significant variables: mixed-use density and intersection density. Higher mixed-use density near a tour origin (home) indicates encouraged walking and biking, while higher mixed-use density near a tour destination (work) shows encouraged transit use. Similarly, the model shows higher intersection density encourages walking and biking for school and transit for other home-based tours. Various socioeconomic attributes of both households and individuals also play significant roles in the models. Table 11 shows a comparison of modeled and observed mode share for all trip purposes in the 2008 base year. Overall, the tour-level model results track closely and are consistent with the observed data.

Table 11. Comparison of mode share for all trip purpose in 2008

Mode	Model (%)				Observed (%)			
	Work	Work-based sub-tour	School	Non-mandatory tour	Work	Work-based sub-tour	School	Non-mandatory tour
Drive alone	77.8	59.2	8.3	34.2	77.9	61.1	11.6	34.0
HOV 2	10.0	16.6	17.0	33.6	9.8	13.4	16.8	35.2
HOV 3+	5.3	7.9	34.6	26.5	5.4	8.5	34.4	25.3
Transit (drive access)	0.6	NA	NA	0.0	0.7	0.0	0.1	0.0
Transit (walk access)	2.6	0.4	4.4	0.6	2.6	0.6	2.7	0.8
School bus	NA	NA	15.2	0.2	0.1	0.0	14.7	0.0
Walk	2.0	14.6	13.9	4.1	1.9	15.6	12.5	3.7
Bike	1.6	1.3	6.5	0.8	1.6	1.0	6.3	1.0

DAYSIM Trip-Level Model

In trip-level models, the number of estimated tours is converted into number of trips. For each trip, the trip level models are applied with the constraints of tour-level predictions. For example, a person bikes to work and he/she cannot drive a car back home from work. Intermediate stop locations are predicted based on the constraints of tour origin and primary destination, using a multinomial logit model with trip characteristics such as tour purpose, tour mode, stop purpose, stop placement in tour, person type, as well as household characteristics. The model was calibrated from top to bottom since the higher level of model adjustments tends to affect the lower level models.

Trip Aggregator

The trip aggregator combines trips from DAYSIM and other sub-models: commercial, airport access and external trips for the trip assignment step. DAYSIM auto person trips were aggregated into traffic analysis zones (TAZs) by mode and time period[7] and stratified by vehicle occupancy[8]. Transit passenger trips were split into two-time periods (peak and off-peak) and distinguished by walk-access, and drive-access. Commercial vehicle trips are not oriented by trip start and end, so they are split equally in both directions by time-of-day. Within the airport access sub-model, airport passenger trips are converted to vehicle trips, including pick-up and drop-offs,. Similarly, the external trip sub-model converts daily person-trips to vehicle trips between the external zone and the internal zone by occupancy and time-of-day. The output of this step is origin-to-destination vehicle or passenger trip tables for highway and transit network assignment.

Trip Assignment

Similar to the 4-step model, the assignment step of SACSIM is performed by converting person tours to vehicle trips, aggregating those trips into trip tables, and assigning them to the highway and transit networks. SACSIM runs over four time periods using multi-class user equilibrium assignments to assign vehicle trips on the transportation network for Single-Occupant Vehicle (SOV) and High-Occupancy Vehicles (HOV). This allows for consideration of priority lanes for HOVs and no-truck routes. For transit, SACSIM uses “all or nothing” user equilibrium assignments for two time periods (peak and off-peak). A user

[7] SACOG uses four-time period: AM peak period (7:00-9:59); Mid-day (10:00-14:59), PM peak (15:00-17:59), and late evening/early morning (18:00-6:59).

[8] Vehicle occupancy indicates number of persons, including driver and passenger(s) in a vehicle at a given time.

equilibrium approach is used to identify the shortest route between each origin and destination by performing 10 feedback iterations across the entire transportation system accounting for capacity restraints and travel times.

To estimate the congested travel time and delay SACSIM uses a modified volume delay function. The convergence criteria used in SACSIM is 0.0001 relative gap[9] or maximum internal iterations of 100. In the SACSIM model, the same assignment function is used for different facility types with a change in intersection and link delays.

In evaluating the trip assignment step, the assignment function of the model was reviewed and key statistics were compared with the CTC and the FHWA guidelines. Estimated and observed volume counts by facility type and regional VMT were also compared with Highway Performance Monitoring System (HPMS) data. [10]

SACSIM uses a capacity constrained assignment function to estimate link volumes and speeds. The root-mean squared error (RMSE)[11] for daily traffic assignment in SACSIM is 0.39. Both are consistent with CTC's "2010 California RTP Guidelines". Further, SACSIM has a correlation coefficient of 0.97 between the modeled and the observed volumes, indicating that the model closely follows observed data. Table 12 compares average weekday traffic volumes to observed traffic counts. Overall, SACSIM overestimated traffic volumes by about 7 percent in 2008. SACOG attributes this to an increase in unemployment, which may have reduced household income and activities over what would otherwise have occurred. Increases in travel cost from increasing fuel prices may also have influenced travel behavior.

Table 12. Comparison of estimated and observed traffic counts in 2008

Facility type	Model	Observed	Difference (%)	FHWA Guidelines (%)
Freeway	8,799,117	8,170,214	7.7	±7
Major Arterials	4,132,778	3,629,931	13.9	±10
Minor arterials	2,471,652	2,480,016	-0.3	±15
Collector and local	541,010	614,265	-11.9	±20

[9] Relative gap measures the relative difference of traffic flow between current iteration and the previous iterations.

[10] Highway Performance Monitoring System is a federally mandated program to collect roadway usage statistics for essentially all public roads in the US.

[11] RMSE measures average error between observed and modeled traffic volumes on links.

FHWA guidance recommends that MPOs validate the estimated VMT against the HPMS. SACOG's estimated regional VMT was about 12 percent higher and 8 percent lower than the HPMS VMT for freeways and arterial streets, respectively. SACOG believes this might be due to the difference in facility type definitions in SACOG's model that differ from HPMS federal-aid roadway classifications. Additionally, HPMS uses annual average daily traffic whereas SACOG uses a typical weekday model.

SACOG's activity-based travel demand model partially addresses induced demand through a feedback mechanism that inputs congested travel time into the DAYSIM to account for travelers who change their travel routes and modes in response to changed travel times. SACOG also addresses induced demand from new transportation investments as part of its growth projections. FHWA and SACOG acknowledge that current travel demand models are not sensitive to changes in travel behavior resulting from highway improvements. To address this issue, SACOG is developing an integrated land use and transportation model which will have a full feedback mechanism to better account for induced demand.

Model Validation and Peer Review

Model validation is a critical step in the development of any regional travel demand model. It establishes the credibility of the model to predict future travel behavior. The CTC Guidelines provide both requirements and recommendations for large MPOs, like SACOG, to enhance the modeling capabilities and validation procedures, as listed in Appendix A.

In performing model validation, SACOG conducted both a base year validation of the SACSIM model as well as future year validation as recommended by the CTC Guidelines. Base year validation is also called static validation and is performed by comparing model results to observed data. Future year (or dynamic) validation tests the predictive capabilities of the model by changing the input data for future year forecasts. For both static and dynamic validation, SACOG compared model outputs to observed data as a check on the reasonableness of its modeling results.

SACOG's base year validation was conducted using 2000 Census data, applied to the whole model system and compared against various recognized data sources such as the 2010 Census, transit on-board surveys, and traffic counts. SACOG's future year validation was conducted by making small changes to network and socio-economic variables. Overall, the direction and magnitude of changes in key model outputs were reasonable.

SACOG conducted a two-day peer review process in November 2008, consisting of five expert practitioners who have previously developed and implemented activity-based modeling or advanced state-of-the-practice in travel demand

modeling. These experts reviewed each of the major model components and provided suggestions on short- and long-term enhancements to SACOG's travel demand model. In general, panel members' comments were encouraging about the activity-based model component of SACSIM.

Looking ahead, the panel suggested the following improvements be prioritized:

- Update value-of-time coefficients in road pricing model
- Change specification of destination choice model to reflect mode choice and other mode level of service measures
- Include pedestrian and bicycle related variables in the model

3. Planned Model Improvements

As a result of the model peer review process, SACOG is considering potential model improvements as part of its next MTP planning cycle. These improvements will help enhance SACOG's ability to analyze the effect of different land use and transportation strategies.

Plans for improvement include implementing a Dynamic Traffic Assignment (DTA) function, which introduces a time-dependent network and travel demand based on a microscopic simulation approach. This improvement is expected to enhance SACOG's capability to evaluate various road-pricing strategies, including: high-occupancy toll lanes, congestion pricing, VMT fees, and transit fares.

SACOG is also in the process of developing an enhanced land use model under the Production Exchange and Consumption Allocation System (PECAS) model framework. This model is intended to predict economic activity associated with land use as a result of changes in transportation investments and policies. SACOG plans to integrate the PECAS model with SACSIM in order to better evaluate the effects of transportation and land use policy changes through interactions between variables and a feedback mechanism.

4. Off-Model Adjustments

SACOG made use of off-model adjustments to account for changes in GHG emissions and other model outputs from strategies in the MTP/SCS that were either not modeled in SACSIM or that were/ insufficiently sensitive to properly quantify. Off-modeled strategies include: transportation demand management (TDM), transportation system management (TSM), intelligent transportation systems (ITS), and work-at-home.

SACOG estimated the potential GHG reductions of these strategies by utilizing three reference documents.[12]

In deploying its TDM, TSM, ITS, and work-at-home strategies, SACOG used a baseline year of 2005 and projected deployment levels for both 2020 and 2035. These deployment levels were then compared to the information in the reference literature to determine the likely VMT and GHG reduction impacts that would result.

Transportation Demand Management

The deployment level of TDM measures in the MTP/SCS is based on a number of assumptions across five policy or program areas: transportation management agencies[13] (TMAs); work-based incentives; vanpool support; car-sharing programs; and accountability/program evaluation.

The Sacramento region currently has 12 TMAs which are designed to conduct education, outreach and coordination with major employers throughout the region. The MTP/SCS includes expansion of the TMAs to account for increasing population and employment. The MTP/SCS also assumes an expansion of TDM measures that would include direct incentives, such as partially or fully-subsidized transit passes, cash incentives for biking or walking, and partial or full subsidies to vanpool participants at targeted worksites accounting for up to 80 percent of the region's workforce. The MTP/SCS also assumes at least two jurisdictions will implement car-sharing programs by 2020, and two additional jurisdictions will implement car-sharing by 2035. Very few, if any, of the effects of these programs can be modeled in SACSIM, and must instead be captured using an off-model adjustment.

The GHG reduction reference documents cite a range of potential VMT and GHG reductions associated with enhanced TDM programs ranging from approximately 4 to 6 percent for voluntary programs to 21 percent, if the TDM programs become mandatory (they are now all voluntary). For the SACOG MTP/SCS, an enhancement of existing voluntary TDM programs could translate to a 0.9 - 1.4 percent reduction in VMT and GHG for 2020 and a 1.0 – 2.5 percent reduction by 2035. With a mandatory program, the range of reductions would increase to 2.5 – 4.5 percent in 2020, and 5.3 – 8.4 percent in 2035.

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[12] "Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emission," The Urban Land Institute (http://commerce.uli.org/misc/movingcoolerexecsum.pdf.); "Transportation and Land Use Policy Briefs," Marlon Boarnet and Susan Handy (http://arb.ca.gov/cc/sb375/policies/policies.htm.); and "Quantifying Greenhouse Gas Mitigation Measures," CAPCOA (http://www.capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf.)

[13] Current TMAs in the SACOG region include: 50 Corridor, McClellan Park, North Natomas, Point West Area, Power Inn Alliance, Sacramento, South Natomas, Yolo, and Yuba-Sutter.

Transportation System Management (TSM) and Intelligent Transportation Systems (ITS)

The current deployment level for TSM/ITS strategies in the MTP/SCS covers: ramp metering; variable message signs; incident management; arterial management; and traveler information.

By 2020, the MTP/SCS envisions a significant expansion of field monitoring and control equipment, including corridor management on the region's major freeway corridors. By 2035, the MTP/SCS would also include the deployment of active traffic management on river crossings in the region. Integrated corridor management would also be included for freeway corridors that include transit service, such as light rail and commuter buses.

While SACSIM can capture regularly occurring congestion, it cannot capture the impacts of traffic incidents or breakdowns. Off-model adjustments can be used to capture the VMT and GHG effects of these programs.

Urban Land Institute's "Moving Cooler" report provides information on the potential effects of implementing the types of TSM/ITS programs included in SACOG's MTP/SCS. The report defines these impacts based on three different levels of deployment: expanded current practice, aggressive deployment, and maximum deployment.

Work-At-Home Policies

SACOG notes that the number of workers telecommuting increased from 4 percent of the commute "mode" share in 2000 to 5.2 percent in 2010. This trend is anticipated to continue to increase into the future. While SACSIM includes a coefficient for working at home, changes to the coefficient did not result in significant changes to the model output, and it was determined that off-model adjustments were needed to capture these impacts.

The MTP/SCS SACSIM model run assumes that the number of work-at-home workers will increase to 5.6 percent in 2020 and remain at that level through 2035. The off-model adjustment was then used to calculate increased deployment level of either 6 or 7 percent in 2020, and 7 or 8.5 percent in 2035. The resulting effects of these additional work-at-home workers would range from a 0.04-0.18 percent GHG reduction in 2020, and a 0.13-0.39 percent reduction in GHG in 2035.

Overall Off-Model Adjustment Impacts

For its 2035 MTP/SCS, SACOG looked at both a "low" and a "high" level of deployment for the combined implementation of TDM, TSM/ITS, and work-at-

home strategies. In 2020, the effect ranges from 1.01-1.82 percent GHG reductions. In 2035, the range of reductions increases to 1.64-3.60 percent. SACOG took the mid-range of these off-model adjustment reductions and is claiming a mid-range reduction of 1.42 percent for 2020, and a mid-range reduction of 2.62 percent for 2035.

5. EMFAC Model

The EMission FACtors (EMFAC 2007) model developed by ARB, is a California specific computer model that calculates daily emissions of air pollutants from all on-road motor vehicles including passenger cars, trucks, and buses for calendar years 1970 to 2035. The model estimates exhaust and evaporative hydrocarbons, carbon monoxide, oxides of nitrogen, particulate matter, oxides of sulfur, methane, and CO_2 emissions. It uses vehicle activity provided by regional transportation planning agencies, and emission rates developed from testing of in-use vehicles. In addition to statewide emissions, the model can also estimate emissions at the county, air district, and air basin levels.

ARB maintains and periodically updates the EMFAC model. EMFAC undergoes an extensive validation process, which includes comparing the model outputs with those from independent data sources, reconciling fuel consumption estimates with fuel sales data, and comparing modeled to ambient emission ratios. Currently EMFAC 2007 is approved by U.S. EPA. ARB has released an updated version of the model, EMFAC 2011, which is currently under review by U.S. EPA.

C. Data Inputs and Assumptions for Modeling Tools

SACOG's MTP/SCS is based upon a number of significant inputs and assumptions, which influence the effectiveness of many of the strategies relevant to GHG emissions reductions. These inputs and assumptions provide the foundation for SACOG's modeling approach, and are used by SACOG's travel model to project changes in the land use and transportation systems. Inputs and assumptions include land use, socioeconomic and transportation network characteristics, and travel costs. ARB staff evaluated the appropriateness of the data on which these inputs and assumptions are based, and how well the model responds to changes in these inputs and assumptions, as demonstrated by SACOG's sensitivity analyses.

1. Demographics and the Regional Growth Forecast

Demographic inputs and assumptions describe the number and key characteristics of the population expected to be living, working, and travelling in a region during the period that an SCS plan is designed to serve. An MPO's employment, population, and household inputs into their models have a direct effect on their estimates of GHG emissions for the region. Each of these inputs to SACOG's MTP/SCS were reviewed.

One of the first steps SACOG undertook in development of the MTP/SCS was estimation of future population, employment, and housing, also referred to as their growth forecast. To prepare the forecast, SACOG contracted with the Center for the Continuing Study of the California Economy (CCSCE) and DB Consulting. The forecast was reviewed by SACOG staff, member cities and counties, and stakeholders, and subsequently adopted by the SACOG Board of Directors.

CCSCE followed standard regional projection methods and based its population and household growth projections on projected job growth. CCSCE's projection method followed three major steps: 1) based employment projections on projections of U.S. and California job growth and the competitive position of the Sacramento region to capture a share of the State's job growth; 2) based population projections on projected job growth and accounting for foreign immigration and domestic migration into the region; and 3) based household projections on projected population growth.

While SACOG's MTP/SCS is centered on a 27-year planning horizon of 2008-2035, SB 375 requires the SCS to demonstrate that it can achieve discrete target reductions in passenger vehicle greenhouse gases by the years 2020 and 2035. For this reason, and because a number of other SACOG planning processes rely on a 2020 phasing scenario, SACOG identified population, housing and employment projections for 2020. While the same economic and demographic factors used to develop the 2035 regional growth forecast were used to develop the 2020 growth forecast, a number of other variables were scrutinized to develop the 2020 forecast to reflect the relatively near-term time frame of 2020 and the expectation of recovery from the economic recession.

These additional variables included vacancy rates, growth rates, household formation behavior, and the health of the home building industry. The regional growth forecast used for the MTP/SCS is shown in the Table 13.

Table 13. MTP/SCS regional growth forecast

Year	Employees	Population	Housing Units
2008	966,316	2,215,044	884,725
2020	1,068,839	2,519,044	1,003,725
2035	1,327,424	3,086,213	1,187,744

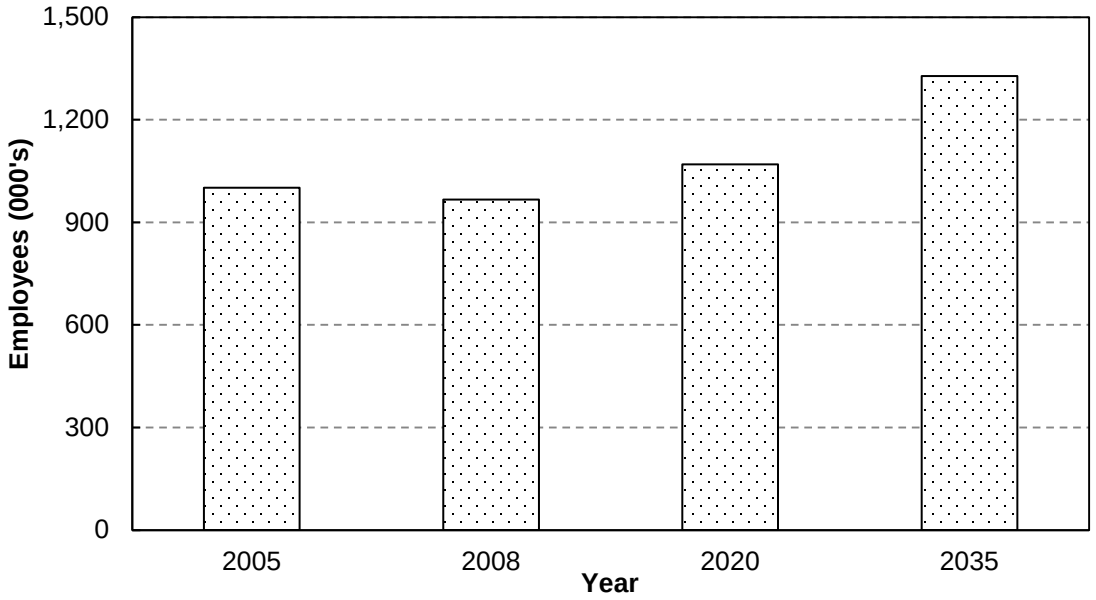
Employment

The first step in updating SACOG's regional growth projections was to develop new regional job projections. The amount of growth expected in the SACOG region depends on the share of U.S. population and job growth, located in California, and the share of that growth located in the SACOG region.

SACOG's forecast, as shown in Figure 7, indicates the need to accommodate approximately 103,000 new employees between 2008 and 2020, and 361,000 new employees between 2008 and 2035. Compared to SACOG's 2005 projections used in their previous plan (2008 MTP), there are about 208,000 fewer jobs in 2035, or a 14 percent decrease. SACOG explains that this decline is primarily a result of expected slower growth in California job and population levels since its previous forecast. The net result is that the region is capturing a slightly higher share of a much lower projected level of jobs in California.

The recent recession also contributes to a reduced rate of economic growth in the early years of the MTP/SCS. This causes the 2020 regional forecast to be slightly lower than it otherwise would have been due to lower expected growth in state government jobs, which are a critical part of the region's economic base.

Figure 7. SACOG employment projection

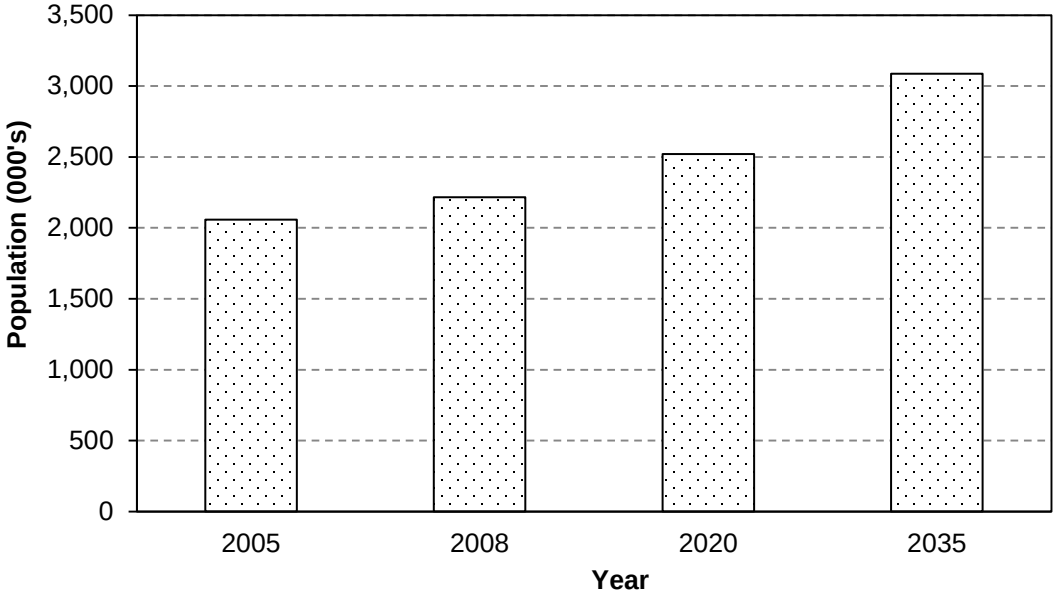


Population

SACOG's regional population projections are developed following a standard regional methodology, and assume that people migrate into or out of the region in response to job opportunities. The population projection process begins by projecting forward a base year population by age, sex, and ethnic group to 2020 and 2035 with initial assumptions about foreign immigration and domestic migration into the region. From this projection, a demographic-based labor force is predicted for comparison with the labor force needed to supply the job growth projected (see discussion above). Assumptions about domestic migration are either raised or reduced until the labor force supply matches the projected labor force needed to fill projected jobs. Assumptions for foreign immigration use an average of the "constant" and the "low" projections released by the U.S. Census Bureau in 2008.

SACOG's 2035 growth forecast, as shown in Figure 8, indicates that population in the plan area is expected to grow by approximately 304,000 people between 2008 and 2020, and 871,000 people between 2008 and 2035. The population growth projections used in this plan are lower than the population projections used in the prior MTP by about 8 percent.

Figure 8. SACOG population projection



A decline in domestic in-migration is the principal cause of the declining population projections compared to the projections used in the prior MTP. The recent recession also contributes to a declining rate of growth between 2008 and 2020.

In May 2012, the Department of Finance (DOF) released their "Interim Projections of Total Population for California and Counties July 1, 2015 to 2050", with projections of population and housing through the year 2050 that reflect currently available 2010 Census data and recent changes in demographic trends. SACOG's projections for population in 2020 and 2035 were compared with DOF's interim projections and were found to be consistent.

Households and Housing

Household projections were prepared for the SACOG region using the age and ethnic profile of the projected population growth as described above, and projections of household formation rates by age and ethnic group. Household formation rates are used to describe how populations in each age and ethnic group form households.

SACOG considered a number of questions in preparing household formation rates for this planning period, including:

- Whether or not the recent pattern of slow income growth will continue and how long it will affect the ability of younger residents to form independent households

- Whether or not the household characteristics of SACOG residents in this decade are a good guide for the household characteristics of residents in 2035
- How the recession and recent housing market turmoil will affect near and medium term housing decisions

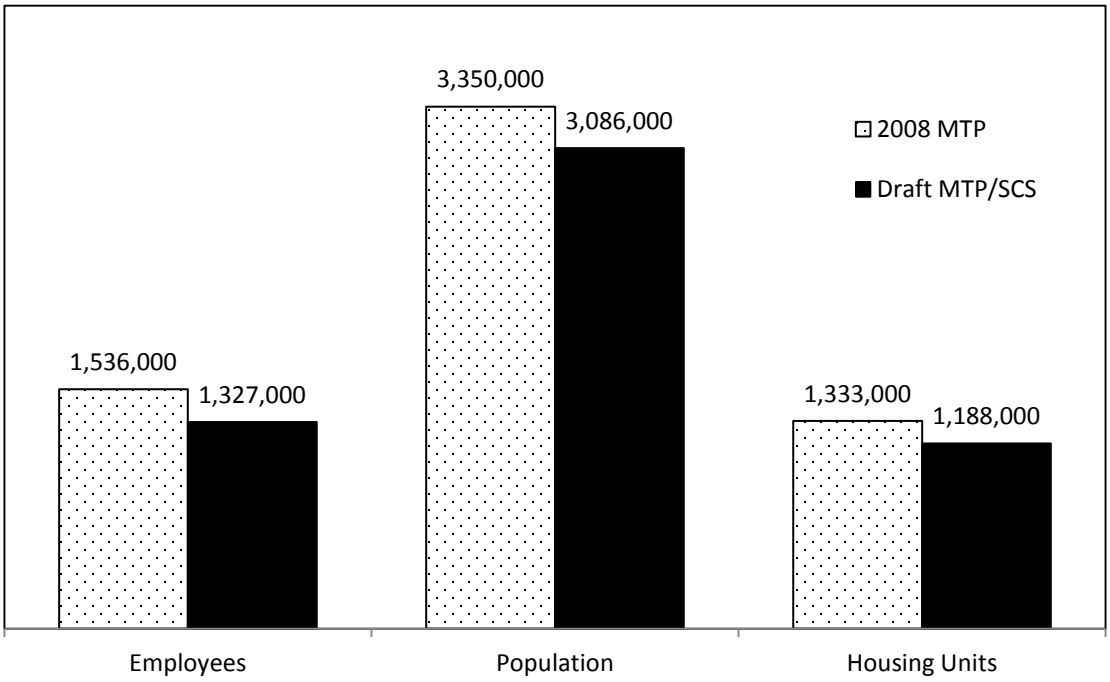
Based on a consideration of these and other factors, SACOG made modest changes to the region's previous household formation rate assumptions. Household size continues to trend downward between 2008 and 2020; however, the trend reverses between 2020 and 2035. The downward trend to 2020 is the result of an increasing number of older residents living alone, as well as an expected acceleration in the rate of income growth over the next 25 years. The upward trend in household size from 2020 to 2035 can possibly be explained by the growth of households with more than one adult (largely from forecasted growth in Hispanic and Asian populations in the region).

Using these assumptions, the SACOG region is projected to add close to 11,000 households per year between 2008 and 2035, for a total of approximately 295,000. Between 2008 and 2020, SACOG projects the region will add over 12,000 households per year, or approximately 148,000 households total. SACOG projects most of the household growth will be headed by residents aged 25-34 in the early years, and all of the growth in households headed by residents aged 35-54 will occur after 2020. Most of the growth in households by 2035 will be headed by residents aged 65 and above.

SACOG derived the projected number of housing units in the region, and the implied construction levels for new housing from the household growth projections noted above, as well as through consideration of other factors. One factor accounts for needed replacement of units that are demolished. Other factors, which tend to be more relevant in the short and medium terms, are housing inventory, vacancy rates, financing terms and consumer sentiment in the region.

At the present time, all of these factors argue for slower growth in housing unit construction relative to the demographic household formation projections. Figure 9 shows the decrease in population, employment, and housing units projected for 2035 between SACOG's 2008 MTP and their MTP/SCS.

Figure 9. SACOG 2008 MTP and MTP/SCS forecasts for 2035



In particular, SACOG points out that for this planning cycle, the region has a large stock of vacant housing that will be refilled over time, therby dampening demand for new housing. The region estimates that while its normal vacancy rate is 5 percent, the recent recession and housing market turmoil have increased the rate to 9 percent. For this reason, SACOG staff assumes that it will take some time to work through the region's oversupply of existing housing and the outlook for near-term construction is lowered. As a result, SACOG projects the need to add just 159,000 housing units between 2008 and 2020, and a little over 343,000 housing units between 2008 and 2035.

State law requires the Department of Housing and Community Development (HCD) to determine SACOG's existing and projected housing need. The passage of SB 375 in 2008 included revisions to this process which, among other things, are intended to promote better coordination between the regional housing plan and regional transportation plan processes. In assessing SACOG's regional housing need, HCD considered available data from both the 2010 Census and the American Community Survey. For this cycle, SACOG also considered the uncertainty of the national, State, and local economies and housing markets, and made adjustments to account for abnormally high vacancies, and unique market conditions. The resulting analysis showed the region needed to accommodate

an additional 5,000 housing units by 2021 beyond what will be available in 2020.[14] When considering the one-year difference in the projection, SACOG's housing unit projection for 2020 is reasonable and consistent with HCD's determination.

2. Current and Future Land Use Development Patterns

MPOs develop a long-range land use forecast during their transportation plan development process that estimates three major characteristics: how much development will occur in the region, where that development will be located, and at what intensity that development occurs. In this case, "development" means both households and employment, and indirectly population.

The anticipated future growth pattern, or land use forecast, is a critical input to an MPO's SCS. This is because people's travel needs depend, to a large extent, on the locations of homes, employment, shopping, recreation and other destinations. Forecasting of future development patterns is an important step to developing an accurate picture of future travel demand in the region. As such, it becomes the basis from which MPOs begin planning what transportation infrastructure and services (transportation supply) are needed to serve the region's future population.

When reviewing SACOG's MTP/SCS, the evaluation focused on the process SACOG used to generate its assumptions about future land use patterns. SACOG's land use forecast was also reviewed to verify that the projected levels of population, housing and employment were accommodated.

Land Use Forecast Process

Federal air quality regulations (40 CFR 93.122) require that the land use assumptions in an MPO's regional transportation reflect the growth pattern that is most likely to occur, based on the best information available.

In documenting its land use forecast process, SACOG states that its MTP/SCS growth and land use forecast considers the general plan documents prepared by cities and counties within the region. In addition, SACOG considers a number of other factors, including pending local plan updates, other land use and transportation policies and regulations, as well as mrket and economic considerations. These factors are consistent with guidance on developing SCS planning assumptions provided in the CTC's 2010 RTP Guidelines and are summarized in Table 14.

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[14] Comparing the projected housing units for 2021 used in this process, 1,008,780, to the projected housing units in the proposed MTP/SCS for 2020 of 1,003,725 there is about a 5,000 unit difference.

Table 14. Factors SACOG considered in its land use forecast

Consideration	Description
Local Plans and Policies	Local general plans, spheres of influence and community and specific plans affect the type and intensity of future land uses. Proposed and pending plan updates are also considered in addition to currently adopted plans.
Other Regulations and Policies	Regulations and policies can include, but are not limited to regulations regarding development in floodplains and other natural hazard areas, federal Clean Water and Endangered Species Act permit requirements and state housing requirements. Policy priorities for transportation funds covered by the MTP are also considered. Through the last two MTP updates, SACOG's overall policy priorities for SACOG funds and establishment of specific programs reflect a commitment to support Blueprint principles. SACOG's emphasis on performance in reducing vehicle miles traveled, increasing transit, walk and bike, and high-occupancy vehicle mode shares, and reducing congestion at key bottlenecks are expected to have some influence on shaping the region's future growth.
Market and Economic Considerations	Market considerations include the strength of sub-regional job markets, people's interest in different types of housing and developers' abilities to deliver that housing at affordable prices. Cost and timing of providing infrastructure such as water, sewer and transportation are considered. Future demographic trends (e.g. age distributions, household composition and income) are also taken into account.

SACOG used an extensive public process to address these issues when developing its land use forecast. SACOG's Planners Committee was the primary venue for coordination with local agency planning staff. In addition, a number of jurisdiction-specific meetings, public workshops, as well as committee and board meetings were used to gather and discuss additional input on the regional land use forecast.

Three land use and transportation scenarios were considered for use as the basis of the MTP/SCS. A mix of land use and transportation elements were considered across the scenarios, with all scenarios built from the same regional employment, population, and housing growth projections, with very small variations in the transportation budget.[15] SACOG designed land use patterns first and then customized a transportation system to support the land use pattern of each scenario. Land use components were designed in a progression from most dispersed development pattern to least dispersed development pattern, and

[15] The scenario transportation budgets ranged from a low of $34.6 billion in Scenario 1 to a high of $36.1 billion in Scenario 3, reflecting variation in the transit fare box recovery rate that ranged from 31 percent in Scenario 1 to 52 percent in Scenario 3. The assumption of higher percentage of transit fares recovered in Scenario 3 results from Scenario 3 containing the highest share of transit-supportive land uses. All other revenue assumptions were constant across scenarios.

the corresponding transportation components followed a progression of most auto-oriented transportation system to most multimodal transportation system. Table 15 describes the three scenarios that SACOG staff workshopped.

Table 15. MTP/SCS workshop scenarios

Scenario	Land Use Characteristics	Transportation Characteristics
1	• Smallest share of new compact housing (61%, same as 2008 MTP) • Smallest share of growth in Transit Priority Areas (20% of new homes, 26% of new jobs) • Most dispersed development pattern and highest amount of developed acres	• Least transit service • Least BRT, street car, and light rail • Highest new roads and road expansion • Least road maintenance and rehabilitation • Least bike and pedestrian projects
2	• Higher share of new compact housing (68%, same as Blueprint growth strategy • More growth in Transit Priority Areas • Less dispersed development than scenario 1, fewer developed acres	• More transit service than scenario 1 • More BRT, street car and light rail • Less new road and road expansion • More road maintenance and rehabilitation • More bike and pedestrian projects
3	• Highest share of new compact housing (75%) • Highest share of growth in Transit Priority Areas • Least dispersed development pattern and fewest development acres	• Highest transit service • Highest BRT, street car, and light rail • Least new roads and road expansions • Same road maintenance and rehabilitation as Scenario 2 • Most bicycle and pedestrian projects

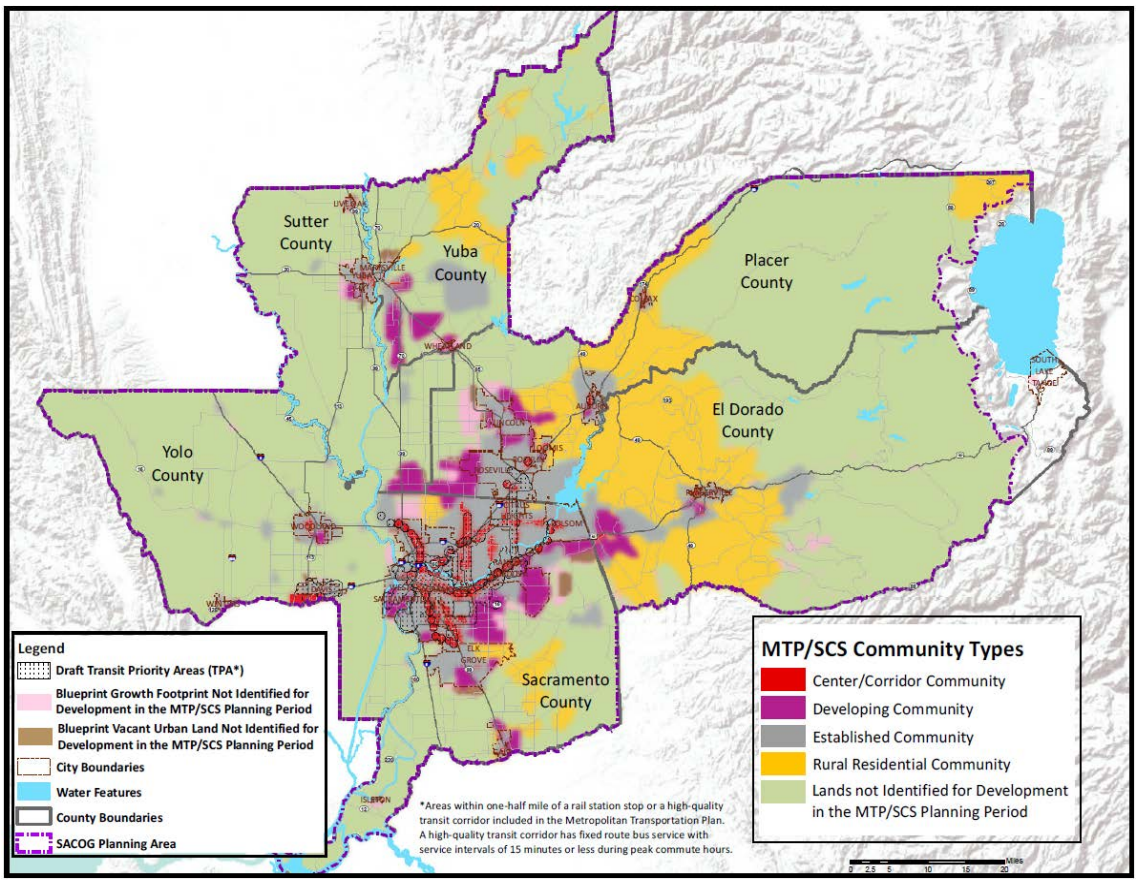
SACOG developed a community-type framework to encourage greater stakeholder understanding, interaction, and discussion of the various scenarios. Table 16 summarizes the five community types.

Table 16. SACOG's community-type franework

Community Types	Description
Center and Corridor Communities	Typically these areas are defined as including historic downtowns, main streets, commercial corridors, rail station areas, central business districts and town centers. Center and Corridor Communities have a wide variety of transportation infrastructure compared to the rest of the region, including frequent transit service, pedestrian and bicycling infrastructure..
Established Communities	These areas are typically adjacent to or surrounding Center and Corridor Communities. Residential and commercial development is at lower to medium densities, and can include office parks and commercial strip centers. Depending on the density of existing land uses, some of these communities have bus service, while others have commuter bus, or very little transit service.
Developing Communities	These areas usually, but not always, are at the edge of existing urban or suburban development. These communities can be residential-only, employment-only or a mix of residential and employment uses. Mixed residential and employment land uses in these communities are typically at low to medium density residential with supporting commercial and public uses.
Rural Residential Communities	Rural Residential Communities are located outside of urbanized areas. These areas are predominantly residential with some small scale hobby and commercial farming. Travel in these communities is almost exclusively by automobile, with little or no transit service available.
Lands Not Identified for Development	These areas are not identified for development to urban levels during the period considered by SACOG's MTP/SCS (2008-2035). Land use on these areas are projected to continue as non-urban uses, such as agriculture, natural resource extraction, forestry, mining, flood protection or combinations of these uses.

After considering input from local planning staffs and the public, SACOG's Board of Directors included a land use forecast in the MTP/SCS based on workshop Scenario 3 with elements of Scenario 2. Figure 10 shows the land use forecast assumed in the MTP/SCS with community type references.

Figure 10. MTP/SCS land use by community type



Evidence for the MTP/SCS Land Use Forecast

The land use forecast included in SACOG's MTP/SCS accommodates a nearly 40 percent increase in population with only a 7 percent increase in the development footprint of the region. SACOG concludes that this land use pattern can be achieved based on available evidence that there will be higher demand for attached and small-lot single family housing products over the MTP/SCS planning period, along with lower demand for large-lot-single-family housing products, which currently make up the majority of housing in the region.

Both the region's local general plans and SACOG's analysis of housing market trends in the region seem to support a preference for increased attached and smaller lot single family housing products. As part of its MTP/SCS planning process, SACOG researched and prepared a white paper on trends in housing demand.[16] This research suggests a shift in the housing products that will be

[16] See Appendix E-6 of SACOG's MTP/SCS for full paper and bibliography.

needed to accommodate the impact of the region's population on housing product demand, this includes the aging of the baby boom generation (those born between 1946-1964), the preferences of the more populous Generation Y cohort (those born between 1978 and 1994), and continued immigration into the region. These findings are directionally consistent with other currently available housing market studies for California.

SACOG also assumes that new housing in the region will be made up of a higher proportion of small-lot and attached housing product types, allowing the region to take advantage of more infill and mixed-use opportunities and accommodate future growth through a more compact land use pattern. The MTP/SCS land use forecast takes advantage of infill and reuse opportunities within Center and Corridor Communities and Established Communities where over 90 percent of the region's current housing and employment is located. The plan places 30 percent of new homes in Centers and Corridor Communities, and 26 percent of new homes in Established Communities over the entire plan period. Taken together, over 50 percent of new growth in housing and over 80 percent of new growth in jobs will occur in the established urbanized areas of the region.

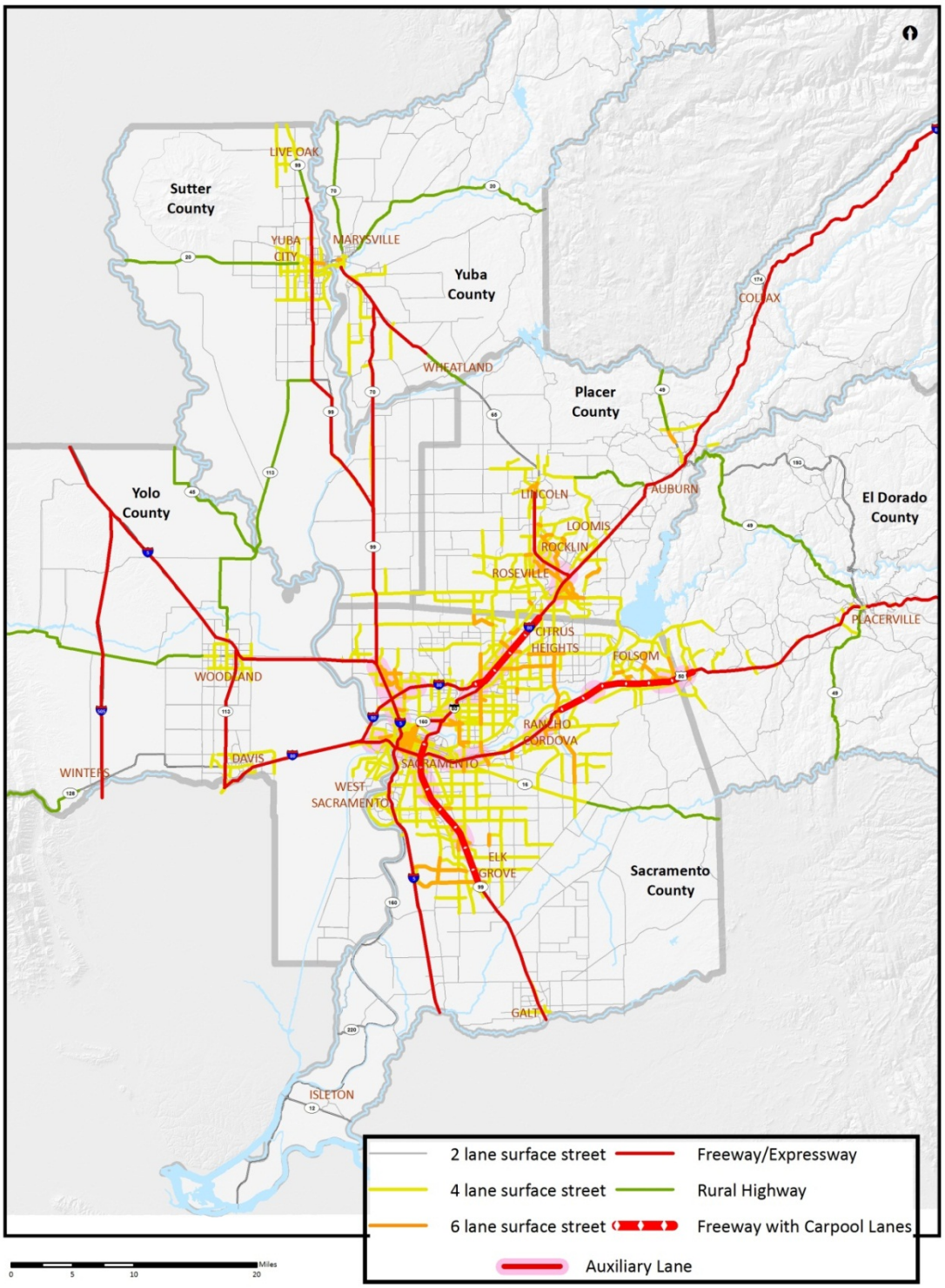
3. Transportation Network Inputs and Assumptions

The transportation network is a map-based representation of the transportation system serving the SACOG region. One part of that transportation network is the highway network, which consists of an inventory of the existing road system, highway travel times and distances, automobile travel simulations, and associated impacts from pollution, energy use, and accidents. The other part of the transportation network is the transit network, data from which is used to model the impacts of transit and land use strategies on travel patterns throughout the region. The regional highway and transit networks, link capacity, and free-flow speed assumptions used in SACOG's regional travel demand model were reviewed. The methodologies SACOG used to develop the transportation network and travel model input assumptions are consistent with guidelines given in the NCHRP Report 365. SACOG performed sensitivity test runs to examine the travel demand model's responsiveness to roadway capacity. A summary of the sensitivity test results is presented in the Model Sensitivity Analysis section of this report.

Highway Network

The SACOG highway network is a representation of the automobile roadway system, which include streets, roads, arterials, and freeways in the region. This network provides the basis of estimating zone-to-zone travel times and costs for the trip distribution and mode choice steps of the modeling process, and for trip routing in the vehicle assignments. The highway network also serves as the basis of bus running times and zonal walk and drive access for transit time and assignment. The 2008 SACOG highway network is presented in Figure 11.

Figure 11. 2008 SACOG roadway network



Roadway types in the SACOG highway network include freeway, expressways, arterials, ramps, rural roadways, and special highway links.[17] SACOG's travel demand model uses facility type classifications consistent with the Federal Functional Highway Classification system. The 2008 lane miles by type of roadway in the SACOG region are summarized in Table 17.

Table 17. Lane miles by roadway type

Roadway Type	Lane Miles (2008)
Freeway general purpose lanes (i.e. mixed flow)	1,462
Freeway managed lanes (e.g. HOV, HOT, Tolled)	64
Freeway auxiliary lanes and ramps	196
Arterial/expressway	3,609
Collector and local streets	22,000

Variables coded to the SACOG highway network include free-flow speed, link distance, link capacity class code, number of lanes, speed-flow curve selector (or facility type), ramp meter indicator (for AM/PM peak period), and access codes for path building and assignment.

SACOG staff compared roadway route mileage[18] and lane mileage[19] to corresponding Highway Performance Monitoring System (HPMS) data for validation purposes. As a result, the modeled result to observed data ratio of route mileage and lane mileage is consistent, at 0.96 and 0.98, respectively.

The description of SACOG's highway network development was compared with the National Cooperative Highway Research Program (NCHRP) Report 365. The NCHRP Report 365 describes travel demand modeling theory and techniques, and their common applications by transportation planning agencies, and observed data for key modeling parameters at the national level. SACOG followed acceptable practice, consistent with the NCHRP 365 report. In addition, the facility type definitions used in the SACOG highway network are consistent with FHWA's Federal Functional Highway Classification system.

[17] Special highway links include centroid connectors, bike/walk links, park-and-ride connectors, and HOV connectors. Centroid connectors are abstract links in the model, intended to represent local street access to the collector-and-above roadway network.

[18] Route mileage is the centerline mileage of roadway, regardless of the number of lanes.

[19] Lane mileage is the centerline length of a roadway multiplied by the number of lanes of roadway provided.

Roadway Capacity

Roadway capacity is defined as the number of vehicles that can pass a certain point of the roadway at free-flow speed in an hour. Roadway capacity is used as an input to the travel demand model for estimating congestion, defined as the additional vehicle-hours of delay traveling below free-flow speed.

Procedures to estimate roadway capacity are described in the Transportation Research Board's "Highway Capacity Manual 2000" (HCM). According to the HCM, a travel model should be able to reflect the change in demand due to new transportation policy or project such as congestion pricing or roadway expansion. In the SACOG travel demand model, roadway capacity is classified by facility type. The roadway capacity varies by the facility types used in the modeling of the SACOG regional highway network and is expressed as hourly capacity in the unit of vehicles-per-lane-per-hour (vplph), as summarized in Table 18. The link capacities used in the SACOG highway network are within reasonable limits because the maximum capacities are less than or equal to the suggested maximum link capacities in the HCM.

Table 18. Roadway capacity and free-flow speed

Facility Type	Range of Capacity (vplph)	HCM 2000 Maximum Capacity Range (vplph)
Freeway	1,500 to 2,000	2,100 to 2,400
Expressway	1,000 to 1,500	1,900 to 2,200
Other urban/suburban surface streets	700 to 850	N/A
Ramps	500 to 2,000	1,800 to 2,200
Rural Roadways	750 to 1,000	N/A

Free-Flow Speed

Free-flow speed is used to calculate the shortest travel time between two points (links) in the highway network. Factors such as the prevailing traffic volume on the link, posted speed limits, adjacent land use activity, functional classification of the street, type of intersection control, and spacing of intersection controls can affect link speed. SACOG considered both peak period and off-peak travel speeds in the estimation of free-flow speed. SACOG's reported posted speeds by facility type are listed in Table 19. Free-flow speeds are coded based on local knowledge and judgment, and vary within specific capacity classes. SACOG staff validated free-flow speed with field data and studies conducted by their consultants.

Table 19. Average free-flow speed by facility type

Facility Type	Average Speed (mph)
Freeway	56.0 to 63.0
Expressway	45.0 to 52.1
Other urban/suburban surface streets	29.2 to 37.2
Ramps	18.3 to 41.7
Rural Roadways	40.3 to 52.3

The methodology SACOG used in estimating highway free-flow speeds was reviewed. SACOG's estimation of free-flow speed based on the posted speed is consistent with the recommended practice indicated in the NCHRP Report 365.

Transit Network

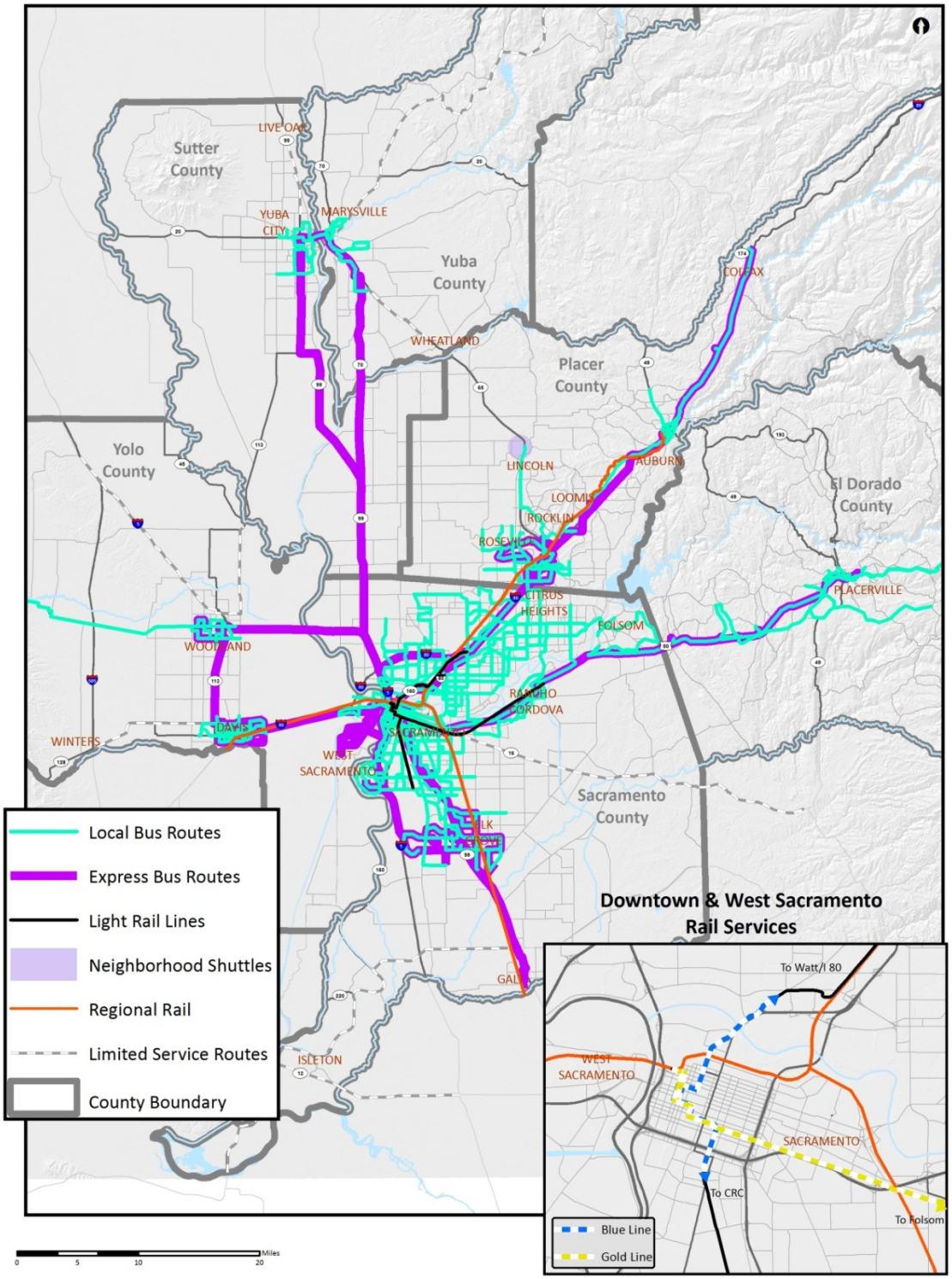
Besides the highway network, the transit network is the second largest part of a region's transportation network. The purposes for development of a transit network are verification of access links and transfer points, performance of system level checks on frequency and proximity between home and transit station/stop, and relating transit speeds to highway speeds. For consistency purposes, procedures used by SACOG for the regional transit network development were compared with those in the NCHRP Report 365 and USDOT-FHWA Manual.

SACOG's regional transit network was built directly off the completed regional highway network and included attributes such as regional transit operators, transit lines, and daily boardings. The 2008 transit system operation coverage in the SACOG region is summarized in Table 20 and shown in Figure 12.

Table 20. Transit system operation miles

Transit System	Operation Miles (2008)
Local, express bus, bus rapid transit, and neighborhood shuttle	3,816
Transit rail	258

Figure 12. 2008 SACOG transit network



The major fixed route transit services in the SACOG region are represented in the transit networks as “lines”, or a series of stops served by a transit vehicle at a specified service frequency. Transit routes were characterized by attributes such as transit line name, transit service type, and fares. The transit network also included detailed frequency and schedule information for both peak and midday service. Park-and-ride locations that have commute period transit service are also coded into the transit network.

For validation purposes, SACOG performed two generic checks of transit networks: schedule running times, and system total revenue hours and miles of service for the region’s major transit operator (e.g. Sacramento Regional Transit District). The scheduled and modeled cumulative running time of the 2008 Light Rail Transit (LRT) station-to-station run times are all within one minute difference. The ratio of the modeled-to-actual revenue hours of service and modeled-to-actual revenue miles of service is reasonable at 0.97 and 1.08, respectively.

The description of the SACOG’s transit network development was compared with procedures discussed in the “NCHRP Report 365” and USDOT-FHWA Manual. SACOG followed acceptable practice, consistent with these reports.

Non-Motorized Network

The non-motorized network is the final part of SACOG’s regional transportation network. This network of bike and walk links are integrated into the completed highway network, and allow for more accurate accounting of trip mode share across locations where only biking or walking is allowed. Table 21 presents the base year non-motorized mode lane miles assumed in the SACOG travel demand model.

Table 21. Non-motorized network lane miles

Non-motorized Mode	Lane Miles (2008)
Bicycle and pedestrian (Class I)	397
Bicycle and pedestrian (Class II)	1,059

SACOG’s non-motorized network was built directly off the completed regional highway network. Two types of bikeway for bicycle and pedestrian use are included in the non-motorized network: Class I and Class II[20] bikeways. The

[20] Class I bikeways provide a completely separated right of way for the exclusive use of bicycles and pedestrians, with cross-flow by motorists minimized. Class II bikeways provide a lane for one-way bike travel on a street or highway, which is separated from autos with road striping.

definitions of Class I and II bikeways are consistent with those given in the "Highway Design Manual" by the California Department of Transportation (Caltrans).

The description of the SACOG non-motorized network development was compared with procedures discussed in the "NCHRP Report 365" and USDOT-FHWA Manual. SACOG followed acceptable practice, consistent with these reports.

4. Travel Demand Inputs and Assumptions

Assumptions related to number of trips and trip lengths influence what the model predicts about the amount of travel occuring in a region. In addition, assumptions related to the cost of travel in a travel demand model influence what is predicted about what modes of travel are used for trips in the region.

ARB staff reviewed inputs and assumptions used in SACOG's travel demand model related to factors that influence the amount of regional travel and travel modes. Specifically, values for trip generation, trip length, vehicle operating cost and transit fare cost were compared to independent data sources. In addition, sensitivity tests such as auto operating cost and transit fare cost were reviewed to examine the performance of the SACOG travel demand model. The results of the sensitivity test runs are summarized in the Model Sensitivity Analysis section of this report.

Trip Generation Rates

Trip generation is the average daily person trips for each trip type in a planning region. Important factors that can influence the amount of travel in a region include, but are not limited to, automobile ownership, income, household size, density and type of employment, the availability of public transportation, and the quality of the transportation system. SACOG used its 2000 SACOG Household Survey data to estimate trip rates in the region.

SACOG models trips as part of tours. A single tour represents all of the activities and travel one person does between leaving home and returning home and includes trips for activities such as work, school, shopping, and recreation. Tours can be grouped into 4 activity categories: home-based work, home-based school, work-based, and non-work/school-based, which follow the standards provided in the "NCHRP Report 365".

To compare trip rates to independent sources such as the 2009 National Household Travel Survey (2009 NHTS), ARB converted SACOG's all-purpose trip rates to trip rates by mode of transportation, by applying SACOG's mode share data. Table 22 summarizes the base year trip rates by mode in the SACOG region compared to trip rates by mode in the 2009 NHTS.

Table 22. Trip rates by mode of transportation

Mode	Average Weekday Person Trips Per Household		
	SACOG (2008)	NHTS (2009)	Difference from NHTS (%)
Drive alone	9.29	7.92	17
Transit	0.14	0.18	-24
All modes	10.57	9.50	11

Overall there is an 11 percent difference between rates of person trips by all modes between SACOG's model assumptions and 2009 NHTS measurements. SACOG's model assumes a slightly higher trip rate per household than the national average. The difference could be based on national and regional distinctions and attributes. Additionally, the data used to estimate trip rates for SACOG's model and the 2009 NHTS study were collected at different times, which could also help to explain the differences.

Trip Length Distribution

In the trip distribution step of the travel demand model, trip lengths are estimated using the highway network and are used as inputs to calculate zone-to-zone travel impedances. To check the reasonableness of the SACOG trip length inputs, SACOG trip length data, by mode of transportation, was compared to the 2009 NHTS data. Table 23 summarizes the average trip length inputs and the comparison to the 2009 NHTS data.

Table 23. Average trip length

Mode	Average Trip Length (miles)	
	SACOG (2008)	NHTS (2009)
Auto	5.8 to 7.1*	12.09
Transit	4.0 to 13.9**	10.18
Bike	1.9	N/A
Walk	0.8	0.98
School Bus	4.8	N/A

*Average trip length is 5.8 and 7.1miles for shared ride and drive alone, respectively.

** Average trip length for transit-walk access and transit-drive access is 4.0 and 13.9 miles, respectively.

SACOG's trip length for auto trips is on average shorter than the national level, while the trip length for transit trips is longer than the national level. Differences

between the SACOG and the 2009 NHTS data are expected because of the dissimilarity between the 2009 NHTS study data and SACOG data.

Vehicle Operating Cost

The SACOG travel demand model assumes that "out-of-pocket" vehicle operating costs have the greatest influence in determining automobile usage. These costs include fuel, maintenance, and tire wear averaged per mile for a "typical" driver. SACOG's travel demand model excluded fixed cost factors such as purchase price of the automobile, financing costs, insurance, and depreciation. The assumed year 2008 vehicle operating cost in the SACOG model expressed in year 2000 dollars is 18 cents per mile, which includes a fuel cost of 13 cents per mile and other costs of 5 cents per mile. Table 24 summarizes the breakdown of auto operation cost items used in the SACOG travel demand model.

Table 24. Auto operating cost breakdown

Variable	Year 2008 Value
Fuel Price Per Gallon (year 2000 $)	$2.79
Average Auto Miles/Gal	21
Gas Cost Per Mile (year 2000 $)	$0.13
Tire, Maintenance Cost per Mile (year 2000$)	$0.05
Total Auto Operating Cost Per Mile (year 2000$)	$0.18

Fuel price is an important factor that influences per capita VMT. The price of fuel is the amount consumers pay at the pump for regular grade gasoline (in dollars/gallon). Studies show that when gasoline prices go up, drivers are expected to decrease their frequency of driving, reduce their travel distance, increase their use of public transit, and/or switch to more fuel efficient cars. Conversely, lower gas prices have the opposite effect.

Fuel costs are the most significant share of auto operating costs in the SACOG modeling analysis. Gasoline price was forecast out to 2035, following the methodology agreed upon by major California MPOs. This consisted of using the high and low gasoline price forecasts from the United States Department of Energy's (USDOE) Energy Outlook with Projection to 2035, taking 75% of the difference between the high value and the low value, adding this to the low value, and then adding $0.25 to account for the higher cost of California gasoline. The forecasted gasoline prices match exactly with those forecasted by the other major MPOs.Forecasted gasoline prices for the years 2020 and 2035 are summarized in Table 25.

Table 25. Gasoline price forecast

Year	SACOG (2009$/gallon)	USDOE (2009$/gallon)	Difference USDOE (%)	CEC (2009$/gallon)	Difference CEC (%)
2020	$4.74	$4.03	18	$4.46	6
2035	$5.24	$5.85	-10	N/A	N/A

The forecasted gasoline prices used as inputs for the SACOG model were also compared to those forecasted by the California Energy Commission (CEC) and US DOE. The differences between the SACOG's forecasted gasoline prices and USDOE's range from -10 to 18 percent, the difference is 6 percent when compared to CEC's year 2020 value.

Transit Fare

Transit fare is the fee paid by a passenger to make use of a public transit system such as local bus, express bus, and commuter rail. Besides generating revenue, transit fare is usually used as a pricing strategy to promote public transit ridership. SACOG used zone-to-zone transit fares as inputs to the mode choice step of its travel demand model.

SACOG disaggregated transit fare types by boarding and transfer fares for each group of transit services, using individual trip payment (also known as the one-way payment), multiple-ride tickets, and unlimited-ride passes. SACOG included the one-way payment and monthly unlimited-ride passes as applicable purchase methods for regional transit fares. Transit services with similar fares were grouped together. The model used average transit fares for 2000 and 2005. Table 26 summarizes the average ranges of transit fares by fare group, operator, and service type used in SACOG's travel demand model.

Table 26. Average transit fares

Fare Group	Operator	Service Type	Subsidy Rate (%)	Average Range of Real Fares (in 2000 dollars)
1,2	Sacramento Regional Transit District	All	20	$1.35 to $1.43
3	Yolobus	Express	20	$1.44 to $1.62
4	Yolobus	Local Fixed Route	20	$1.03 to $1.22
5	Roseville Transit	Commuter	20	$2.05 to $2.43
5	Yuba Sutter Transit	Commuter	20	$2.33
8	El Dorado Transit	Commuter	20	$2.50 to $3.16
8	Placer County Transit	Commuter	20	$3.06
9	Placer County Transit	Local Fixed Route	20	$1.50 to $1.38
9	Roseville Transit	Local Fixed Route	20	$0.81 to $1.12
9	Yuba Sutter Transit	Local Fixed Route	20	$0.76
9	El Dorado Transit	Local Fixed Route	20	$1.10 to $0.84
10	Unitrans	Local Fixed Route	N/A	N/A
10	Hornet	Local Fixed Route	N/A	N/A

D. Model Sensitivity Analysis

As they relate to an MPO travel demand model, the use of sensitivity analyses is intended to provide an indication of how the model actually behaves (compared to how it is expected to behave) and whether the model is capable of producing forecasts that could reasonably be expected to result from the data inputs and assumptions used. Sensitivity analyses are not intended to quantify model inputs or outputs or provide an analysis of actual modeled data. They are simply intended to assess the performance of the model itself.

Conducting a sensitivity analysis consists of a process of changing one single model input variable at a time (such as increased transit frequency, fuel price, or residential density) to see if and to what extent certain model outputs, such as VMT, react (or are sensitive) to such changes. Travel modelers will typically rate models as being sensitive as long as changes in model outputs result from changes in model inputs. ARB's analysis goes further by asking whether or not the results of the SCS sensitivity analysis demonstrate that the model is showing output changes that are within the range of values published in relevant empirical literature. In those cases where SACOG's sensitivity analysis findings could not be corroborated by the empirical literature, ARB staff indicated that the findings were sensitive, meaning that changes in model inputs resulted in changes to model outputs. In those instances where the findings were corroborated by the empirical literature, the findings were referred to as either directionally sensitive, meaning that the direction of change was consistent with findings in the empirical literature, or sensitive in magnitude, meaning that the amount of change predicted was consistent with the literature.

SACOG staff provided a sensitivity analysis report generated from SACSIM. The report contained a series of sensitivity test results for the following model variables:

- Auto Operating Cost
- Transit Fares
- Household Income
- Roadway Capacity
- Regional Accessibility
- Mix of Use
- Proximity to Transit
- Street Pattern
- Residential Density

ARB staff evaluated the results of SACOG's sensitivity analyses to understand how the model outputs changed as the inputs changed. Changes in model outputs were compared with expected changes indicated in the empirical literature. In those cases

where the range of elasticities[21] was available in the literature, ARB staff applied them to changes in model inputs that were used in SACOG's sensitivity analyses. This information provided a better understanding of the travel demand model's capacity to effectively capture the GHG emissions impacts of SACOG's SCS on key model outputs such as VMT, trips, and mode share.

This section provides a summary of the evaluation. We note that neither the sensitivity analyses, nor pertinent findings in the empirical literature, are in all cases definitive. The integration of sustainable community strategies into transportation modeling is still relatively new, resulting in analytical knowledge gaps that experience and new research will overcome over time. Nevertheless, based on examination of SACOG's specific sensitivity analyses and the relevant empirical literature, the evaluation shows that SACOG's analysis of model output changes is reasonable, and that SACSIM is generally sensitive for the variables tested. For many of the variables, SACOG's results were consistent with the empirical literature. In some cases, no comparable empirical studies were available which examined the same inputs and outputs as SACOG's analysis. Such a comparison is important to ensure that staff's analysis is technically sound. In a few of the individual test runs SACOG's results were slightly outside the range of expected impacts based on the literature. These instances are explained in more detail in the following sections with explanations of factors that may have affected the sensitivity test results.

1. Auto Operating Cost

Auto operating cost is an important factor influencing travelers' auto use. When auto operating costs increase, travelers tend to drive less. Conversely, when auto operating costs decrease, travelers are expected to drive more.

SACOG performed six sensitivity test runs to examine the responsiveness of the travel demand model on the change of auto operating cost. The six test results range from a 6.7 percent to 53.3 percent change from the base case. Relative elasticities of VMT to auto operating costs were reviewed based on the empirical literature.

Based on this review, the short-run elasticities (less than five years) of VMT relative to auto operating cost ranged from -0.02 to -0.09 (Small and Van Dender, 2007), -0.15 (Agras and Chapman, 1999), and -0.23 (Oum et al, 1992). The long-run elasticities (greater than five years) from these studies ranged from -0.11 to -0.34 (Small and Van Dender, 2007), -0.32 (Agras and Chapman, 1999), and -0.28 (Oum et al, 1992).

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[21] An elasticity is defined as the percent change in one variable divided by the percent change in another variable.

Table 27 summarizes the results of SACOG's sensitivity test runs on VMT changes with respect to the change of auto operating cost. As expected, the modeled VMT for each of the test cases changed in the same direction. However, the change in magnitude for 3 of the cases do not fall into the expected ranges. The difference between the modeled VMT values that do not fall into the expected ranges and the respected boundary value of the expected range is within 1 percent. For example, in the case where auto operating costs increase 20 percent from the base case, the difference between the SACOG modeled VMT and the minimum value of the long-run expected range is 0.3 percent. Some possible explanations for the difference are the way the empirical literature defines "auto operating cost", the difference in study location, and differences in when the studies were performed.

Table 27. Auto operating cost sensitivity tests

Test Case	SACOG Modeled VMT (thousands)	Short-run Expected Range*		Long-run Expected Range**	
		Minimum	Maximum	Minimum	Maximum
53% decrease from base case	38,611	35,865	39,839	37,568	41,921
13% decrease from base case	35,471	35,581	36,574	36,006	37,095
7% decrease from base case	35,862	35,533	36,030	35,746	36,290
Base case	**35,486**	--	--	--	--
7% increase from base case	35,132	34,942	35,439	34,682	35,226
20% increase from base case	34,793	33,854	35,344	33,073	34,705
53% increase from base case	32,849	31,133	35,107	29,051	33,404

* Calculated based on short-run elasticities of -0.02 to -0.23.

** Calculated based on long-run elasticities of -0.11 to -0.34.

2. Transit Fare

SACOG performed sensitivity tests to gauge the impact of increasing and decreasing transit fares to VMT changes in the model. Tests were conducted by varying transit fare in the model by 5, 10, and 50 percent from the 2005 base year fare, and analyzing the resultant changes in VMT and travel behavior such as the number of transit person trips.

The empirical literature on transit fare changes indicates that as transit fares decrease, transit person trips should increase. Conversely, increasing transit fares should result in fewer transit person trips. As shown in Table 28, SACSIM estimates increasing

numbers of transit person trips when transit fares were decreased and conversely, transit person trips decreased with increased transit fares.

Table 28. Transit fare sensitivity tests

	Transit Person Trip Changes (thousands)						
	-50%	**-10%**	**-5%**	**2005**	**+5%**	**+10%**	**+50%**
Modeled Values	109	100	98	97	96	96	87
Expected ranges*	105 - 109	99 - 100	98 - 98	-	92 - 96	87 - 96	49 - 87

*Elasticity range of 0.17 – 1.0 percent change in ridership per percent increase/decrease in fare

The empirical literature cites research showing an expected elasticity of between 0.17 percent for rail ridership (McCollom and Pratt, 2004) and 1 percent for bus ridership over the long run (Paulley et al. 2006). ARB staff applied these elasticities to the changes in transit fares tested by SACOG. The resulting range of trips showed consistency with the results of SACOG's sensitivity runs.

3. Household Income

SACOG's household income distribution sensitivity test was also evaluated. The test simulated changes in the distribution of incomes among households in the region, and predicted changes in the travel behavior and mode choice for households within the region.

The determining factor in selecting different transportation modes of travel depends largely on the available income per household. According to the U.S. Energy Information Administration, higher income correlates to higher VMT per household. On average, lower income households own fewer or no cars, drive fewer miles, and tend to use public transportation more often than higher income cohort groups. Studies have shown that as household incomes decrease, transit commute mode shares often increase and VMT decreases.

Based on the region's 2005 income distribution, SACOG's simulated changes of 5, 10, and 50 percent in incomes of all households and analyzed the predicted changes in travel behavior and mode choices from their model. The expectation was that by varying income to each household, VMT, transit person trips, and vehicle trips should all change.

Table 29 illustrates that SACOG's model is directionally sensitive to income shifts. However, directly relevant empirical literature that describes income in a similar manner could not be identified to determine if the model appropriately reflects the magnitude of changes observed from this variable.

Table 29. Household income sensitivity tests

	Sensitivity to Household Income						
	-50%	-10%	-5%	2005	+5%	+10%	+50%
VMT	32,548,415	35,152,520	35,471,134	35,486,428	34,559,502	35,773,594	36,459,546
Vehicle Trips	4,549,640	5,057,850	5,095,193	5,132,308	5,168,399	5,194,912	5,376,822
Transit Trips	109,192	89,800	88,183	85,997	86,036	85,901	79,837

4. Roadway Capacity

Roadway capacity represents the maximum number of vehicles at free-flow speed that can pass a certain point on a road in one hour. Changes in roadway capacity affects travel speeds in the region. When roadway capacity increases, total VMT in the region is expected to increase. The opposite happens when roadway capacity decreases.

SACOG conducted 4 sensitivity tests examining the model's responsiveness to changes in roadway capacity: increasing capacity by 5 and 10 percent, and decreasing capacity by 5 and 10 percent. Modeled results were compared to the most recent empirical literature. The expected relative short-run elasticities of VMT with respect to the change in roadway capacity include 0.1 to 0.56 (Cervero and Hansen, 2002) and 0.5 (Noland, 2001). The expected relative long-run elasticities of VMT with respect to the change in roadway capacity include 0.39 to 0.84 (Cervero, 2002) and 0.8 (Noland, 2001). Table 30 summarizes the modeled results, and the expected number of trips based on the empirical literature.

Table 30. Roadway capacity sensitivity tests

Test Case	SACOG Modeled VMT (thousands)	Short-run Expected Range*		Long-run Expected Range**	
		Minimum	Maximum	Minimum	Maximum
10% decrease from base case	57,485	55,174	57,863	53,537	56,168
5% decrease from base case	58,040	56,810	58,155	55,992	57,307
Base case	**58,447**				**--**
5% increase from base case	58,701	58,739	60,084	59,587	60,902
10% increase from base case	58,935	59,031	61,720	60,726	63,357

* Calculated based on short-run elasticities of -0.1 to -0.56.

** Calculated based on long-run elasticities of -0.39 to -0.84.

Based on results presented in Table 31, the modeled change of VMT moves in the same direction as expected; however, the magnitude of change does not fall into the expected ranges for all of the tests. Instead, the difference in the magnitude of change can be explained by differences in study locations and time of study.

5. Land Use and Transportation Variables

SACOG performed sensitivity tests for five land use and transportation variables: regional accessibility, mix of use, proximity to transit, street pattern, and residential density. SACOG used cross-sectional sensitivity testing for these variables. Cross-sectional tests are used to provide better information when testing the interaction of land use and transportation variables, which are difficult to model independent of one another. For example, increasing residential or employment density means adding population or jobs to a given area. Such a change, however, can affect the mix of use and regional accessibility, obscuring the particular relationships being researched. Cross-sectional testing uses statistics to help sort out the relationships between multiple input and output variables.

SACOG's cross-sectional testing analyzed a single model run to find the correlations between land use and transportation factors to VMT, transit use, and the frequency of walking to a destination. The resolution of information contained in the single model run is an important component of the analysis. The more detailed the information modeled, the greater the ability to identify precise correlations between variables. SACOG's SACSIM model contains a number of features that increase the resolution of land use, population, and travel factors:

- Land use data in SACSIM is maintained at a parcel/point level, which allows for more nuanced and accurate representation of the land use context for a given area.
- Demographics are represented in the model by a disaggregated, representative population file rather than a summary of zonal data or a cross-classification of households.
- The activity-based modeling approach used for household-generated travel allows for a more complete accounting of travel by residents of the region.

Table 31 summarizes the results of SACOG's statistical analysis of land use and transportation variables, compared to elasticities summarized from the empirical research. ARB staff used elasticities from a summary of empirical research conducted by Handy, et al. in 2010 for most of the factors analyzed by SACOG. For the "Street Pattern" and "Proximity to Transit" factors, the Handy study did not quantify elasticity. Therefore for those two factors, ARB staff used values from a metastudy conducted by Ewing and Cervero in 2010.

Table 31. Land use and transportation factor sensitivity tests

Land Use and Transportation Factor	Elasticities*		
	Estimated From SACSIM (all variables)	Estimated from SACSIM (single variable)	ARB[1]
Regional Accessibility	-0.14	-0.26	-0.05 to -0.25
Mix of Use	-0.12	-0.24	-0.02 to -0.11
Street Pattern	-0.05	-0.21	-0.12[2]
Proximity to Transit	-0.02	-0.08	-0.05[2]
Residential Density	-0.01	-0.10	-0.05 to -0.12

*Elasticity is the percent change in VMT per 1 percent change in the variables.

[1] http://arb.ca.gov/cc/sb375/policies/policies.htm

[2] Ewing, R. and Cervero, R., "Travel and the Built Environment: A Meta-Analysis," *Journal of the American Planning Association*, Vol. 76, No. 3, Summer 2010.

SACOG estimated elasticities for land use and transportation variables in two ways. First, the variables were isolated to ignore impacts that any one factor may have on another. These isolated elasticities are listed in the "single variable" column. Second, the elasticities listed in the "all variables" column accounted for interactions between variables. These two methods of calculating elasticities form a range with which to compare the values calculated from research.

With the exception of the "Mix of Use" variable, the elasticity range calculated by SACOG for the land use and transportation variables overlaps, or falls within the values estimated by ARB's research. The SACSIM range of elasticity of VMT for "Mix of Use" is slightly higher than the range found in ARB's empirical literature, indicating that

SACSIM is slightly more sensitive to this factor than the literature would suggest. There are several factors that may cause the elasticities in a particular MPO model to differ from those reported in the literature. These are primarily due to differences in model structure, area type differences, and age of the study used.

E. SCS Performance Indicators

ARB staff evaluated changes in a subset of key indicators that describe SCS performance. These indicators are examined to determine if they can provide qualitative evidence that the SCS could meet its GHG targets if implemented. The directional consistency of the indicators with SACOG's modeled GHG emissions reductions, as well as the general relationships between those indicators and GHG emissions identified in the empirical literature were evaluated. The indicators include: land use mix, jobs/housing balance, housing type changes, proximity to transit, residential density, street pattern/walkability, passenger VMT, mode share, average trip length, congested VMT, and non-motorized travel. The assessment relies on key empirical studies for each indicator that illustrate qualitatively how changes can increase or decrease VMT and/or GHG emissions. Below is a summary of the evaluation for the land use and transportation-related performance indicators.

1. Land Use Indicators

In order to determine the benefits of the development pattern in the MTP/SCS on GHG emissions from passenger vehicles, the evaluation focused on the following performance indicators related to land use: changes in land use mix, jobs/housing balance, mix of housing types, housing and employment in Transit Priority Areas (TPAs), residential density, and street pattern as it relates to walkability.

Land Use Mix

Land use mix or mixed use development can be defined as the practice of accommodating more than one type of land use function within a building, a set of buildings, or a specific area. These functions include residential, office, retail, and personal services, as well as parks and open space. Because mixed use neighborhoods offer a variety of employment, shopping, and recreational opportunities within short distances of residences, they can encourage the use of non-automobile travel modes and can shorten or eliminate car trips, which in turn may reduce passenger vehicle VMT and passenger vehicle greenhouse gas emissions.

SACOG reports mix of use using an internally developed index that measures mix on a 0 to 100 scale with 0 representing homogenous areas, and 100 representing perfect mix of use. SACOG's mix index measures the degree to which the regional balance in total jobs per household, retail jobs per household, service jobs per household, and K12 school enrollment (i.e. school capacity) is provided within a one-half mile radius of the place of residence.

Within the SACOG region, mix of use is highest in its identified Center and Corridor and Established Community types, largely because these areas are

located near jobs and commercial centers. In 2008, Developing, Rural Residential, and Lands Not Identified for Development in the MTP/SCS were very low in measured mix of land use, with all below 14 of 100 on the SACOG mix index. The most significant change in mix of use between 2008 and 2035 occurs in Developing Communities. This change reflects a significant amount of growth and consideration of land use mix in the planning for these areas.

At the regional level, SACOG reports that their MTP/SCS achieves an increase of over 6% in mix of use by 2035 from a 2008 level. This is directionally consistent with what would be expected to support SACOG's reported increases in walk and bike mode share, and decreases in VMT and GHG emissions by 2035.

Jobs-Housing Balance

Jobs/housing balance refers to the approximate distribution of employment opportunities and workforce population across a geographic area. It is usually measured in terms of the proportion of jobs per household. For example, a jobs/housing balance of 1.25 means there are 5 jobs for every 4 households. The aim of jobs/housing balance is to provide local employment opportunities that may reduce overall commuting distance among residents, and also the reverse – to provide homes near workplaces. The literature reports that a jobs/housing balance is sensitive to the area of analysis. In one study, an area defined as a "commute shed" is an area of about 14 miles in radius around an employment center, and a jobs/housing ratio between 1.0 and 1.3 is considered "balanced" (Armstrong 2001). As the area of analysis expands, the jobs/housing ratio becomes less informative. For example, a jobs/housing ratio considered balanced for a "commute shed" area is not necessarily balanced for larger areas. Generally, a jobs/housing ratio near 1.3 is accepted as "balanced" considering that California's households have an average of 1.3 workers (Kroll 2008). SACOG's MTP/SCS sets a regional jobs/housing goal of 1.2 for growth between 2008 and 2035.

Evaluating the trend over time of a regional jobs/housing ratio can be useful to gauge the projected impact of land use policies on the location of jobs and housing. SACOG's MTP/SCS evaluates the jobs/housing ratio for 16 areas in the region, which are defined as areas within a four mile radius around major employment centers of the region. Table 32 compares the jobs/housing ratios for each employment center for 2008 and projected for 2035. The values for the projected ratios in 2035 are consistent with SACOG's goal of moving towards a jobs/housing ratio of 1.2, as employment centers with a jobs/housing ratio below 1.2 in 2008 increase in 2035, while, with the exception of Folsom, areas with a jobs/housing ratio above 1.2 in 2008 decrease in 2035. Considering the major employment centers in the SACOG region as a whole, the region continues to

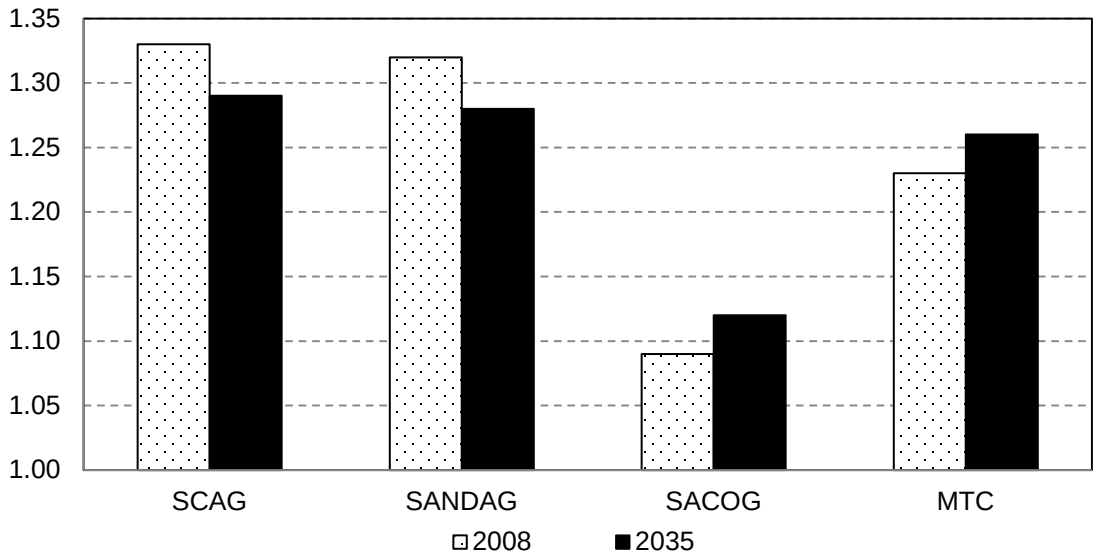
move closer to a balanced jobs/housing ratio in these areas in 2035 from 1.38 to 1.35.

Table 32. Jobs/housing ratios for regional employment centers

County	Employment Center	Jobs/Housing Ratio	
		2008	2035
Jobs/Housing Ratio below 1.2			
Sacramento	Elk Grove/Laguna Springs	0.61	0.75
El Dorado	Latrobe Business Park	0.98	1.14
Placer	Roseville-Douglas Corridor	0.98	1.12
Placer	Sunset Industrial Area	0.98	1.17
Sutter	Yuba City/Hwy 20	1.08	1.10
Yuba	Downtown Marysville	1.09	1.11
Sacramento	Northgate/North Market Area	1.14	1.22
Jobs/Housing Ratio above 1.2			
Yolo	UC Davis	1.31	1.30
Sacramento	Power Inn/Florin-Perkins	1.34	1.18
Sacramento	Folsom	1.38	1.41
Yolo	NE Woodland Industrial Area	1.47	1.44
Sacramento	Rancho Cordova	1.52	1.44
Sacramento	Expo-Arden-Point West Area	1.80	1.68
Sacramento	East Sac/UC Davis Medical Center	1.92	1.72
Yolo	West Sacramento/ Harbor/Industrial Area	2.16	1.87
Sacramento	Downtown Sacramento	2.25	2.00
	Average	**1.38**	**1.35**

Figure 13 compares the jobs/housing ratio for the SACOG region to the three other largest MPOs in California. In comparison to the other regions, SACOG has a lower jobs/housing ratio. The jobs/housing ratio for the entire SACOG region, including its major employment centers, was 1.09 in 2008 and 1.12 projected for 2035. The increase in the jobs/housing ratio for the SACOG region is consistent with the region's goal for a jobs/housing ratio of 1.2 and suggests that the future land use pattern, if implemented by local jurisdictions, will move the region toward a land use pattern that places job opportunities and housing options closer, reduces commute trips, VMT, and greenhouse gas emissions.

Figure 13. Jobs/housing ratios for the largest MPOs in California



Note: MTC data for 2010 and 2035

Related to jobs-housing balance, the MTP/SCS recognizes that "jobs-housing fit" is also important, in which the local workers' wages reflect the cost of housing in each area. In fact, jobs-housing fit is one of the Blueprint Principles in the MTP/SCS. This factor affects the jobs-housing balance by considering not only the availability of housing near employment, but the affordability of housing to the types of jobs in the area. SACOG's MTP/SCS notes that it is in the process of developing a jobs-housing fit tool. It is also analyzing housing plus transportation costs in the region through funding from a U.S. Department of Housing and Urban Development Sustainability Challenge Grant. The tool is expected to be completed by the end of 2012 for use in development of future MTP/SCSs.

Housing Type Mix

Housing type mix influences what land use patterns can be achieved in a region. The greater the proportion of housing growth that is small-lot and attached

housing product types, the more opportunity a region has to accommodate future growth through a more compact land use pattern.

Between 2008 and 2035, SACOG's MTP/SCS shows a significant increase in single-family small-lot and attached housing types compared to rural residential and single-family large-lot housing. Of the total new housing unit growth expected in the region, attached housing is estimated to grow to 34 percent between 2008 and 2020, and 49 percent between 2021 and 2035.

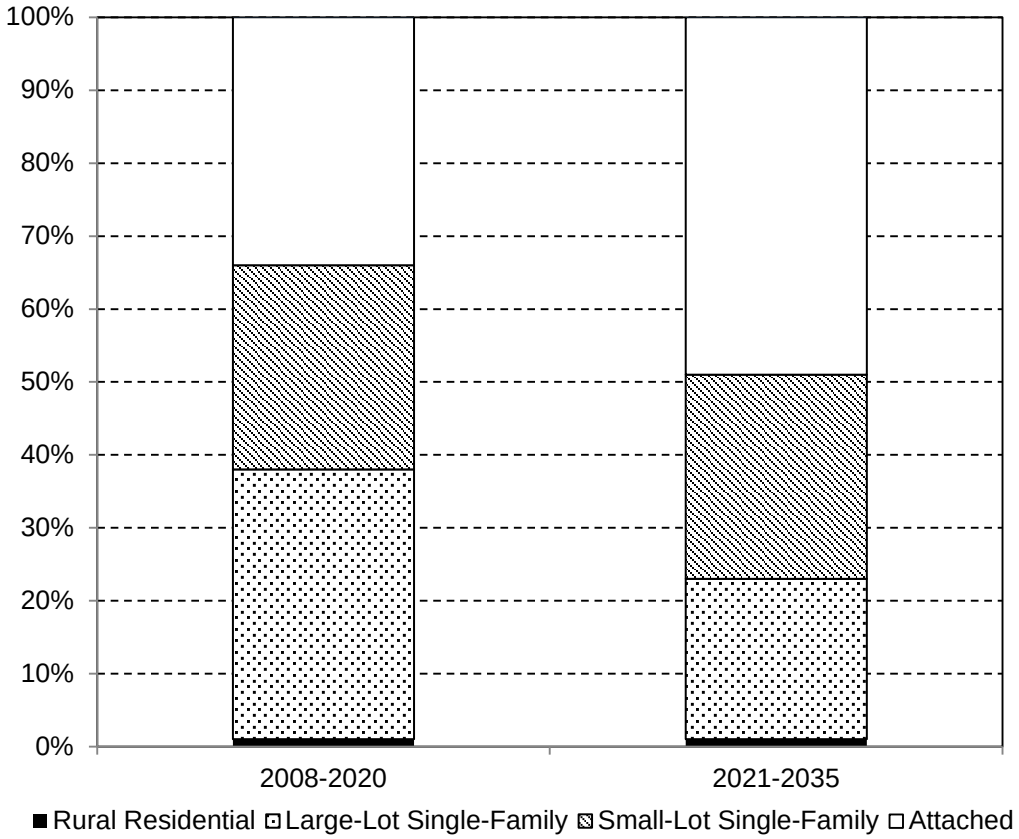
The MTP/SCS categorizes four types of housing products. Rural Residential housing includes single-family detached homes built at densities less than one dwelling unit per acre. Large-lot, single-family housing includes single-family detached homes built at densities between one and eight dwelling units per acre. Small-lot single-family housing are single-family detached homes built at densities between 8 and 25 dwelling units per acre. The last category is Attached housing, which includes single-family and multi-family homes ranging from duplexes, triplexes, lofts, apartments, condominiums, townhomes, row houses, half-plexes, etc., built at densities from 8 to over 50 dwelling units per acre.

Table 33 shows the change in housing type share for 2008 and projected growth for 2020 and 2035. Figure 14 shows a comparison of the share of housing unit type growth projected for 2008 to 2020 and the projected housing unit type growth for 2021 to 2035.

Table 33. Share of housing product by type

Housing Product	2008 Existing Conditions (%)	MTP/SCS 2020 Housing Growth (%)	MTP/SCS 2035 Housing Growth, 2008-2035 (%)
Rural Residential and Single-Family Large-Lot	65%	38%	29%
Single-Family Small-Lot and Attached	35%	62%	71%

Figure 14. Share of housing type growth



Both the region's local general plans and SACOG's analysis of housing market trends in the region seem to support a preference for increased attached and smaller-lot single-family housing products. As part of the MTP/SCS planning process, SACOG researched and prepared a white paper on trends in housing demand.[22] This research suggests a shift in the housing products that will be needed to accommodate the region's population, with the aging of the baby boom generation (those born between 1946 and 1964), the preferences of the more populous Generation Y cohort (those born between 1978 and 1994), and continued immigration into the region having a major impact on housing product demand. These findings are directionally consistent with other currently available housing market studies for California.

[22] See Appendix E-6 of SACOG's MTP/SCS for full paper and bibliography.

Proximity to Transit and Transit Priority Areas

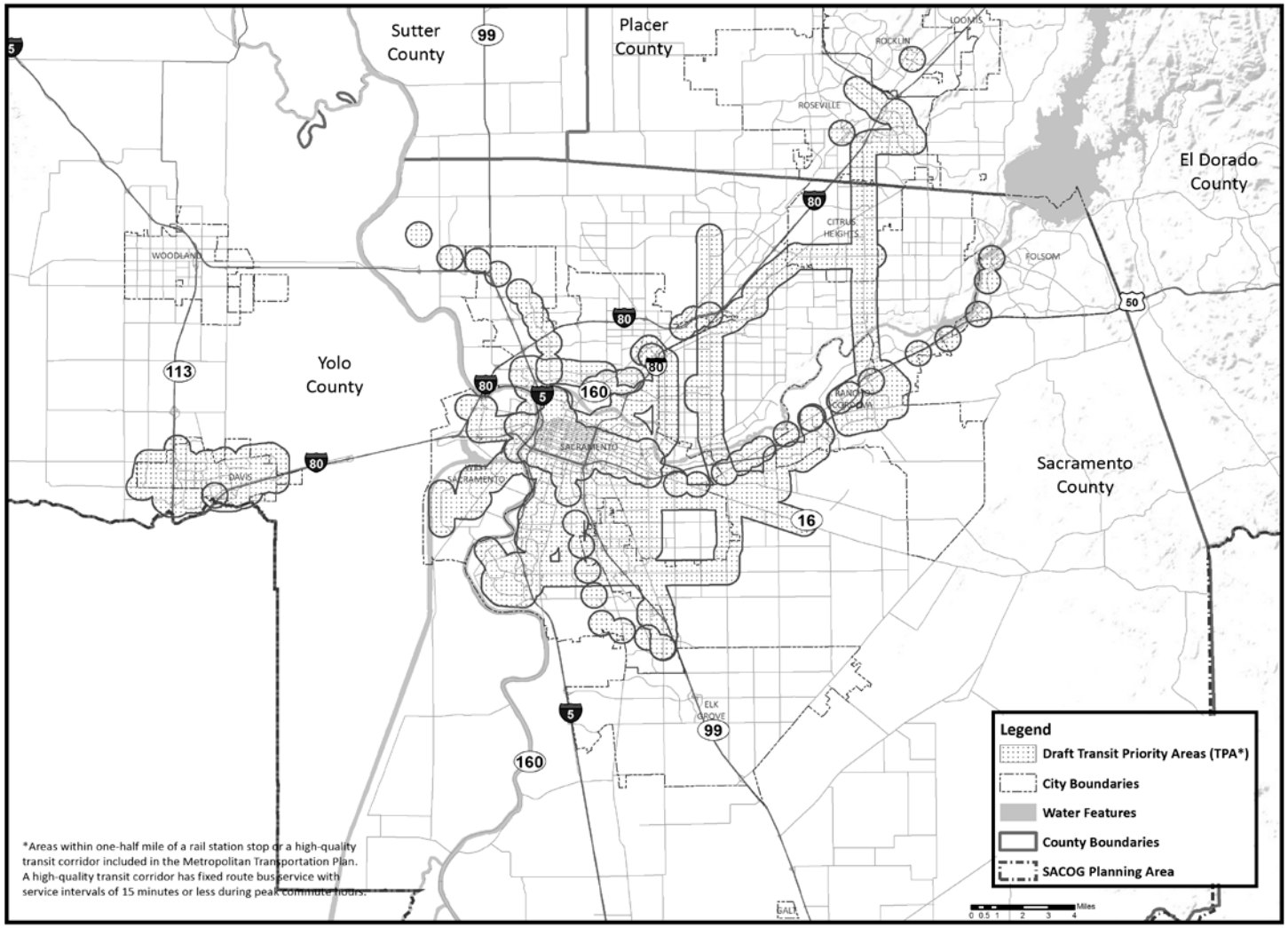
Proximity of housing and employment to transit is a commonly used performance measure for evaluating the effectiveness of transit oriented development (TOD). The empirical literature indicates that focusing growth in areas with access to transit will encourage the use of transit, reducing vehicle trips and subsequently reducing passenger vehicle-related GHG emissions.

Studies show that proximity of housing and employment to transit stations is highly correlated with increased transit ridership as housing and employment increases within a one mile radius of transit stations (Kolko 2011). Other studies show significant VMT reductions for placement of housing and employment closer to rail stations and bus stops (Tal, et.al 2010).

SACOG reports proximity to transit as an average distance in miles from place of residence to the nearest transit station or stop. At the regional level, SACOG reports that with the MTP/SCS, the average distance to transit from residences will decrease by over 23 percent between 2008 and 2035. SACOG's MTP/SCS helps to achieve this by focusing future growth near existing and planned transit areas.

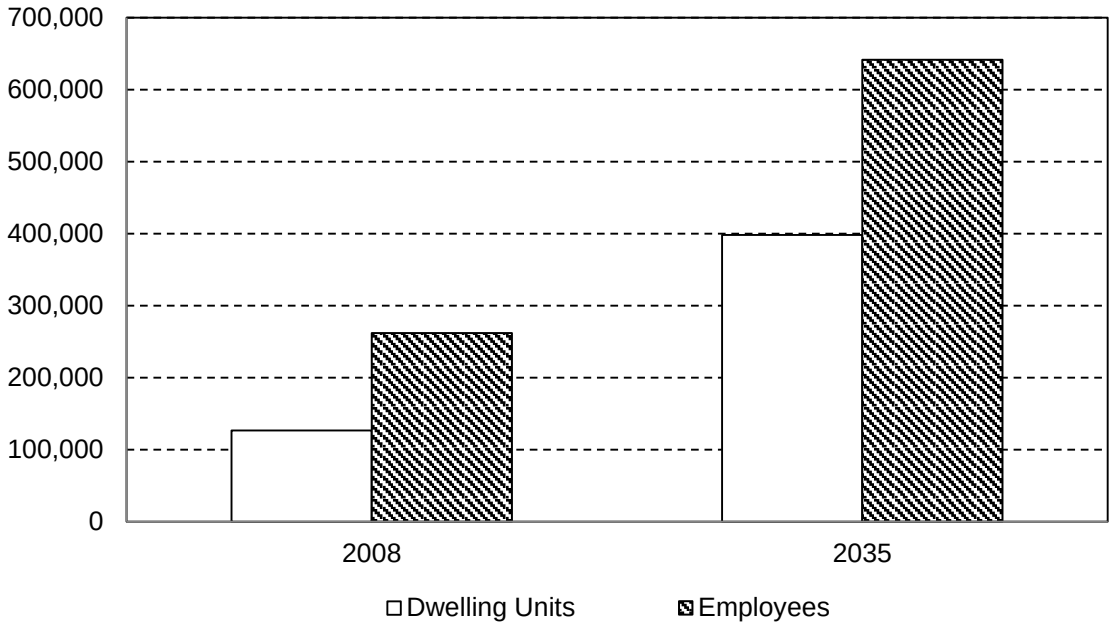
One way SACOG's MTP/SCS measures proximity of housing and employment to transit is in relation to transit priority areas (TPAs), or areas within a half mile of a major transit stop with 15 minute or less service frequency during peak commute hours. Figure 15 shows the TPAs in the SACOG region.

Figure 15. TPAs in SACOG region



In 2008, only 14 percent of the housing units and 27 percent of the jobs in the region were within TPAs. By 2035, SACOG projects that 34 percent of housing units and 30 percent of jobs will be within TPAs. Figure 16 shows the projected growth in housing units and jobs within TPAs with the plan.

Figure 16. Housing and employment within TPAs



Residential Density

Residential density is a measure of the average number of dwelling units per acre of developed land. Travel characteristics in the region are expected to change as the housing market shifts from single unit homes on larger lots, to single unit homes on smaller lots, townhomes, and multifamily housing. These changes in travel behavior include reductions in average trip length, and could eventually result in decreased regional VMT.

A review of relevant empirical literature reveals this is likely to be the case. Brownstone and Golob analyzed National Household Travel Survey (NHTS) data and observed that denser housing development significantly reduces annual vehicle mileage and fuel consumption, which directly results in the reduction in GHG emissions. They also reported that households in areas with 1,000 or more units per square mile drive 1,171 fewer miles and consume 64.7 fewer gallons of fuel than households in less dense areas. Boarnet and Handy (2010) reported that doubling residential density reduces VMT an average of 5 to 12 percent. Litman (2010) reported that increased population density leads to a 0.2 to 1.45 percent decrease in the demand for car travel.

SACOG's MTP/SCS projects that between 2008 and 2035, residential density increases by over 27 percent. SACOG reports residential density as dwelling units per net residential acre within a half mile of a residence. The changes in residential density by community type are summarized in Table 34.

Table 34. Average residential density by community type

	Community Type				
	Centers / Corridors	Established	Developing	Rural Residential	Region
2008 MTP	10.1	3.8	1.3	0.2	1.5
2035 MTP/SCS	15	4.1	4.5	0.2	1.9
Change from 2008 (%)	48	5.7	240	6.0	27

These increases in density are consistent with the empirical literature and indicate the likelihood of reductions in VMT and auto trip length, shifts in travel mode away from single occupant vehicles, and reductions in GHG emissions.

Street Pattern/Walkability

Street pattern is used as an indicator of how walkable a given area and the likelihood that a person will walk to their destinations based on particular street characteristics. The empirical research has established a correlation between the number of intersections with smaller block size and the increased potential for walking connections in an area (Handy, el al, 2010).

At the regional level, SACOG reports intersections per square mile as trending upwards with an over 3% increase by 2035 from the 2008 level. This is directionally consistent with what is expected in order to support SACOG's reported increases in walk share mode and decreases in VMT and GHG emissions by 2035.

Table 35. Intersections per square mile

	Region
2008 MTP	83
2035 MTP/SCS	86
Change from 2008 (%)	3.60

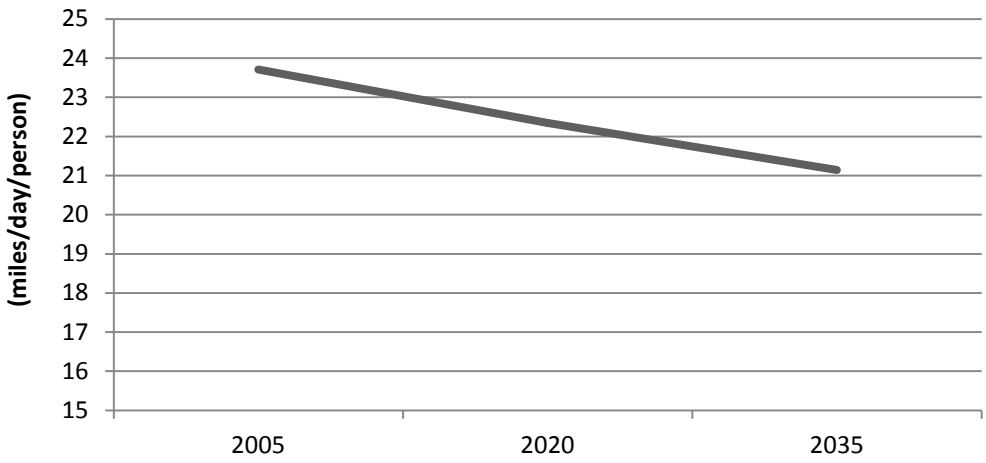
2. Transportation-Related Indicators

Five performance indicators related to the transportation system along with supporting data inputs, assumptions, and sensitivity analyses were evaluated. These indicators are passenger VMT, mode share, average trip length, congested VMT, and non-motorized transportation.

Passenger Vehicle Miles Traveled

The SACOG MTP/SCS reports shows a decline in per capita passenger vehicle VMT between 2020 and 2035, which is shown in Figure 17. The quantification of GHG emissions from passenger vehicles is a function of both VMT and vehicle speeds. These results are directionally consistent and support SACOG's reported GHG emissions reduction trend over time.

Figure 17. Passenger vehicle weekday VMT per capita



Mode Share

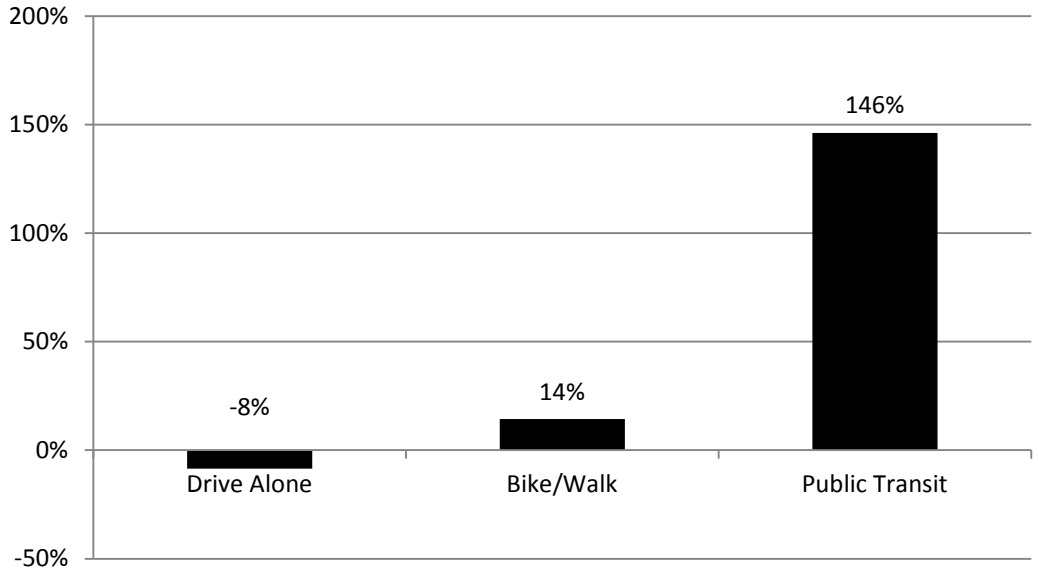
Mode share measures the change over time in the means by which people travel. Shifting of trips from vehicle to non-vehicle modes (e.g. transit, bike and walk, work at home) or carpool modes reduce vehicle GHG emissions in a region. While a change in mode shares cannot generally be used to quantify a change in GHG emissions, the empirical literature indicate that GHG emissions per person are likely to decrease as automobile mode share decreases and transit and bike and walk mode shares increase.

A series of mode share metrics reported by SACOG were reviewed. These included both commute and non-commute trip mode shares, measuring how people travel from home-to-work and back, as well as how they travel for school,

shopping, personal business, and all non-work trip purposes. For both metrics, SACOG reported statistics in terms of percentage of weekday trips by the region's residents that are drive alone, carpool, transit (bus and rail), bike, walk, and other (primarily school bus).

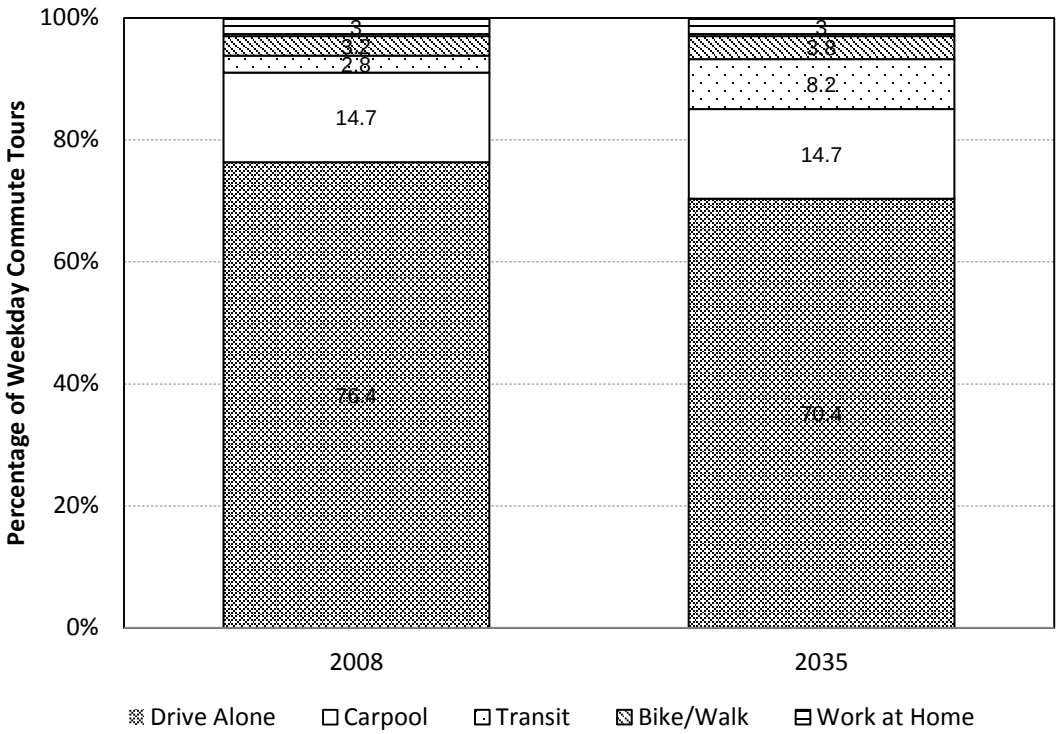
Figure 18 shows the expected percent change in mode share by 2035 with respect to 2008 for all trips. Over the plan period, the drive alone mode share decreases nearly 4 percent. Bike and walk mode share increases from 9 percent in 2008 to 10.3 percent in 2035, while transit mode share more than doubles from 1.3 percent in 2008 to 3.2 percent by 2035. These results are directionally consistent and support SACOG's reported GHG emissions reduction trend over time.

Figure 18. Percent change in mode share by 2035 with respect to 2008 (all trips)



In addition to reviewing the all-trip mode share metric, mode share for commute or work trips separate from non-commute or non-work trips was also reviewed. Figure 19 shows SACOG's reported commute trip mode shares for 2008 and 2035 with implementation of the MTP/SCS. While the rate of driving alone for commute purposes is typically higher than for other trip purposes, SACOG reports a significant reduction over the plan period of the drive-alone mode share for commute trips. Transportation investments provide better alternatives to driving alone for commuters, resulting in increased transit use for commute purposes from 2.8 percent in 2008 to 8.2 percent by 2035. Similarly, use of bike and walk modes for commute purposes increase from 3.2 percent in 2008 to 3.8 percent by 2035.

Figure 19. Commute trip mode share

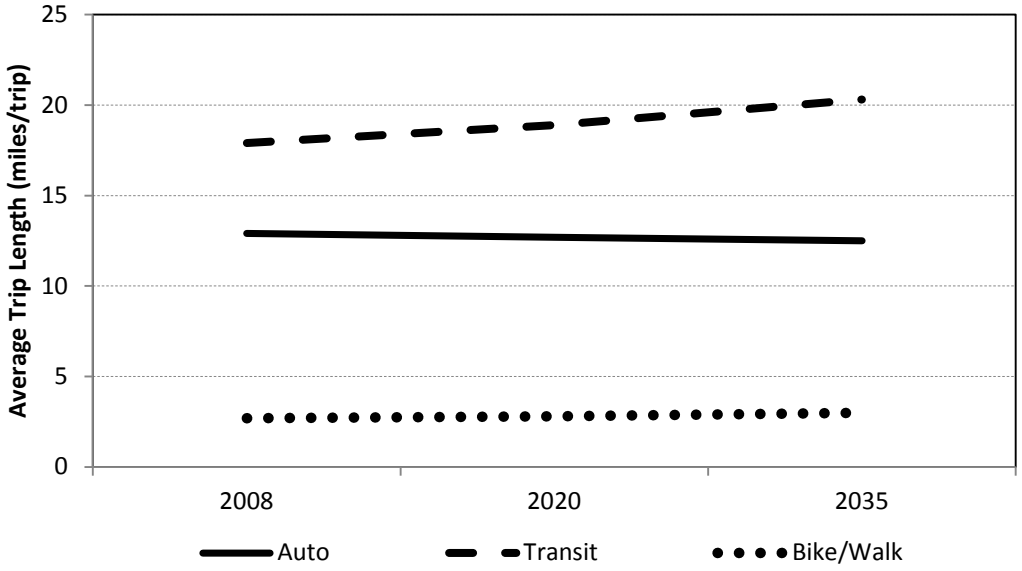


Average Trip Length

Changes in the average trip length by mode can contribute to an overall reduction of GHG emissions in a region. Decreases in average trip length for trips by auto can reduce a region's GHG emissions by decreasing overall miles traveled in a vehicle. Increases in average trip length for trips by non-auto modes indicates greater trip mileage travelled by transit, biking, and walking, which can contribute to the reduction of GHG emissions.

Figure 20 shows the change in average trip length by mode for all trip purposes as reported by SACOG. The data shows that the average automobile trip length decreases by 3 percent, or by half a mile, from 12.9 miles in 2008 to 12.5 miles in 2035. During the same time period, average trip length for both transit and bike and walk modes increase. The average length of trips by transit shows the largest change of all the modes, increasing over 13 percent from 17.9 miles in 2008 to 20.3 miles in 2035. These trends are directionally consistent and support SACOG's reported GHG emissions reduction trend.

Figure 20. Average trip length by mode

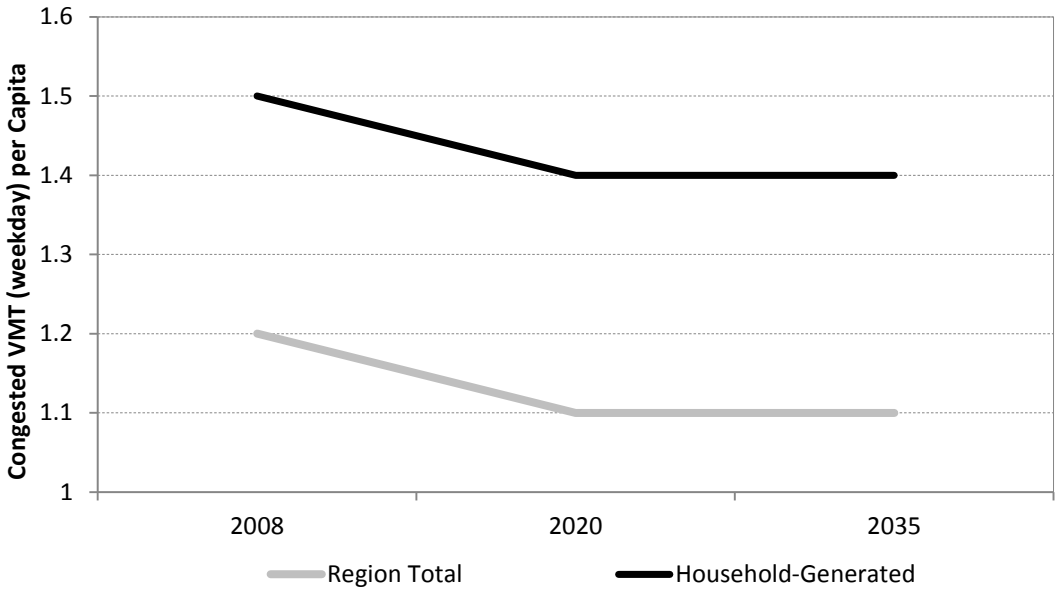


Congested Vehicle Miles Traveled

Congested VMT is used to indicate the level of traffic demand and the available capacity by facility in a region. SACOG defines congested VMT as VMT that occurs on roadways with volume-to-capacity ratios of 1.0 or greater. Increases in congested VMT are often characterized by slower speed, longer travel times, increased queuing and often times increased vehicle GHG emissions per mile of travel in a region.

Figure 21 shows both total and household-generated congested VMT, normalized for population, in the SACOG region for 2008, 2020, and 2035. Household-generated congested VMT per capita declines by 10.4 percent, while total congested VMT per capita declines by nearly 7 percent between 2008 and 2035. Both hold nearly steady from 2020 to 2035. These statistics indicate that overall traffic flow on the planned network is not expected to deteriorate with the region's anticipated growth, helping to support SACOG's reported GHG emissions reduction trend over time.

Figure 21. Congested VMT per capita



Non-Motorized Transportation

Increasing the number of miles of bikeways and sidewalks, making changes to existing bike/pedestrian infrastructure to improve the safety, security, or comfort of cyclists and pedestrians, or creating better bike/pedestrian links to transit stations are among the strategies that have been found to increase the likelihood of a shift in trips from cars to bicycles, walking, and/or transit. This shift can be expected to reduce regional VMT, and overall GHG emissions.

SACOG's MTP/SCS includes $2.8 billion (in current year dollars) budgeted for bicycle facilities, pedestrian improvements, and ADA retrofits to help reduce VMT in the region, a $100 million decrease in expenditures compared to the amount budgeted in the 2008 MTP. However, SACOG notes that it's a 5 percent per capita increase, when using the projected 2035 population from the 2008 MTP. In addition, SACOG estimates that almost $600 million of the road maintenance and rehabilitation budget will be spent on bicycle and pedestrian facilities, and at least 8 percent of the road capital projects will have a bicycle or pedestrian component that is not included in the budget for bike/pedestrian-specific improvements.

Bike/pedestrian-specific projects included in the MTP/SCS increase the number of miles of Class I bike/pedestrian paths and Class II bike lanes in the region. As shown in Table 36, in 2008, the SACOG region had a total of 1,456 miles of bike paths and lanes. The MTP/SCS adds another 1,118 miles by 2035, bringing the

total miles of bike lanes and paths to 2,574, or a 77 percent increase from 2008. Per capita, this is about a 27 percent increase in lane/path miles by 2035.

Table 36. Existing and proposed bike lane miles

Bike/Pedestrian Feature	2008 (base year)	2020	2035
Bike lane miles (Class II)	1,059	1,181	1,781
Bicycle and pedestrian lane miles (Class I)	397	397	793
Total Bike/Ped lane miles	1,456	1,578	2,574

With the MTP/SCS's addition of bike lane/path miles, sidewalk gap closures, ADA retrofits, intersection improvements, and other complete street projects, one would expect to see an increase in the number of trips people make by bicycle and on foot, and would therefore expect to see an increase in the share of non-motorized transportation mode choices, and a resulting decrease in the share of single-occupancy vehicle mode choice. This is, in fact, what SACOG's modeling shows. SACOG's MTP/SCS shows that the number of bicycle and pedestrian trips is expected to rise from 779,000 in 2008 to 1,253,000 in 2035 (Table 37). This is a per capita increase from 0.35 in 2008 to 0.41 in 2035, or a 17 percent increase.

Table 37. Non-motorized trips

Mode of Travel	2008	2035
Bicycle Trips	152,300	228,800
Walk Trips	626,700	1,024,200
Total Non-Motorized Trips	779,000	1,253,000

As a result of the MTP/SCS, SACOG expects the share of commute travel from bicycling and walking to increase from 3.2 percent in 2008 to 3.8 percent by 2035. Although the change in mode share cannot generally be used to quantify a change in GHG emissions, this increase in bike/walk mode share is directionally consistent with SACOG's expected reduction in VMT and a resulting reduction in GHG emissions.

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APPENDIX A. SACOG's Modeling Data Table

This appendix contains SACOG's responses to data requests, received March 8, 2012, to supplement staff's evaluation of SACOG's quantification of GHG emissions. The requests are consistent with the evaluation methodology.

Modeling Parameters	2005 (if available)	2008 (base year)	2020	2035	MTP SCS Chapter-Page(s)
DEMOGRAPHIC					
Total population	2,057,243	2,215,044	2,519,044	3,086,213	3-4
Group quarters population[23]	n/a	n/a	n/a	n/a	---
Total number of households	768,100	819,300	967,000	1,114,500	---
Persons per household	2.68	2.70	2.61	2.77	---
Auto ownership per household	1.85	1.87	1.83	1.85	---
Total jobs	1,000,887	966,316	1,068,839	1,327,424	3-4
Average unemployment rate (%)	n/a	n/a	n/a	n/a	---
Average household income (2009$)	$77,400	$75,500	$77,700	$79,200	---
LAND USE					
Total housing/dwelling units	825,000	844,725	1,003,725	1,187,744	3-4
Total acreage developed	---	721,872	745,720	775,138	3-25
Total acreage in region[24]	3,863,373				3-25
Total housing units within 1/4 mile of transit stations and stops	---	495,127	548,948	670,354	---
New housing units within 1/4 mile of transit stations and stops	---	---	53,821	121,406	---
Total housing units within 1/2 mile of transit stations and stops	---	656,630	736,650	891,760	---
New housing units within 1/2 mile of transit stations and stops	---	---	80,021	155,109	---
Total housing units within TPAs[25]	---	126,694	142,946	398,376	3-31
New housing units within TPAs	---	---	16,252	114,466	3-31
Total employment (employees) within 1/4 mile of transit stations and stops	---	709,412	772,007	952,631	---
New employment (employees) within 1/4 mile of transit stations and stops	---	---	62,594	180,624	---
Total employment (employees) within PLANNED 1/2 mile of transit stations and stops	---	822,420	909,107	1,133,147	---

[23] Group quarters population is not included, other than dormed college/university students.

[24] Total acreage in SACOG region, inclusive of developed and undeveloped land.

[25] For metrics related to TPA, use definition of TPA as discussed in SACOG's proposed MTP/SCS page 3-29.

New employment (employees) within PLANNED 1/2 mile of transit stations and stops	---	---	86,687	224,041	---
Total employment (employees) within TPAs	---	261,662	275,933	641,349	3-31
New employment (employees) within TPAs	---	---	14,271	139,674	3-31
Total attached housing units (single- and multi-family) – Percentages are GROWTH except 2008	---	26%	34%	43%	3-21
Total small-lot single family detached housing Units– Percentages are GROWTH except 2008	---	9%	28%	28%	3-21
Total large-lot single family detached housing units– Percentages are GROWTH except 2008	---	58%	37%	28%	3-21
Total rural residential single family detached housing units– Percentages are GROWTH except 2008	---	7%	1%	1%	3-21
Acreage of land zoned (used and available) for mixed use	---	---	---	---	---
Acreage of DEVELOPED land identified as Center/Corridor Communities	---	25,539	27,680	29,985	3-25
Acreage of DEVELOPED land identified as Established Communities	---	266,419	276,520	286,175	3-25
Acreage of DEVELOPED land identified as Developing Communities	---	23,476	32,665	47,469	3-25
Acreage of DEVELOPED land identified as Rural Residential Communities	---	406,437	408,854	411,507	3-25
Acreage of land identified as Lands Not Identified for Development in the MTP/SCS Planning Period	---	n/a	n/a	n/a	---
Average regional accessibility – total jobs within 30-min drive from place of residence (Region)	---	379,598	---	498,359	5A-10
Center/Corridor Communities	---	561,970	---	729,235	5A-10
Established Communities	---	391,325	---	515,642	5A-10
Developing Communities	---	254,496	---	351,964	5A-10
Rural Residential Communities	---	132,585	---	196,759	5A-10
Average walkability – intersections per square mile within ½ mile of place of residence (Region)	---	83	84	86	5A-10
Center/Corridor Communities	---	115	112	111	5A-10

Established Communities	---	87	89	90	5A-10
Developing Communities	---	64	60	67	5A-10
Rural Residential Communities	---	17	18	20	5A-10
Average mix of use – based on SACOG's 0-100 scale (Region)	---	31	32	33	5A-10
Center/Corridor Communities	---	37	36	38	5A-10
Established Communities	---	33	34	35	5A-10
Developing Communities	---	14	20	28	5A-10
Rural Residential Communities	---	10	10	11	5A-10
Average distance to transit – distance from place of residence to nearest transit station or stop (miles) (Region)	---	0.72	0.61	0.55	5A-10
Center/Corridor Communities	---	0.21	0.15	0.12	5A-10
Established Communities	---	0.55	0.44	0.42	5A-10
Developing Communities	---	1.22	1.07	0.7	5A-10
Rural Residential Communities	---	2.91	2.65	2.65	5A-10
Average residential density - housing units per developed residential acre (Region)	---	1.5	1.6	1.9	5A-10
Center/Corridor Communities	---	10.1	11.5	15.0	5A-10
Established Communities	---	3.8	3.9	4.1	5A-10
Developing Communities	---	1.3	3.0	4.5	5A-10
Rural Residential Communities	---	0.25	0.20	0.2	5A-10
TRANSPORTATION SYSTEM					
Freeway general purpose lanes –-mixed flow(lane miles)	---	1,462	1,491	1,522	DEIR 2-39
Freeway managed lanes--HOV, HOT, Tolled, etc. (lane miles)	---	64	114	182	DEIR 2-39
Freeway auxiliary lanes and ramps (lane miles)	---	196	237	262	DEIR 2-39

Arterial / Expressway[26] (lane miles)	---	3,609	4,246	5,095	DEIR 2-39
Collector and Local Streets[27] (lane miles)	---	22,000	25,000	28,000	DEIR 2-39
Bicycle and pedestrian (Class I) lane miles	---	397	397	793	DEIR 2-39
Bike lane miles (Class II)	---	1,059	1,181	1,781	DEIR 2-39
Local, express bus, bus rapid transit, and neighborhood shuttle operation miles[28]	---	3,816	---	6,702	DEIR 2-39
Transit rail operation miles[6]	---	258	---	458	DEIR 2-39
Transit total daily vehicle service hours[29]	---	4,074	4,347	8,062	DEIR 2-39
TOUR DATA[30]					
Commute Tours					
Totals					
Person Tours	---	679,749	792,064	911,495	---
Person Trips	---	1,814,546	2,120,315	2,458,417	---
Vehicle Trips	---	1,584,514	1,813,640	1,974,427	---
VMT (internal, hh-gen.)	---	18,221,915	20,104,667	21,900,881	---
Rates					
Trip Per Tour	---	2.67	2.68	2.70	---
VT/Person Trip	---	0.87	0.86	0.80	---
VMT/Tour	---	26.81	25.38	24.03	---
VMT/Person Trip	---	10.04	9.48	8.91	---
VMT/Veh Trip	---	11.50	11.09	11.09	---
Tour Complexity					
% of Tours = Simple	---	61.3%	61.0%	60.3%	---
Of Complex Tours, % with…					
…1 added stop	---	60.1%	60.1%	59.4%	---
…2 added stops	---	20.2%	20.2%	20.1%	---
…3 + added stops	---	19.6%	19.8%	20.4%	---

[26] "Arterial / Expressways" include all surface streets with functional class minor arterial or higher, including arterial streets, expressways, rural highways, etc.

[27] "Collector and Local Streets" are below minor arterial in functional class.

[28] Transit miles are a measure of service coverage, not service intensity. Example: a one mile stretch of road with one bus per hour = one bus route mile; the same one mile stretch of road with 20 buses per hour = one bus route mile.

[29] One vehicle service hour = one transit vehicle operating for normal revenue service for one hour.

[30] This section replaces a data request which includes tour terminology not applicable to SACSIM. The provided data are based on a prepared summary SACOG staff uses, modified to provide the basic content requested by CARB staff.

Purpose of Added Stops:					
Work	---	12.9%	12.9%	13.0%	---
School	---	0.3%	0.3%	0.3%	---
Non-Work/Non-School	---	86.8%	86.8%	86.8%	---
School Tours					
Totals					
Person Tours	---	561,164	582,205	683,871	---
Person Trips	---	1,353,284	1,408,537	1,658,452	---
Vehicle Trips	---	460,227	476,513	523,379	---
VMT (internal, hh-gen)	---	2,660,557	2,749,991	2,978,835	---
Rates					
Trip Per Tour	---	2.41	2.42	2.43	---
VT/Person Trip	---	0.34	0.34	0.32	---
VMT/Tour	---	4.74	4.72	4.36	---
VMT/Person Trip	---	1.97	1.95	1.80	---
VMT/Veh Trip	---	5.78	5.77	5.69	---
Tour Complexity					
% of Tours = Simple	---	74%	73%	73%	---
Of Complex Tours, % with…					
…1 added stop	---	46%	44%	44%	---
…2 added stops	---	21%	21%	21%	---
…3 + added stops	---	34%	35%	35%	---
Purpose of Added Stops:					
Work	---	10.0%	10.8%	10.4%	---
School	---	4.6%	4.5%	4.5%	---
Non-Work/Non-School	---	85.3%	84.7%	85.1%	---
All Work-Based Tours					
Totals					
Person Tours	---	453,763	531,172	614,977	---
Person Trips	---	977,733	1,144,176	1,324,940	---
Vehicle Trips	---	688,794	782,991	864,383	---
VMT (internal, hh-gen)	---	2,903,978	3,254,027	3,574,445	---
Rates					
Trip Per Tour	---	2.15	2.15	2.15	---
VT/Person Trip	---	0.70	0.68	0.65	---
VMT/Tour	---	6.40	6.13	5.81	---
VMT/Person Trip	---	2.97	2.84	2.70	---
VMT/Veh Trip	---	4.22	4.16	4.14	---
Tour Complexity					
% of Tours = Simple	---	87%	87%	87%	---
Of Complex Tours, % with…					
…1 added stop	---	87%	87%	87%	---
…2 added stops	---	12%	11%	11%	---
…3 + added stops	---	2%	2%	2%	---
Purpose of Added Stops:					
Work	---	17.9%	17.9%	17.8%	---
School	---	0.5%	0.5%	0.4%	---
Non-Work/Non-School	---	81.6%	81.6%	81.7%	---

All Non-Work/Non-School Tours					
Totals					
Person Tours	---	1,748,684	2,026,955	2,582,055	---
Person Trips	---	4,516,929	5,245,674	6,727,324	---
Vehicle Trips	---	2,710,854	3,120,989	3,854,017	---
VMT (internal, hh-gen)	---	14,991,672	17,058,329	20,595,254	---
Rates					
Trip Per Tour	---	2.58	2.59	2.61	---
VT/Person Trip	---	0.60	0.59	0.57	---
VMT/Tour	---	8.57	8.42	7.98	---
VMT/Person Trip	---	3.32	3.25	3.06	---
VMT/Veh Trip	---	5.53	5.47	5.34	---
Tour Complexity					
% of Tours = Simple	---	63%	63%	62%	---
Of Complex Tours, % with…					
…1 added stop	---	65%	65%	64%	---
…2 added stops	---	20%	20%	20%	---
…3 + added stops	---	16%	16%	16%	---
Purpose of Added Stops:					
Work	---	1.2%	1.2%	1.1%	---
School	---	0.4%	0.4%	0.3%	---
Non-Work/Non-School	---	98.4%	98.5%	98.5%	---
Average Trip Length by Mode (miles)					
Drive Alone	---	7.1	6.8	6.6	---
Shared Ride	---	5.8	5.9	5.9	---
Transit-Drive Access	---	13.9	14.5	15.3	---
Transit-Walk Access	---	4.0	4.4	5.0	---
Bike	---	1.9	2.0	2.1	---
Walk	---	0.8	0.8	0.9	---
School Bus	---	4.8	4.9	4.8	---
All Modes	---	5.9	5.8	5.7	---
Household Rates (All Purposes)					
Person Tours Per Household	---	4.20	4.07	4.30	---
Person Trips Per Household	---	10.57	10.26	10.92	---
Veh. Trips Per Household	---	6.65	6.41	6.47	---
VMT Per Household	---	47.33	44.64	44.01	---
Trip Mode Share (All Purposes)					
Drive Alone	---	44.8%	44.6%	41.0%	---
Shared Ride	---	43.1%	42.5%	43.9%	---
Transit-Drive Access	---	0.1%	0.2%	0.3%	---
Transit-Walk Access	---	1.2%	1.7%	2.9%	---
Walk	---	1.8%	1.8%	1.9%	---
Bike	---	7.2%	7.6%	8.4%	---
School Bus	---	1.8%	1.6%	1.6%	---
All Modes	---	100.0%	100.0%	100.0%	---

CONGESTED TRAVEL MEASURES					
Congested weekday VMT on freeways (miles, V/C ratios >1.00)	---	1,554	1,599	1,669	---
Congested VMT on all other roadways (miles, V/C ratios >1.00)	---	1,744	1,880	2,611	---
CO2 EMISSIONS					
Total CO2 emissions per weekday for passenger vehicles (ARB vehicle classes LDA, LDT1, LDT2, and MDV) (tons)[31]	23,690	---	26,970	31,080	See Appendix C4, Chap 12, Table 12-6
Total II +IX/XI (Internal) CO2 emissions per weekday for passenger vehicles (tons)	23,193	---	26,296	30,303	See Appendix C4, Chap 12, Table 12-6
Total XX trip CO2 emissions per weekday for passenger vehicles (tons)	497.5	---	674.3	777.0	See Appendix C4, Chap 12, Table 12-6
Roadway Weekday VMT—Passenger Vehicles[32]					
Internal (I-I)	39,055,931	---	45,167,116	52,750,470	---
Through (XX)	1,046,178	---	1,443,750	1,673,250	---
Internal-External (IX/XI)	9,715,891	---	11,139,134	12,506,280	---
Total	49,818,000	---	57,750,000	66,930,000	---
INVESTMENT[33]					
Total plan period investment ($)	n/a	n/a	$12.3 billion	$35.2 billion	4-2
Highway capital and operational improvements ($)	n/a	n/a	$0.7 billion	$2.2 billion	4-12
Other road capital and operational improvements ($)	n/a	n/a	$2.0 billion	$5.2 billion	4-12, 4-13

[31] Not counted are post-processing adjustments, which are computed as percentage reductions and taken off as percentages in the SB375 ghg reduction calculation.

[32] GHG calculations for SB375 only required total passenger vehicles, and X-X or through passenger vehicles. IX-XI VMT and GHG was "split" at MPO boundary, per agreement with MTC, SJCOG, BCAG, and TRPA.

[33] All dollar amounts reported in current year dollars.

Road and Highway Maintenance and Rehabilitation (S)	n/a	n/a	$4.3 billion	$11.5 Billion	4-5
Transit capital ($)	n/a	n/a	$1.3 billion	$3.4 billion	4-7
Transit operations ($)	n/a	n/a	$2.4 billion	$7.9 billion	4-7
Rail transit operations ($)	n/a	n/a	$0.8 billion	$3.0 billion	Appendix B1
Bike and pedestrian projects ($)	n/a	n/a	$1.0 billion	$2.8 Billion	4-14
Programs, Planning, Enhancements ($)	n/a	n/a	$0.8 billion	$2.2 Billion	4-14
TRANSPORTATION USER COSTS AND PRICING					
Vehicle operating costs (2009$ per Mile)	$0.19	$0.21	$0.27	$0.29	---
Gasoline price (2009$ per gallon)	$2.67	$2.67	$4.74	$5.24	---
Parking price (2000$ per day)[34]	---	$0.04 /day avg.	+7% fr. 2008	+98% fr 2008	---
Toll price ($)	n/a	n/a	n/a	n/a	---
Congestion price ($ per mile)	n/a	n/a	n/a	n/a	---

[34] Parking costs are used in the model in a number of ways. Presented are TAZ average daily parking costs, with the % change in average cost from 2008 for 2020 and 2035. The average cost in 2008 reflects the relatively isolated locations in which paid parking is prevalent. Increases for 2020 and 2035 come both in increase rates at existing-to-remain facilities, and new facilities which are likely to charge for parking in new areas.

APPENDIX B. 2010 CTC RTP Guidelines Addressed in SACOG's MTP/SCS

This Appendix describes the requirements in the CTC Guidelines that are applicable to SACOG's regional travel demand model, as well as the recommendations that SACOG incorporated into the model.

Requirements

- Each MPO shall model a range of alternative scenarios in the RTP Environmental Impact Report based on the policy goals of the MPO and input from the public.
- MPO models shall be capable of estimating future transportation demand at least 20 years into the future. (Title 23 CFR Part 450.322(a))
- For federal conformity purposes, each MPO shall model criteria pollutants from on-road vehicles as applicable. Emission projections shall be performed using modeling software approved by the EPA. (Title 40 CFR Part 93.111(a))
- Each MPO shall quantify the reduction in greenhouse gas emissions projected to be achieved by the SCS. (California Government Code Section 65080(b)(2)(G))
- The MPO, the state(s), and the public transportation operator(s) shall validate data utilized in preparing other existing modal plans for providing input to the regional transportation plan. In updating the RTP, the MPO shall base the update on the latest available estimates and assumptions for population, land use, travel, employment, congestion, and economic activity. The MPO shall approve RTP contents and supporting analyses produced by a transportation plan update. (Title 23 CFR Part 450.322(e))
- The metropolitan transportation plan shall include the projected transportation demand of persons and goods in the metropolitan planning area over the period of the transportation plan. (Title 23 CFR Part 450.322(f)(1))
- The region shall achieve the requirements of the Transportation Conformity Regulations of Title 40 CFR Part 93.
- Network-based travel models shall be validated against observed counts (peak- and off-peak, if possible) for a base year that is not more than 10 years prior to the date of the conformity determination. Model forecasts shall be analyzed for reasonableness and compared to historical trends and other factors, and the results shall be documented. (Title 40 CFR Part 93.122 (b)(1)(i))
- Land use, population, employment, and other network-based travel model assumptions shall be documented and based on the best available information. (Title 40 CFR Part 93.122 (b)(1)(ii))
- Scenarios of land development and use shall be consistent with the future transportation system alternatives for which emissions are being estimated. The distribution of employment and residences for different transportation options shall be reasonable. (Title 40 CFR Part 93.122(b)(1)(iii))

- A capacity-sensitivity assignment methodology shall be used, and emissions estimates shall be based on methodology which differentiates between peak- and off-peak link volumes and speeds and uses speeds based on final assigned volumes. (Title 40 CFR Part 93.122 (b)(1)(iv))
- Zone-to-zone travel impedance used to distribute trips between origin and destination pairs shall be in reasonable agreement with the travel times that are estimated from final assigned traffic volumes. (Title 40 CFR Part 93.122(b)(1)(v))
- Network-based travel models shall be reasonably sensitive to changes in the time(s), cost(s), and other factors affecting travel choices. (Title 40 CFR Part 93.122 (b)(1)(vi))
- Reasonable methods in accordance with good practice shall be used to estimate traffic speeds and delays in a manner that is sensitive to the estimated volume of travel on each roadway segment represented in the network-based travel model. (Title 40 CFR Part 93.122(b)(2))
- Highway Performance Monitoring System (HPMS) estimates of vehicle miles travel (VMT) shall be considered the primary measure of VMT within the portion of the nonattainment or maintenance area and for the functional classes of urban area basis. For areas with network-based travel models, a factor (or factors) may be developed to reconcile and calibrate the network-based travel model estimates of VMT in the base year of its validation to the HPMS estimates for the same period. These factors may then be applied to model estimates of future VMT. In this factoring process, consideration will be given to differences between HPMS and network-based travel models, such as differences in the facility coverage of the HPMS and the modeled network description. Locally developed count-based programs and other departures from these procedures are permitted subject to the interagency consultation procedures of Section 93.105(c)(1)(i). (Title 40 CFR Part 93.122(b)(3))

Recommendations

- The models should account for the effects of land use characteristics on travel, either by incorporating effects into the model process or by post-processing.
- During the development period of more sophisticated/detailed models, there may be a need to augment current models with other methods to achieve reasonable levels of sensitivity. Post-processing should be applied to adjust model outputs where the models lack capability, or are insensitive to a particular policy or factor. The most commonly referred to post-processor is a “D’s” post-processor, but post-processors could be developed for other non-D factors and policies, too.
- The models should address changes in regional demographic patterns.

- Measures of means of travel should include percentage share of all trips (work and non-work) made by all single occupant vehicle, multiple occupant vehicle, or carpool, transit, walking, and bicycling.
- To the extent practical, travel demand models should be calibrated using the most recent observed data including household travel diaries, traffic counts, gas receipts, Highway Performance Monitoring System (HPMS), transit surveys, and passenger counts.
- It is recommended that transportation agencies have an on-going model improvement program to focus on increasing model accuracy and policy sensitivity. This includes on-going data development and acquisition programs to support model calibration and validation activities.
- When the transit mode is modeled, speed and frequency, days, and hours of operation of service should be included as model inputs.
- When the transit mode is modeled, the entire transit network within the region should be represented.
- Agencies are encouraged to participate in the California Inter-Agency Modeling Forum. This venue provides an excellent opportunity to share ideas and help to ensure agencies are informed of current modeling trends and requirements.
- MPOs should work closely with state and federal agencies to secure additional funds to research and implement the new land use and activity-based modeling methodologies. Additional research and development is required to bring these new modeling approaches into mainstream modeling practice.
- These regions should develop 4-step travel models as soon as is possible. In the near-term, post-processing should be used.
- The travel model set should be run to a reasonable convergence towards equilibrium across all model steps.
- A simple freight model should be developed and used.
- Several employment types should be used, along with several trip purposes.
- The models should have sufficient temporal resolution to adequately model peak and off-peak periods.
- Agencies should investigate their model's volume-delay function and ensure that speeds outputted from the model are reasonable. Road capacities and speeds should be validated with surveys.
- Agencies should, at a minimum, have four-step models with full feedback across travel model steps and some sort of land use modeling.
- In addition to the conformity requirements, these regions should also add an auto ownership step and make this step and the mode choice equations for transit, walking and bicycling and the trip generation step sensitive to land use variables and transit accessibility.
- Walk and bike modes should be explicitly represented.

- Small Traffic Analysis Zones (TAZ) should be used, to increase sensitivity to infill potential near to rail stations and in Bus Rapid Transit (BRT) corridors. Parking quantity and cost should be represented in the travel model.
- The carpool mode should be included, along with access-to-transit sub modes.
- Feedback loops should be used and take into account the effects of corridor capacity, congestion and bottlenecks on mode choice, induced demand, induced growth, travel speed and emissions.
- Freight models should be implemented in the short term and commodity flows models within a few years.
- Simple Environmental Justice analyses should be done using travel costs or mode choice log sums, as in Group C. Examples of such analyses include the effects of transportation and development scenarios on low-income or transit-dependent households, the combined housing/transportation cost burden on these households, and the jobs/housing fit.
- Agencies should develop models that test joint (or simultaneous)-choice of mode and destination.
- The next household travel survey should include activities and tours.
- Where use of transit currently is anticipated to be a significant factor in satisfying transportation demand, the travel times that are estimated from final assigned traffic volumes times should also be used for modeling mode splits. (Title 40 CFR Part 93.122 (b)(1)(v))
- Household travel surveys should be activity-based and include a tour table. GPS sampling is encouraged or extra emphasis should be placed on accurate geocoding of households, workplace locations, and stops. Regions should take care in the design and data collection procedures of the survey to ensure survey results are appropriate to the type of model being utilized. Coordination with Caltrans' travel survey efforts is encouraged.