**TECHNICAL EVALUATION OF THE
GREENHOUSE GAS EMISSIONS REDUCTION QUANTIFICATION FOR THE
SAN DIEGO ASSOCIATION OF GOVERNMENTS' SB 375 SUSTAINABLE
COMMUNITIES STRATEGY**

December 2015

California Environmental Protection Agency

⊘▤ Air Resources Board

Electronic copies of this document can be found on ARB's website at
http://www.arb.ca.gov/cc/sb375/sb375.htm

Contents

LIST OF TABLES

LIST OF FIGURES

I. EXECUTIVE SUMMARY

The Sustainable Communities and Climate Protection Act of 2008 (Senate Bill 375) is intended to support the State's broader climate goals by encouraging integrated regional transportation and land use planning that reduces greenhouse gas (GHG) emissions from passenger vehicle use. The metropolitan planning organizations (MPOs) of California develop regional Sustainable Communities Strategies (SCS) as part of the Regional Transportation Plan (RTP). These SCSs demonstrate whether the MPO can meet the per capita passenger vehicle-related GHG emissions targets (targets) for 2020 and 2035 set by the California Air Resources Board (ARB or Board).

As the MPO for San Diego County (County), San Diego Association of Governments (SANDAG) is the transportation planning agency responsible for developing and implementing a regional vision for San Diego's future. It does this by coordinating transportation planning and growth management efforts among the local jurisdictions and by building transportation infrastructure in the region.

SANDAG serves the second most populous county in California with a total population of over 3.1 million. The county is unique for its numerous Native American reservations, three major military bases with the largest concentration of military force in the U.S., and the shared border with Mexico with one of the busiest border crossings in the world at San Ysidro. SANDAG has direct responsibility for planning, funding, and constructing the region's transit systems, enabling more seamless integration of land use and transportation infrastructure.

For the San Diego region, the Board set targets of seven percent per capita reduction in 2020 and 13 percent per capita reduction in 2035, from a base year of 2005. In October 2011, SANDAG adopted its first RTP/SCS and the Board determined that the SCS, if implemented, would achieve the 2020 and 2035 GHG emission reduction targets.

SANDAG has worked over the past four years to begin implementing its 2011 SCS while simultaneously developing the second SCS. Elements of the first SCS implemented to date include the completion of bike and pedestrian projects and the expansion of transit with new rapid bus service. New region-wide policies established by SANDAG, such as the Complete Streets Policy and Transit Oriented Development Strategy, will assist local jurisdictions in implementing the SCS.

On October 9, 2015, SANDAG adopted its second RTP/SCS, *San Diego Forward: The Regional Plan*. This RTP/SCS continues to emphasize the key strategies in the first SCS that support a more sustainable future for the San Diego region and also altered

the phasing of key transit and managed lane investments to better match forecasted growth patterns. SANDAG anticipates cities will continue to grow within existing urban boundaries with higher density development instead of sprawling outward. This new SCS continues on the course set by the 2011 SCS to direct investments within existing urbanized areas. The plan includes an extensive regional bus system, improved commuter and light rail service, an expanded regional bicycle network, improved pedestrian infrastructure, dedicated highway lanes for carpool and express buses, and several transportation demand management programs that reduce the number of vehicle trips. The outcomes of this plan include an increase in the number of homes and jobs near transit, a reduction in transit travel time, and economic benefits due to reduced congestion and the construction of transportation infrastructure. SANDAG's quantification of GHG emissions reductions from the 2015 SCS indicates that the plan would result in per capita emissions reductions of 15 percent by 2020 and 21 percent by 2035 from a base year of 2005.

SANDAG has invested significant resources over the past four years to improve its regional travel model, which is the primary tool for forecasting the outcomes of the SCS. SANDAG relied on a trip based model for its first SCS, but employed an activity based regional travel demand model for the 2015 SCS. This new model disaggregates travel behavior information to better assess how different groups are affected by policies and investments. The new model, with updated inputs and assumptions such as auto operating cost and demographics, was a key to analyzing the outcomes of the plan, but also helped to inform the project selection process.

SB 375 directs the Board to accept or reject the determination of each MPO that its SCS submitted to ARB would, if implemented, achieve the region's GHG emissions reduction targets for 2020 and 2035. This report reflects ARB staff's technical evaluation of SANDAG's 2015 RTP/SCS and describes the methods used to evaluate the MPO's GHG quantification. Based on all the evidence, including the models, the data inputs and assumptions, the SCS strategies, and the performance indicators, ARB staff concludes   SANDAG's 2015 RTP/SCS would, if implemented, meet the targets of seven and 13 percent.

II.   IMPLEMENTATION OF SANDAG'S FIRST SCS

The purpose of this report is to provide an overview and analysis of the SANDAG's 2015 RTP/SCS, also known as *San Diego Forward: The Regional Plan*. Because this is the second SCS for the region, it is important to understand the progress SANDAG has made in implementing the first SCS, which was adopted in 2011. Implementation actions since 2011 have helped to refine the focus of the second SCS and established a platform for implementing the second SCS.

SANDAG's first SCS identified short-term and long-term goals to further improve the regional transportation system in a manner that supports more sustainable urban development. The 2011 RTP/SCS projected future development in and near existing urban areas and proposed a transportation network that provides transit near 80 percent of all housing by 2035.

Since the adoption of the 2011 SCS, the region has completed multiple transportation projects, provided funding for local alternative transportation and smart growth projects, and developed tools that provide a foundation for jurisdictions to continue SCS implementation. SANDAG's focus over the past four years has been on implementing the 2011 SCS, including securing the necessary funding.

Transportation Projects

Many transportation projects completed since the adoption of the 2011 RTP/SCS increase the choice, safety, and efficiency of travel in the San Diego region:

- Carpool lanes were added on segments of I-805 between Chula Vista and San Diego.
- Rapid bus service began operating between Escondido and San Diego.
- Bike lanes were added to the regional bike network, including segments of the Bayshore Bikeway.
- A pedestrian railroad crossing was completed in Encinitas which will provide safe beach access.

Source: SANDAG 2015 RTP/SCS and SANDAG.org

Funding Programs

SANDAG supports the implementation of the 2011 SCS through two locally-funded grant programs, which fund capital and planning projects in local jurisdictions. These programs were established before SB 375 and are currently in their third round of funding.

- The **Active Transportation Grant Program** encourages local jurisdictions to plan and build facilities that provide multiple travel choices for residents. SANDAG awarded $8.8 million in 2012 for capital and planning projects that provided bicycle amenities and streetscape improvements.
- The **Smart Growth Incentive Program** helps local jurisdictions implement smart growth projects throughout the region. SANDAG awarded $9.6 million in 2013 for capital and planning projects such as: 300 new pedestrian and vehicular wayfinding signs in Downtown San Diego, a city-wide Healthy Communities Program in Chula Vista, and an updated Vista Downtown Specific Plan to encourage multi-family and mixed use development.

Policies and Strategies

In addition to the above construction projects and local funding assistance, the SANDAG Board of Directors directed staff to complete several regional policy documents that support implementing the 2011 SCS. All of the following were completed since October 2011.

- *Regional Transit Oriented Development (TOD) Strategy*
  In September 2015, the SANDAG Board adopted this strategy, which will assist cities in the region to implement TOD projects and neighborhoods around the region's existing and future public transit network.

4

- *Regional Complete Streets Policy*
  SANDAG supports and encourages Complete Streets implementation by local jurisdictions and Caltrans by providing direct technical support, design and policy resources. The policy, adopted in December 2014, also ensures that SANDAG projects consider local mobility plans and accommodate the needs of all travel modes.
- *Regional Bicycle Early Action Program*
  In September 2013, the Board of Directors approved $200 million for the Bicycle Early Action Program to expand the bicycle network within 10 years with projects totaling 77 miles of new bikeways.
- *Active Transportation Implementation Strategy*
  The primary objectives with this strategy are to enhance bicycle and pedestrian access to public transit, improve safety at highway interchanges, and connect transportation investments to schools. In April 2013, SANDAG's Transportation Committee incorporated this strategy in the 2015 RTP/SCS.

Early implementation of land use and transportation policies is critical to achieving long-term GHG reductions. SANDAG's actions over the past four years demonstrate the region's commitment to implementing the first SCS and establish a foundation for continued implementation of the policies and programs reflected in both the 2011 and 2015 plans.

Source: SANDAG 2015 RTP/SCS

III.   REGIONAL LAND USE AND TRANSPORTATION TRENDS

The growth vision for the region has changed significantly over the past 20 years, with the current emphasis on compact urban centers rather than suburban sprawl. It is one of the fastest growing regions in the State, with the population growing from 2.5 million in 1990 to 3 million in 2010, and forecasted to grow to 3.5 million in 2020. In 2000, the region had a higher household income and higher per capita vehicle miles traveled (VMT) than the statewide averages, which holds true today. The economy of the region is substantially driven by the high tech, tourism, and defense industries in the employment centers around downtown San Diego and north of downtown San Diego in the area known as University Towne Center-Sorrento Valley-Torrey Mesa.

While this section identifies areas in which little change has occurred over the past decades, the 2015 RTP/SCS is intended to make a substantial change in the land use and transportation characteristics of the region by 2035 and beyond.

A.   Land Use

The majority of San Diego County residents live in the western third of the county in one of 18 cities. The most populous city, San Diego, is home to 1.3 million people, over 40 percent of the county population. About 16 percent of the population resides in the unincorporated portion of the county, which includes several smaller communities and Native American reservations.

Figure 1 illustrates the evolution of local and regional land use policies over the past two decades, by contrasting the forecasted development pattern based on adopted local land use plans in 1999 and 2014. The brown and gold shading indicates areas of new growth, which are significantly reduced in the current growth forecast. Local governments no longer expect to sprawl eastward and instead plan to accommodate growth near existing development in the western third of the county. Focusing growth in the existing urban areas of the country decreases development pressure to convert open space and natural resource areas. Almost half the county's total land area (1.2 million acres) is currently preserved as open space, wildlife habitat, parks, and forest.

Figure 1: Projected Future Regional Growth, 1999 vs. 2014

Prior Regional Growth Forecast
(Series 9, 1999)

Current Regional Growth Forecast
(Series 13, 2014)
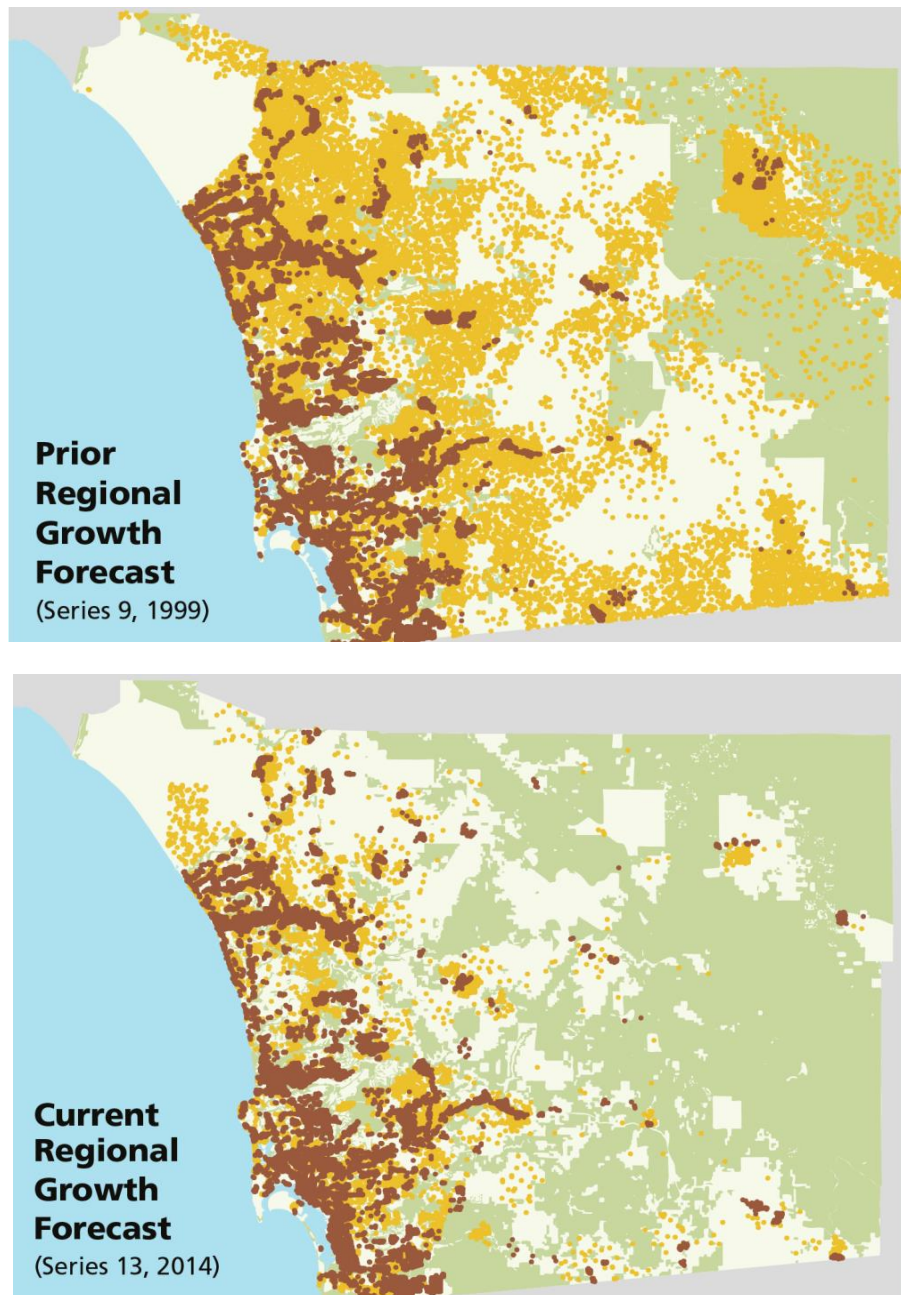
Source: San Diego Forward 2015, Figure 2.2

Although updated local policies and plans provide direction to grow more sustainably, physical changes in the built environment can take decades to occur. The county's current mix of 60 percent single family and almost 40 percent multi-family homes reflects the legacy of dispersed, suburban growth from the past 30 years.

This proportion of single family to multifamily homes has not changed appreciably between 2006 and 2014 (Figure 2) due to the fact that it takes time to change development patterns. However, the steps that SANDAG is taking to implement the SCS will help to increase the diversity of housing by 2035.

Figure 2: San Diego Housing Trends 2006-2014
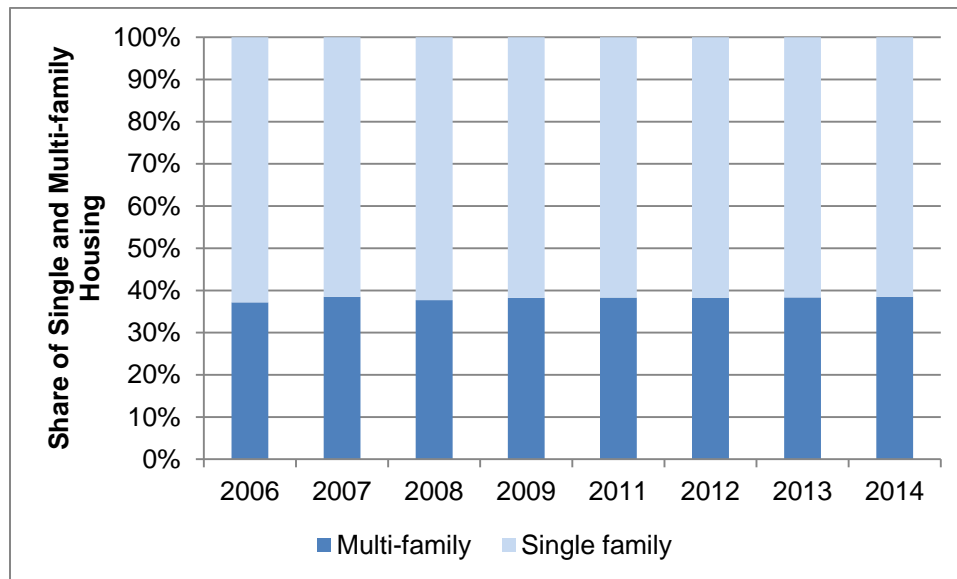
Source: U.S. Census, American Community Survey

Figure 3 shows the current concentrations of population and employment centers from Camp Pendleton in the north to the Mexican border in the south. The 2015 RTP/SCS includes investments that will allow the region to accommodate future growth within these existing urbanized areas, and support that growth with an efficient and sustainable transportation system.

Figure 3: Population and Employment Density 2012

Source: San Diego Forward 2015, Figure 2.1

B. Transportation

San Diego County's mobility relies on an extensive multimodal network of road, rail, transit, bikeway, maritime, aviation, and pedestrian infrastructure. The majority of trips in the region are taken by automobile, either in single occupant vehicles (SOV) or as shared ride trips in high occupant vehicles (HOV). Mode share often reflects the choices travelers have based on existing land use and transportation infrastructure. SANDAG's steps to implement the first SCS provide opportunities to make different mode choices in the future. The 2015 SCS makes significant investments in transit, active transportation, and alternative modes to reduce the reliance on SOV travel.

Figure 4 illustrates the mode split of trips in San Diego County during the period of 2006-2014. There have been only slight changes in mode share between 2006 and 2014, with driving alone remaining the predominate mode of travel for trips in the county. Mode share often reflects the choices travelers have based on existing land use and transportation infrastructure. SANDAG's steps to implement the first SCS provide opportunities to make different mode choices in the future. The 2015 SCS makes significant investments in transit, active transportation, and alternative modes to reduce the reliance on SOV travel.

Figure 4: SANDAG Mode Share 2006-2014
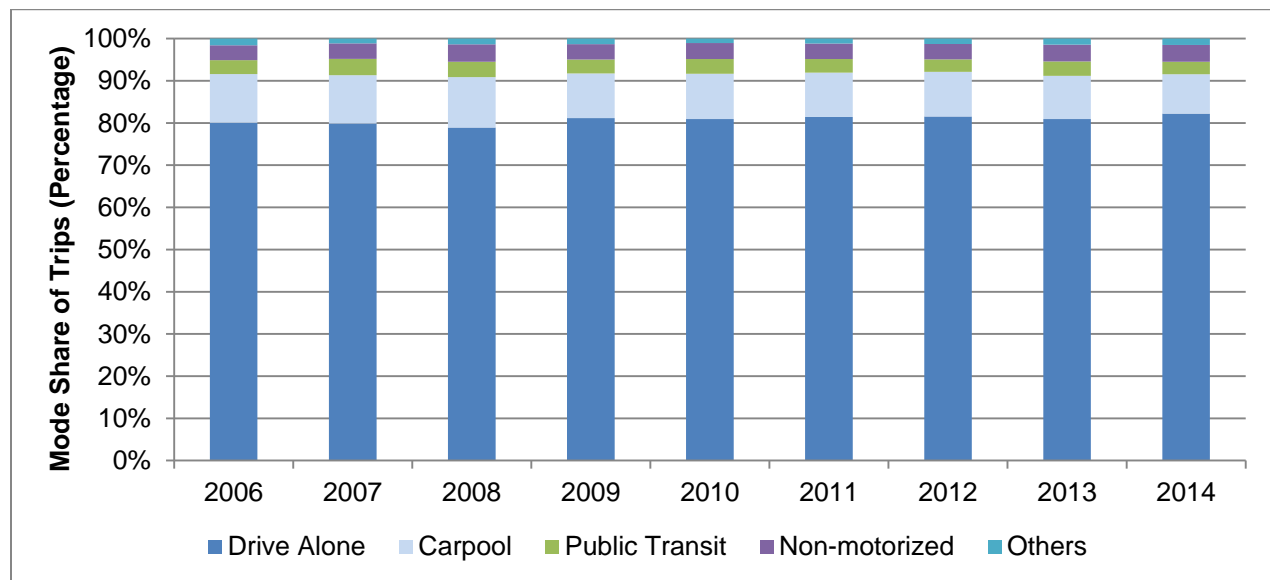
Source: U.S. Census, American Community Survey

Roads

SANDAG is shifting its investment priorities away from single purpose highway lanes towards transit investments and managed lanes that support high occupancy vehicles

and transit. The San Diego region is incrementally building a managed lanes system, with about 30 miles currently in place on sections of Interstate 5, Interstate 15, and Interstate 805. The 20-mile stretch of managed lanes on Interstate 15 was completed as recently as 2012. Managed lanes encourage the use of carpool, vanpool, transit and low emission vehicles, and include express lanes, transit-only lanes and carpool lanes that prioritize HOV travel and sometimes charge fees for SOV access.

Transit

Transit ridership has grown from 42 million annual transit boardings in 1981 to over 100 million in 2013. Local and regional rail serve neighborhoods within the county and provide connections to neighboring counties, including Orange, Los Angeles, and Riverside. The county's two transit providers, North County Transit District and San Diego Metropolitan Transit System, operate multiple bus services: fixed route (BREEZE, MTS Buses, MTS Rapid), paratransit (LIFT and MTS Access), and on-demand service (FLEX). One of the challenges for transit, given the dispersed land use pattern in the county, is the length of time to travel from residential areas like Otay Mesa to job centers like University Towne Center.

Active Transportation

San Diego's active transportation network includes 1,340 miles of bicycle infrastructure and 9,400 miles of sidewalks[1]. SANDAG supports active transportation with grants and programs such as Safe Routes to School. In 2010, the SANDAG Board approved "Riding to 2050: San Diego Regional Bicycle Plan," which established a vision for an interconnected network of bicycle corridors, supporting facilities and awareness programs (like Bike to Work Month). In 2013, SANDAG approved the Regional Bike Early Action Program which funded $200 million to finish high-priority projects within a decade. In March 2015, SANDAG launched gobybikesd.org—a source of information about biking in San Diego including new lanes under construction.

Other Transportation Alternatives

Transportation Demand Management:

SANDAG works to alleviate congestion and provides alternative travel options with strategies like the iCommute program, which offers tools and incentives to commuters and employers to reduce driving alone including: free ride-matching services, vanpool support, bicycle encouragement programs, and support for teleworking.

---

[1] SANDAG 2015 RTP/SCS pg. 48

Private Transportation Companies:

Car sharing businesses like Car2Go and Zipcar that offer short-term car rentals are becoming firmly established in the region. As of 2014, more than 33,000 people in San Diego were carshare members with access to more than 400 vehicles region wide. Transportation network companies, including Lyft and Uber, provide on-demand transportation service in the region. In 2014, DecoBike launched its bike sharing services and currently offers 1,700 bikes at 180 stations across several San Diego neighborhoods.

Electric Vehicles:

As of 2015, the public electric vehicle charging station network includes more than 500 public chargers, including over 20 DC fast chargers. These and many more private chargers support more than 16,000 plug-in electric vehicles that currently operate in the region[2]. The SCS includes strategies to accelerate expansion of the electric vehicle charging system.

IV.   2015 SCS DEVELOPMENT

Since the adoption of the first SCS in 2011, SANDAG has continued to study travel behavior in the region and to use this new information to improve its modeling capability. The 2015 RTP/SCS, known as *San Diego Forward*, builds upon these data collection and modeling efforts and reflects feedback from stakeholders and the public. Similar to the first SCS, the planning horizon for the 2015 SCS extends to 2050 to take advantage of local TransNet sales tax, which will generate more than $14 billion in revenue for transportation and environmental enhancements through 2048. SANDAG's quantification of GHG emissions reductions from the 2015 SCS indicates that the plan would result in per capita emissions reductions of 15 percent by 2020 and 21 percent by 2035.

Developing *San Diego Forward* included steps to estimate future growth, establish performance metrics, and develop the transportation project list. Throughout each of these steps, SANDAG engaged the public with multiple rounds of workshops, coordinated with a network of community-based organizations and convened stakeholder working groups who informed the plan with a broad range of perspectives about public health, equity, economic, tribal, border and other issues.

---

[2] SANDAG 2015 RTP/SCS pg. 79

SANDAG anticipates that cities will continue to grow within existing urban boundaries with higher density development along key transportation corridors instead of sprawling outward. The phasing of investments is intended to support the pace of development in communities, with increasing frequency of transit service in later years to support increases in population.

San Diego Forward provides transportation options for residents, which offer competitive alternatives to single occupancy driving. The expected performance of the plan includes benefits for public health, safety, and system-wide efficiency, which can lead to quicker and safer travel for all users. Specific transportation and land use performance measures are discussed in section V. B. (Plan Performance).

The potential economic benefits of the planned transportation investments include reduced congestion, improved road safety, improved environmental quality, access to economic opportunities, and consumer savings. Using a benefit-cost analysis, SANDAG found that the benefits outweigh the costs of investments in the plan almost two to one. This is primarily a result of the system's improved efficiency which provides time savings to drivers and transit riders.

The equity analysis of the RTP/SCS' impacts through 2050 compared each vulnerable population relative to the non-vulnerable population, regarding current conditions. The analysis found there would be no significant impacts to low-income, minority or senior populations. Some measures showed improvements for vulnerable populations such as time of travel to work by transit and access to bike facilities.

This section summarizes the alternative scenario development process and highlights the key land use and transportation strategies reflected in the adopted SCS.

A.   Alternative Land Use Scenarios

Concurrent with the development of the 2015 RTP/SCS, SANDAG evaluated three alternatives to accommodate the region's future job and housing growth (Figure 5). These scenarios were based on the assumptions and projections of the Series 13 Regional Growth Forecast (RGF), but did not reflect the adopted local land use plans.

Scenario A: Secondary units and infill. This scenario would spread future growth across incorporated jurisdictions as second units on existing properties and as infill development in urban and suburban areas, with uniform job distribution across the region.

Scenario B: Transit-oriented development. This scenario would concentrate population and employment growth in mid-rise, mixed-use buildings within about a mile of existing and future transit stations[3].

Scenario C: Focus growth. This scenario assumed that new growth would occur as mid- and high-rise, mixed-use buildings in existing urban cores and corridors like Downtown San Diego and Chula Vista.

Figure 5: Alternative Land Use Scenarios

Scenario A: Second Units and Infill   Scenario B: Transit Oriented Development   Scenario C: Multiple Dense Cores

Note: The brown shading represents the location and intensity of new growth.

SANDAG's analysis found that these land use scenarios could potentially result in additional GHG emissions reductions of between zero and three percent per capita from current levels, but would require major revisions of local land use plans (i.e., general plans). For this reason, SANDAG determined not to move forward with any of these in the development of the 2015 SCS, but rather, retain the land use scenario represented in the 2011 SCS. The scenario analysis was essentially an exercise demonstrating that the local land use plan updates that have occurred between the Series 9 and Series 13 Growth Forecasts (1999-2014) captured the majority of land use related GHG reductions. The SANDAG Board concluded that effective transportation investments would have the most potential to further reduce regional GHG emissions.

---

[3] Future transit stations were based on the 2011 RTP/SCS project list.

B.   Alternative Transportation Scenarios

To select transportation projects for the RTP/SCS, SANDAG developed the unconstrained project list, determined revenue projections, and established evaluation criteria[4] that would determine which projects to include in the adopted SCS. This process resulted in two transportation scenarios that varied in their mix of highway and transit investments, but included the same active transportation projects and similar Transportation Demand Management (TDM) and Transportation System Management (TSM) strategies. In response to public and stakeholder feedback, a third blended transportation scenario was developed that addressed the trade-offs between the transit and highway improvements and the desire to make the best use of near term revenues.

Scenario 1 focused on strengthening existing transit corridors and providing connections to job centers. Projects included "Express" services along the existing Blue and Orange light rail trolley lines, early operational efficiency improvements on SPRINTER commuter rail service, and completion of two managed lanes on Interstate 5 and Interstate 805 by 2025.

Scenario 2 emphasized a wider system of bus rapid transit (BRT) that would complement light rail lines and provide new transit service to more areas. The four managed lane projects for I-5 and I-805 would be built out by 2035, instead of phasing two earlier in the plan like Scenario 1.

The **Blended Scenario** includes all projects common to both Scenarios 1 and 2. It also combined the early managed lane phasing of Scenario 1 with the widespread transit network investment of Scenario 2. It also improves the frequency of existing local bus routes to 15 minute headways in key corridors by 2020 and ten minute headways by 2035.

In September 2014, the SANDAG Board accepted the Blended Scenario for its ability to deliver more transit services sooner. This scenario strengthens the options in key travel corridors and improves the overall system connectivity by combining the rapid bus network from Scenario 2 with early improvements to the SPRINTER from Scenario 1, as well as improved local bus frequency. The phasing of two managed lanes earlier in the plan will allow rapid buses to take advantage of these facilities, while completing the full four managed lanes later in the plan years.

---

[4] 2015 RTP/SCS Appendix M

V.   2015 SCS Policies and Performance

The following is an overview of the land use and transportation strategies in the 2015 SCS, the expected outcomes of the plan as expressed by selected performance measures, and the region's implementation strategy.

A.   SCS Strategies

1.   Land Use

San Diego Forward consolidates two important regional planning documents, the RTP/SCS and the Regional Comprehensive Plan (RCP). Integrating these two documents provides a single regional planning document that articulates transportation and land use policies, and other sustainability goals for the region like energy efficiency and protection of sensitive habitat and open space.

Between 2010 and 2035, San Diego County is expected to grow by 23 percent, or by about 710,000 people. Over half of new housing growth would occur in the city of San Diego, and the cities of San Diego and Chula Vista would see the biggest increases in absolute growth. This reflects more housing and jobs locating near San Diego and the Mexican border. Most Northern County cities are expected to experience more moderate growth. Unincorporated communities are expected to grow at an overall rate comparable to the regional average.

Land use decisions made at the local level influence development patterns and the GHG emissions from passenger vehicles. *San Diego Forward* reflects smart growth trends in local general and specific plans, which direct growth in existing urbanized areas and along key transportation corridors. This development pattern will bring people and destinations closer together in more mixed-use, compact communities that facilitate walking and use of transit.

> Almost 70 percent of all jobs and 60 percent of housing will be within a half mile of high frequency transit by 2035. (See Figure 9 on pg. 23)

Some examples of local infill and transit-oriented development plans include National City's proposal to add 10,000 new multifamily housing units near existing and planned trolley lines. The City of San Marcos plans to add mixed-use developments along the SPRINTER rail corridor near the California State University San Marcos.

Overall, these types of strategies would result in closer proximity of homes and jobs to high frequency transit, with almost 70 percent of all jobs being within a half mile of transit by 2035, and almost 60 percent of new housing being within a half mile of transit

by 2035. In addition, multifamily housing would make up 76 percent of new housing units through 2035, and the total share of multifamily units would increase from 37 percent in 2012 to 44 percent in 2035.

2.   Transportation

The budget for *San Diego Forward* resembles that of the 2011 RTP/SCS in terms of percentage of funding allocated for each mode of transportation. The total of proposed investments is $204 Billion (year of expenditure) through 2050. Figure 6 illustrates that half of the budget is dedicated to transit, and over 20 percent for highway projects.

Figure 6: San Diego Forward Budget 2015-2050
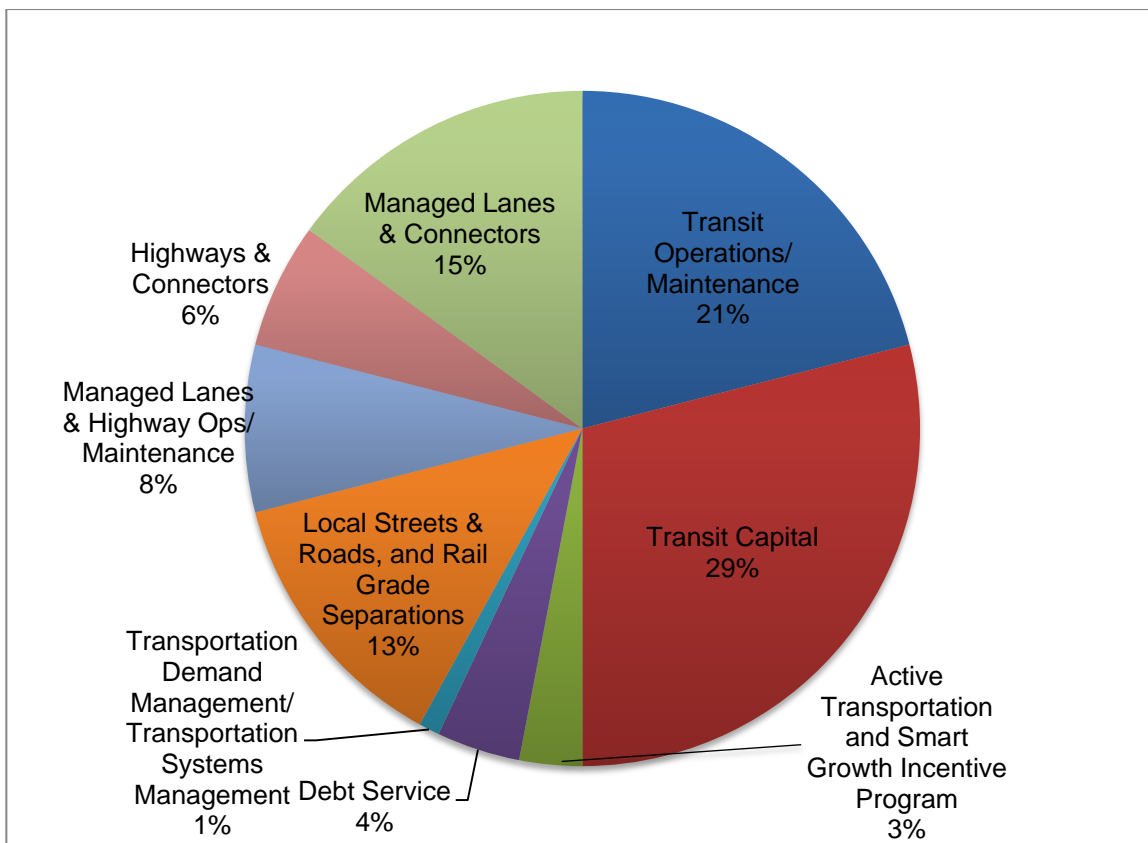
Source: San Diego Forward 2015, pg. 113

Transit

Nearly half of the RTP budget is allocated for transit investments. SANDAG plans to expand the number of destinations served by transit and increase the frequency of service.

Rail: Both the COASTER and SPRINTER commuter rail will increase in frequency through double tracking and efficiency improvements. The Trolley network will also be expanded and improved. For example, the Mid-Coast Trolley Extension project will serve major jobs and housing centers in University City and U.C. San Diego, neither of which are currently served by regional transit.

Bus: Bus frequency in key corridors will improve to 15 minutes by 2020 and ten minutes by 2035. The expanded network of rapid bus services will provide higher-speed alternatives to local bus services in high-volume arterial corridors. This will complement the trolley and SPRINTER line by extending to areas not served by rail. For example, South Bay Rapid will provide frequent service along a 21-mile route connecting the Otay Mesa Port of Entry to employment and activity centers in Downtown San Diego and the South Bay.

> Transit boardings are projected to double between 2012 and 2035. (See Figure 12 on pg. 26)

Overall, these types of strategies are expected to result in improved transit services and increased transit ridership, including:

- Travel times in key corridors would be reduced by an average of 18 minutes by 2035. For example, travel between Otay Ranch and University Town Center would decrease from 121 minutes in 2012 to 55 minutes by 2035.
- Transit mode share would increase over 60 percent from 1.8 percent of trips in 2012 to 3 percent of trips in 2035.
- Ridership is expected to nearly double from about 356,000 daily boardings in 2012 to over 775,000 in 2035.

Streets & Roads

Over 40 percent of the RTP budget is allocated for road projects. Of that, half is allocated for the improvement of local roads and rehabilitation of existing highways. The other half would fund new highway lanes, connector improvements, and several managed lane projects. Managed lanes support carpooling, vanpooling, and rapid transit services, and can also accommodate fee-paying options, like the FasTrak system which uses fees to support transit services along the Interstate 15 corridor.

Bike and Pedestrian Facilities

Three percent of the RTP budget funds active transportation facilities and smart growth projects. The RTP/SCS will help to increase the number of class I and II[5] bikeway miles from 1,050 in 2012 to 1,136 in 2035. The plan's Active Transportation Implementation Strategy also includes educational programs and data collection efforts used to improve safety for bikers and pedestrians.

Transportation Demand Management and Transportation Systems Management

TDM and TSM funding represents a small portion of the overall budget, but these strategies support alternative modes of transportation and leverage road and transit investments to make them operate more efficiently.

SANDAG's TDM programs encourage the use of alternative modes of transportation. Existing programs include the regional vanpool program, the Regional Bike Parking Program, and commuter services like Guaranteed Ride Home. New TDM elements include mobility hubs, shared-use mobility like bike-sharing, and transportation network companies (Uber/Lyft/Sidecar).

> Car sharing membership is expected to increase to 20 percent of the adult population by 2035.

TSM investments are expected to promote greater multi-modal system efficiencies that support mode and trip changes. Existing TSM investments include the traveler information program, roadways and transit management, and an electronic payment system. SANDAG will continue to fund these strategies and will invest in vehicle automation, transit infrastructure electrification, and advanced transit technology.

B.   Plan Performance

Implementation of the projects and strategies in the RTP/SCS is expected to lead to changes across the region, as evidenced by several indicators. ARB staff analyzed these indicators including density, mode share, and passenger vehicle VMT, to determine whether they provide supportive, qualitative evidence that the SCS could meet its GHG targets. Staff relied on the relationships expressed in the empirical literature between each metric and VMT and/or GHG emissions to understand whether the changes are consistent with the SCS's forecasted GHG emission reduction trends.

---

[5] Class I is a separated bike path, Class II is a bikeway separated by lane striping.

Data for this analysis came from the SANDAG Data Table (Appendix A), which provided data for 2020 and 2035. However, Appendix N of *San Diego Forward* illustrates that the benefits continue to accrue through 2050, the horizon year of the RTP/SCS.

1.   Land Use Indicators

Land use influences the travel behavior of residents including both mode choice and trip length. To determine the benefits of the SCS development pattern on GHG emissions from passenger vehicles, the evaluation focused on these land use related performance indicators: residential density, housing type mix, and the percentage of housing and employment near transit.

a)   Residential Density

Residential density is a measure of the average number of dwelling units per acre of developed land. A review of empirical literature reveals that increases in density could reduce VMT. Denser housing development significantly reduces annual vehicle mileage and fuel consumption (Brownstone and Golob 2009). A doubling of residential density can reduce VMT an average of 5 to 12 percent (Boarnet and Handy 2013) and a 1 percent increase in population density leads to a 0.2 to 1.45 percent decrease in the demand for car travel (Litman 2013).

As shown in Figure 7, SANDAG projects that between 2012 and 2035, the regional density will increase 6 percent both within the incorporated cities and in the county net residential average. The county's 2012 density of 6.4 units per net residential acre is relatively high and the main gains in density through 2035 will occur in incorporated cities.

Figure 7: Residential Density
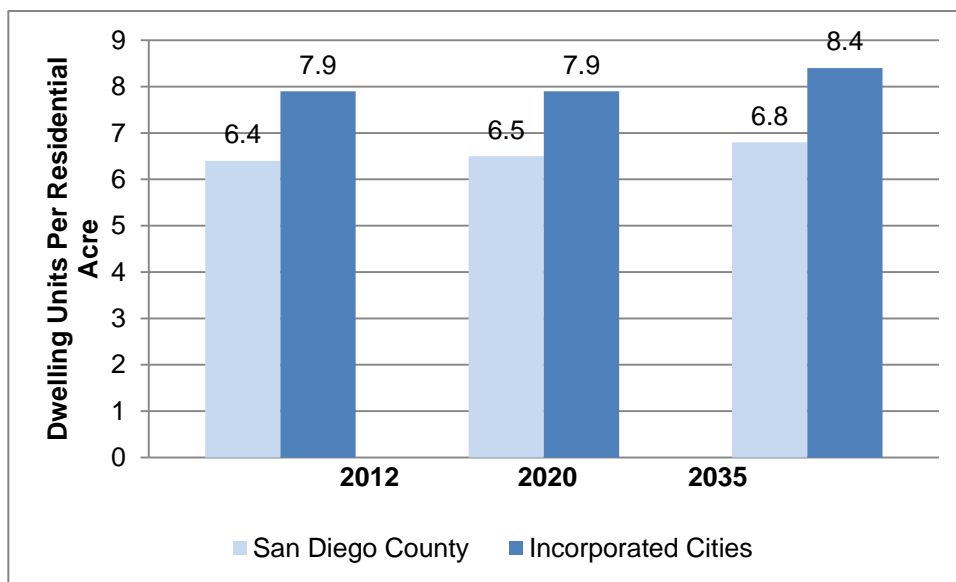
b) *Housing Type Mix*

Travel characteristics in the region are expected to change as the housing market shifts from single family homes towards multi-family housing units. A greater proportion of multi-family development allows for higher densities that support lower VMT, as discussed above.

Between 2012 and 2035, SANDAG shows an increase in multi-family households relative to the total number of households. Currently, multifamily housing units make up 37 percent of SANDAG's housing stock. By increasing the percentage of new multifamily housing, this total will shift to 44 percent by 2035.

Of the new households added to the region since 2012, multi-family households are estimated to make up 82 percent of new housing growth through 2035. Figure 8 shows the percentage of new housing that is multi-family for 2020 and 2035. This trend further supports the forecasted GHG emissions reductions.

Figure 8: Shift Towards More Multi-Family Housing
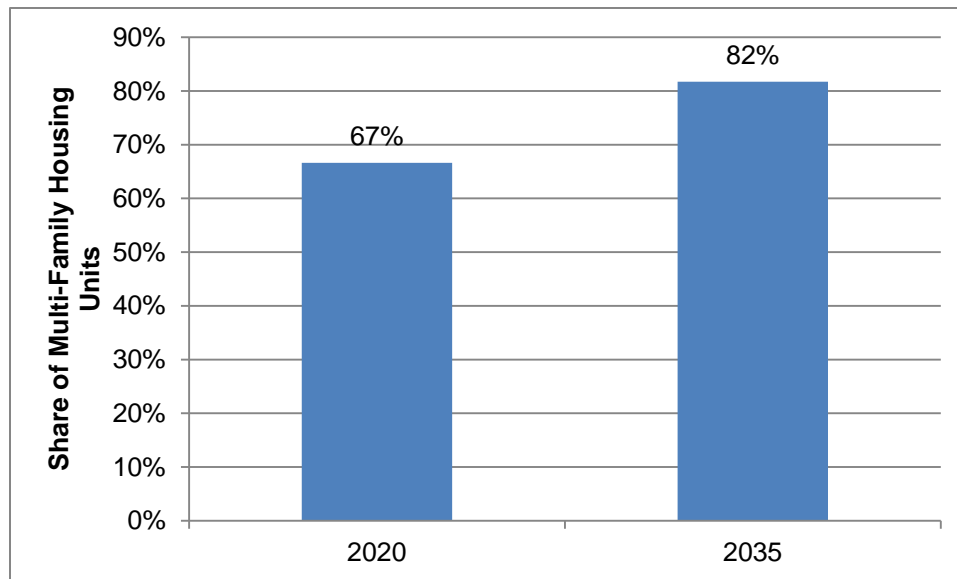
c) *Housing and Employment Near Transit*

The SCS includes strategies to invest in transit near existing and future housing and employment locations. The empirical literature provides supporting evidence that concentrating housing and employment near transit stations can result in VMT and GHG emission reductions in the region. Tal, et al. (2010) suggests a six percent VMT decrease per mile closer to the rail station starting at 2.25 miles from the station and a two percent VMT decrease per 0.25 mile closer to a bus stop starting at 0.75 miles from the stop.

In the SANDAG region, the projected percentage of housing and employment within a half mile of transit stations is anticipated to increase between 2012 and 2035. Figure 9 shows that housing within a half mile of a transit station doubles from 30 percent in 2012 to 60 percent in 2035. For housing closer, within a quarter mile of transit stations, the percentage of units more than doubles between 2012 and 2035, from 19 percent to 44 percent.

Figure 9: Housing and Jobs Near Transit
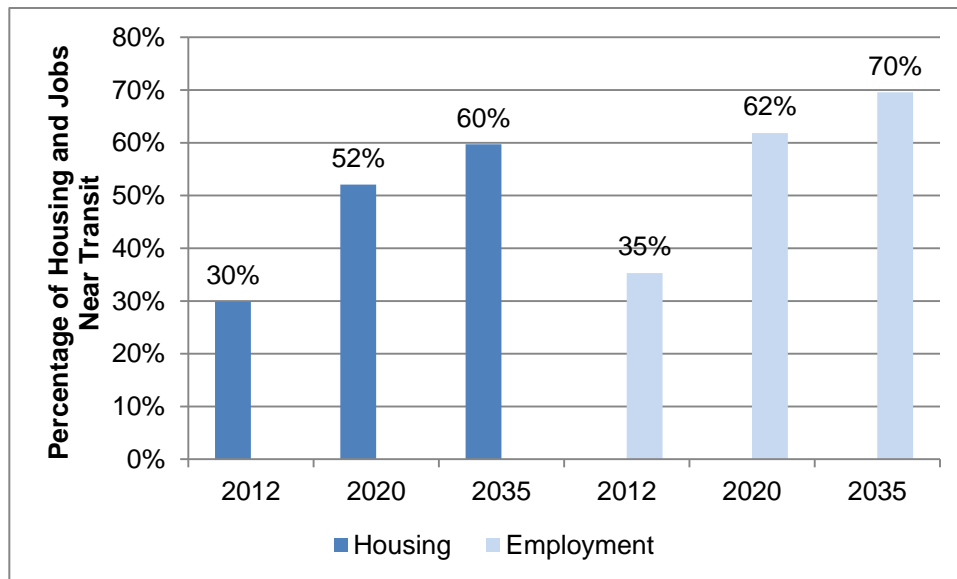
2. Transportation-Related Indicators

ARB staff evaluated transportation-related performance indicators to determine whether the trends represented by the strategies in the SCS support GHG emission reductions.

a) Mode Share

Shifting trips from vehicle to non-vehicle modes (e.g. bike, walk, working at home) can reduce vehicle GHG emissions in a region. While 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, bike, and walk mode shares increase.

Mode share for all trips measures how people travel from home-to-work and back, and how they travel for school, shopping, and all other non-work trip purposes. Figure 10 shows the expected mode share changes in 2020 and 2035 as compared to the mode share in 2012. The drive alone mode share is projected to decrease over five percent by 2035. The bike/walk and transit mode shares increase by over six and 66 percent respectively. These results are directionally consistent with and supportive of the reported GHG emission reduction trend.

Figure 10: Mode Share Changes
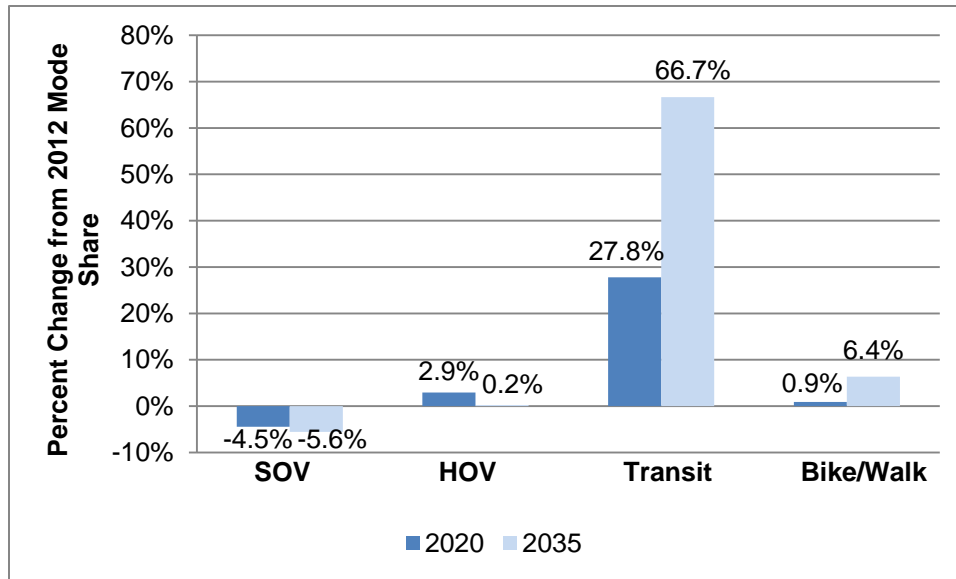
b) Travel Time for Transit

One factor in whether a person takes a trip by car or transit is the duration of the trip. The average travel time for transit trips reduces for both riders that drive to start their trip (park-and-ride) and those who walk to transit. This trend is consistent with expectations to encourage transit ridership and mode choice decisions which might lead to GHG emission reductions. Figure 11 shows that the time it takes for walk-to-transit and drive-to-transit trips decreases 10 percent by 2035.

Figure 11: Reduction in Transit Trip Times
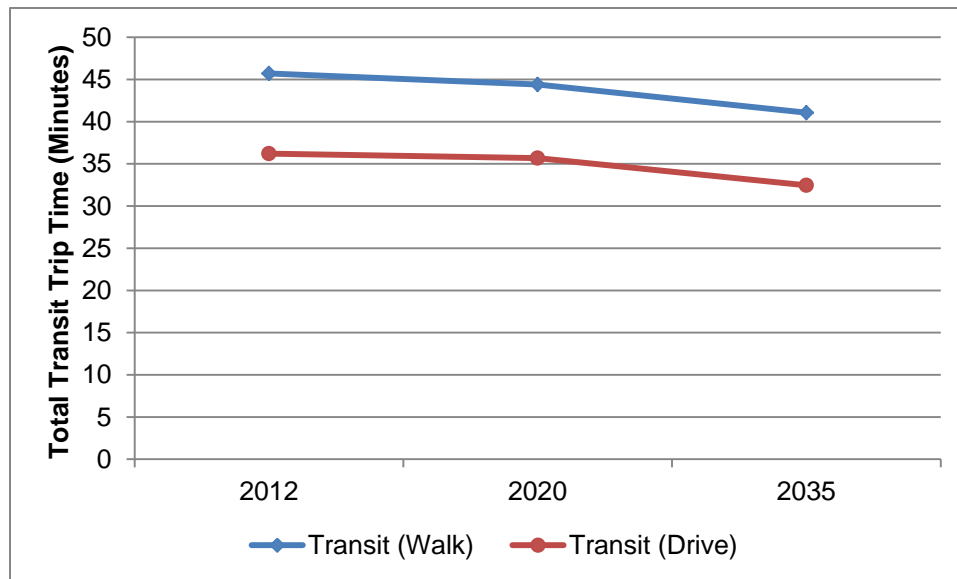
The reduction in transit travel times is greater for certain travel corridors. For example, travel by transit in the Otay Ranch- UTC corridor will take half as long, reducing from 118 minutes in 2012 to 54 minutes in 2035.

c)   *Daily Transit Ridership*

Changes in transit ridership illustrates whether the SCS's transit investments will lead to increased transit system use. Transit service has a greater potential for reducing miles driven if it attracts riders who would otherwise drive versus attracting riders who would otherwise walk or use other transit for a particular trip. Figure 12 illustrates that the daily transit boardings are projected to increase 120 percent between 2012 and 2035.

Figure 12: Increase In Transit Riders
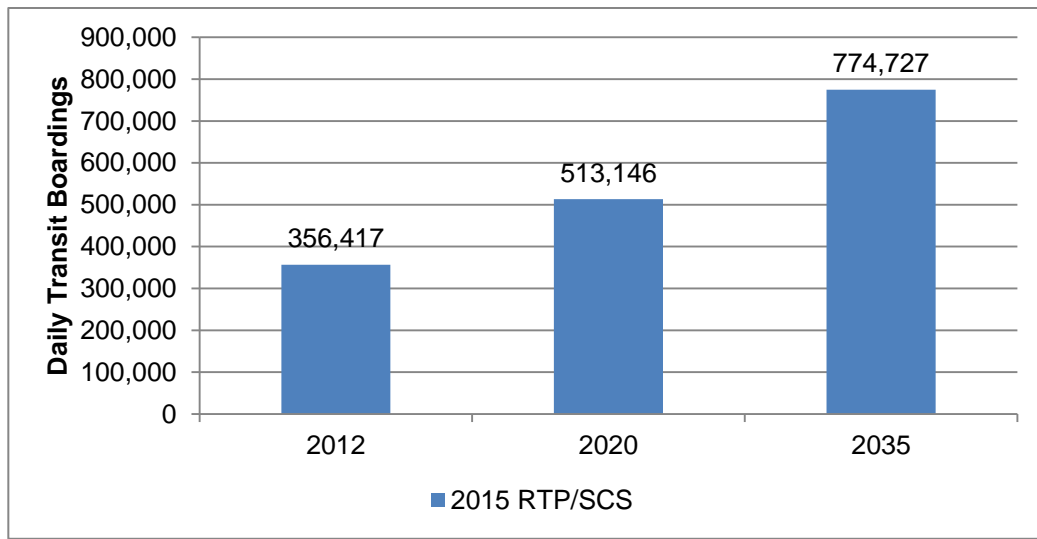
d) *Average Auto Trip Length and Passenger Vehicle Miles Traveled*

A decline in vehicle miles travelled per capita can result from a reduced amount of vehicle trips, due to mode shifting, or of reduced trip distances due to a more compact urban form.

Decreases in average trip length for trips by auto can reduce a region's GHG emissions by decreasing overall miles traveled in a vehicle. Figure 13 illustrates the slight downward trend of both HOV and SOV trip lengths, which each decrease about 6 and 3 percent, respectively, between 2012 and 2035.

Figure 13: Declining Average Trip Lengths
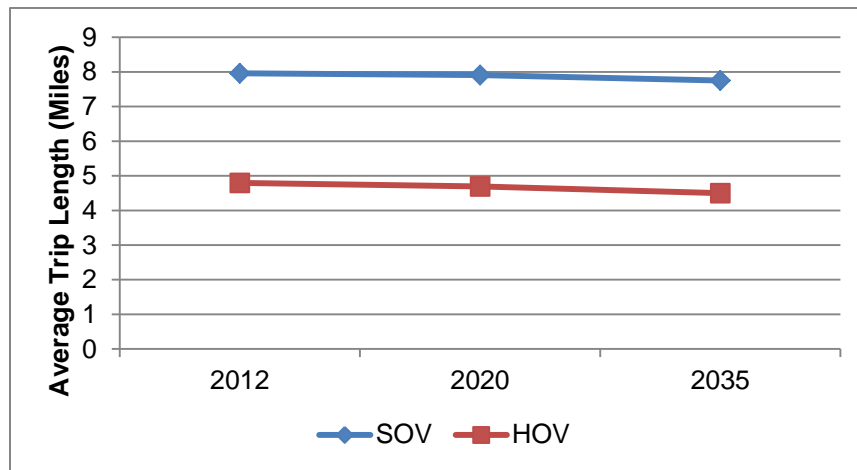
SANDAG's data projections show a decline in per capita passenger vehicle VMT. VMT per capita decreases 7.9 percent between 2012 and 2035 (from 23.8 weekday per capita VMT to 21.9), as shown in Figure 14.

Figure 14: VMT Reductions
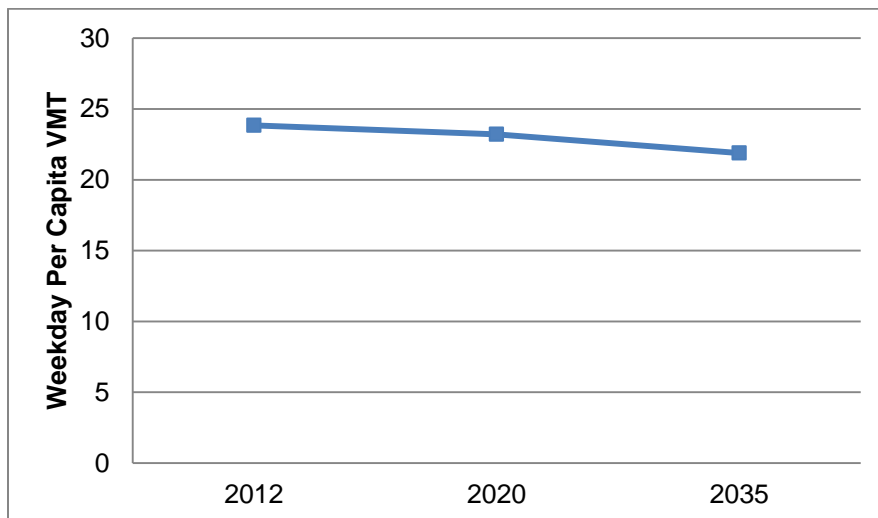
The quantification of GHG emissions from passenger vehicles is a function of both VMT and vehicle speeds. These results are directionally consistent with and supportive of the reported GHG emission reduction trend.

C.   2015 SCS Implementation

The ability of the region to achieve the goals in *San Diego Forward* and meet the performance metrics described above will depend on successful implementation by both

SANDAG and local governments, in collaboration with transit operators, Caltrans, developers, and a wide range of interest groups. Policies established through implementing the 2011 RTP/SCS, detailed in section II, set a foundation to implement the 2015 RTP/SCS.

SANDAG is working to implement the 2015 RTP/SCS by securing resources from federal and state government, and providing local governments with policy guidance, funding, and technical support. (Refer to Chapter 5 of the RTP/SCS for a more detailed description of near term and ongoing actions to implement the SCS.)

State Funding Programs

SANDAG projects it will receive approximately $315 million from the California Transportation Commission's Active Transportation Program through 2035. It also anticipates that the State Cap and Trade programs will award a combined $992 million (year of expenditure) in funding through 2035[6].

As of October 2015, SANDAG has been awarded over $52 million in Greenhouse Gas Reduction Funds through four programs:

- *Affordable Housing and Sustainable Communities:* $7 million awarded for the South Bay BRT, and $9.24 million for the Westside Infill Transit Oriented Development in National City
- *Transit and Intercity Rail Capital Program:* $4 million awarded for the South Bay BRT expansion, $1.675 million for the AMTRAK LOSSAN Corridor, nearly $32 million for trolley capacity improvements, and $41 million for Metrolink corridor improvements in multiple counties
- *Low Carbon Transit:* $100,000 awarded for ADA accessibility improvements, $630,000 for station shelter improvement at El Cajon Transit Center, and $473,000 for transit center improvements
- *Low Carbon Transportation:* $300,000 awarded for the Car Sharing and Mobility Options Pilot Project

SANDAG has also been awarded funding through these state programs that will facilitate implementation of the SCS:

- SANDAG accepted a $500,000 grant from Caltrans in December 2014 to work with Imperial County to develop potential mobility hub locations, design

---

[6] 2015 RTP/SCS, Table 3.1

guidelines and infrastructure requirements, cost estimates and implementation strategies. The study is expected to conclude in the spring of 2017 and will support the implementation of the mobility hubs TDM element.

- SANDAG accepted a $300,000 grant from the California Energy Commission in March 2015 to implement recommendations from the 2014 Regional Electric Vehicle Readiness Plan. This grant will allow SANDAG to develop guidelines for siting charging stations in multiunit buildings, spread electric vehicle awareness, and support local governments with the permitting, inspection and installation of electric vehicle charging stations.

- SANDAG accepted three Sustainable Transportation Planning Grants from Caltrans in March 2015. The first is to identify best practices in social equity analysis of proposed plans and projects and to also develop a statewide modeling tool for future social equity analysis. The second is to develop an intra-regional Tribal Transportation Strategy to identify multimodal projects to improve tribal mobility. The third is for flexible transportation for seniors.

- In late 2014, Caltrans approved over $26 million in Active Transportation Funding for projects in San Diego County.

Local Funding Assistance

SANDAG provides direct funding to local governments through it regional grant programs. In July 2015, the SANDAG Board approved $12 million in funding for Smart Growth projects and $3 million for Active Transportation projects in local jurisdictions. SANDAG is also looking to develop innovative financing tools to help self-finance projects for the new border crossing at Otay Mesa East.

Policy Guidance

The recently adopted regional Complete Streets and Transit Oriented Development policies will support local jurisdictions in providing more opportunities for residents to walk, bike, or use transit. On a project development level, maximizing transportation investments, especially transit, depends on the particular mix of land uses and the urban design in the immediate vicinity of existing and planned transit stations. SANDAG's Regional Transit Oriented Development Strategy[7] can help implement development projects that are sensitive to the needs of transit users and provide recommended strategies for local jurisdictions, developers, transit agencies, and SANDAG.

---

[7] 2015 RTP/SCS Appendix U4

SANDAG is working to develop a long-term specialized transportation strategy to address the need for specialized services to seniors and people with disabilities.

Technical Assistance

SANDAG assists its local jurisdictions by providing a suite of planning and finance tools under the Smart Growth Toolbox, including Smart Growth Design Guidelines and a Regional Parking Management Toolbox. These tools provide technical assistance to the local jurisdictions as they implement projects consistent with the SCS. SANDAG plans to work with partner agencies to develop a regional Transportation Systems Management and Operation Strategy which would help to improve the efficiency of the transportation system. In addition, SANDAG plans to expand the Integrated Corridor Management Concept[8] to improve mobility and system efficiency.

---

[8] Integrated Corridor Management allows individual transportation systems to be operated and managed as a unified corridor network

VI. ARB STAFF REVIEW

SB 375 calls for ARB's "acceptance or rejection of the MPO's determination that the Sustainable Communities Strategy (SCS) would, if implemented, achieve the GHG emission reduction targets" in 2020 and 2035. SANDAG's quantification of GHG emissions reductions in the SCS is central to its determination that the SCS would meet the targets established by ARB in September 2010. The remainder of this report describes the method ARB staff used to review SANDAG's determination that its SCS would meet its targets and reports the results of staff's technical evaluation of SANDAG's quantification of passenger vehicle GHG emissions reductions.

SANDAG determined that the SCS would result in a 15 percent per capita reduction in GHG emissions from passenger vehicles by 2020, and a 21 percent per capita reduction by 2035. ARB staff's evaluation of the SCS and its technical documentation indicates that, if implemented, the SCS would meet the GHG emissions reduction targets of 7 and 13 percent for 2020 and 2035, respectively.

A.   Application of ARB Staff Review Methodology

Technical review of SANDAG's RTP/SCS focused on the aspects of regional modeling that underlie the quantification of GHG emission reductions. ARB staff examined SANDAG's modeling inputs and assumptions, model responsiveness to variable changes, and model calibration and validation results. The general method of review is outlined in ARB's July 2011 document entitled "Description of Methodology for ARB Staff Review of Greenhouse Gas Reductions from Sustainable Communities Strategies Pursuant to SB 375." ARB's methodology is tailored to address each region's unique characteristics. SANDAG published its activity-based model and provided base year model inputs to ARB staff, which enabled a first-hand assessment of the model's structure and performance.

B.   Data Inputs and Assumptions for Modeling Tools

SANDAG's RTP/SCS is based upon several inputs and assumptions, which influence the modeled effectiveness of many strategies relevant to GHG emissions reductions. The socioeconomic and travel costs provide the foundation for SANDAG's modeling approach, and are used by SANDAG's travel model to project changes in the land use and transportation systems. SANDAG's latest long-range forecast of population,

housing, and employment growth for the San Diego region is the Series 13[9], Regional Growth Forecast. SANDAG forecasts population, employment and housing using its Demographic and Economic Forecasting Model (DEFM) which combines an econometric forecasting module and a demographic module. ARB staff evaluated the appropriateness of the data on which these inputs and assumptions are based. This involved using publicly available, well documented sources of information, such as national and statewide survey data on socioeconomic and travel factors. ARB staff also evaluated documentation of regional forecasting processes and approaches.

Demographics

In the DEFM, three key elements are used to forecast population change: births, deaths, and domestic and international migration. To forecast employment, SANDAG used an inter-industry analysis to capture the interrelationship among industries in an economy. The output for each industry was forecast from a composite index of international, national, and local demand, productivity levels, and the relative competitiveness of the San Diego economy. Finally, projected values for labor productivity were used to arrive at a forecast for the total number of employees in the region. SANDAG estimated the number of households based on the total population minus the population living in group quarters (e.g., a nursing home or military barracks). From the adjusted population figures, SANDAG used head of household rates by age, gender, and ethnicity to arrive at the number of households.

SANDAG forecasts that their region's population will grow from 3.1 million in 2012, to approximately 3.4 million by 2020, and to 3.8 million by 2035. This represents a 22.6 percent increase over the 2012 to 2035 period. SANDAG expects that employment will grow 22 percent over the same period, from 1.45 million in 2012, to a little over 1.6 million by 2020, and to 1.8 million by 2035. Over the period of 2012-2050, the median age is expected to increase from 35 to 39 years and the number of people above 70 years old will double. Older people tend to make fewer trips, which reduces total VMT and related GHG emissions.

---

[9] SANDAG denotes forecasts by a sequential series number. The current working forecast is known as the Series 13: 2050 Regional Growth Forecast. The forecast used in the 2050 Regional Transportation Plan and its Sustainable Communities Strategy adopted by the Board of Directors in October 2011 was the Series 12: 2050 Regional Growth Forecast.

Income Distribution

Household income is used as a predictor of a household's decision to either drive or take transit. The DEFM is used to forecast income distribution based on income sources ranging from payroll to dividends and adjusted for the place of residence.

ARB staff evaluated SANDAG's income distribution and found that the average household income was lower by about 17 percent compared to the previous plan. SANDAG staff explained that the household income forecasts were lowered based on feedback from a review of historical trends in the region by an expert panel of demographers, economists, and academics. However, the proposed plan still forecasts an increase of 24 percent in real income growth over the life of the plan. When the average household income shifts downward, the households will have fewer available vehicles and similarly, fewer trips and less VMT. Due to decreases in average household income, projected transit mode share has increased and auto VMT has decreased in the 2015 RTP/SCS compared to the previous plan.

Auto Operating Cost

Auto operating cost is one of the major factors determining the mode of transportation for a trip. ARB staff reviewed the auto operating costs used as inputs in SANDAG's ABM (Table 1). SANDAG came to agreement with MTC, SCAG, and SACOG to use a consistent methodology to estimate auto operating cost[10]. The MPOs agreed to define auto operating cost as a combination of region-specific fuel price, non-fuel-related price, and effective passenger vehicle fuel efficiency. SANDAG forecasted the fuel price based on the 2013 U.S. Department of Energy's annual forecast of motor vehicle gasoline prices and with historical information from 2005. In addition, they added 32 cents to account for gasoline being more expensive in California than the rest of the nation.

---

[10] Automobile Operating Cost for the Second Round of Sustainable Communities Strategies; MOU by MTC, SCAG, SACOG and SANDAG. October, 2014.

Table 1: **SANDAG Region Auto Operating Costs (Prices in Year 2010 dollars)**

Year	Fuel price (dollars per gallon)	Non-fuel-related price (dollars per mile)	Effective passenger vehicle fuel efficiency[*] (miles per gallon)	Modeled automobile operating cost (Cents per Mile)
2005	2.84	0.05	18.89	20.0
2020	4.11	0.07	23.98	24.0
2035	4.87	0.09	27.20	26.7

* EMFAC2011 Model

Source: Automobile Operating Cost for the Second Round of Sustainable Communities Strategies, SANDAG, October 2014.

ARB staff observed that the auto operating cost has increased compared to the previous plan. SANDAG staff explained that the 6 percent and 26 percent increase in auto operating cost in 2020 and 2035, respectively, are due to updates in the methodology to be consistent with other MPOs. When auto operating cost goes 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. Lower auto operating cost would be expected to have the opposite effects on VMT. In this plan the auto operating cost has increased compared to the previous plan which has reduced the per capita VMT and GHG emissions.

Network Inputs

ARB staff also reviewed the coding procedures of SANDAG's highway and transit networks, and travel demand model base year link capacity, free-flow speed assumptions, parking cost and value of time. The methodologies SANDAG used to develop the transportation network and travel demand model input assumptions follow guidelines in the National Cooperative Highway Research Program (NCHRP) Report 716. The NCHRP Report 716 reflects current travel characteristics, and provides guidance on travel demand forecasting procedures and their applications for solving common transportation problems.

C.   Overview of Modeling Tools

SANDAG uses a land use scenario planning tool, an activity-based model (ABM), an off-model tool and the ARB vehicle emissions model (EMFAC2014) to quantify the GHG emissions for its 2015 RTP/SCS. A land use scenario planning tool is used for developing and comparing land use scenarios or assumptions before input into a travel

demand model. SANDAG's activity-based travel demand model employs a computer software package (TransCAD)[11] to calculate changes in travel demand based on several different modeling inputs, including population, employment, housing, the transportation network and planning assumptions about future year land use. Based on these and other inputs, the travel demand model produces vehicle activity outputs such as VMT, vehicle hours traveled, number of vehicle trips, and average speed. SANDAG employs off-model tools to account for additional VMT and GHG emissions reductions related to land use and transportation strategies to which the travel demand model is not responsive. SANDAG converted VMT outputs to GHG emissions by running ARB's vehicle emissions model, EMFAC 2014.

1.   Land Use Model

The land use alternatives discussed in section IV. A. (Alternative Land Use Scenarios) were developed using the UrbanFootprint sketch modeling tool. The UrbanFootprint model is a land use planning, modeling, and data organization framework designed to facilitate more informed planning. The model's analytical engines produce these metrics for scenario-based planning: land consumption, vehicle miles traveled (VMT), travel mode, fuel consumption, transportation GHG and air pollutant emissions, building energy and water consumption, costs, related GHG emissions, household costs for housing, transportation and utilities, public health impacts and costs, and local fiscal impacts.

2.   Activity-Based Travel Demand Model

SANDAG has moved to an ABM from a traditional trip-based model to improve the sensitivity to land use and transportation strategies. The ABM SANDAG used for *San Diego Forward* is based on the Coordinated Travel Regional Activity-Based Modeling Platform (CT-RAMP). SANDAG's ABM predicts person-level and household-level travel choices including the interactions between household members. It analyzes travel as a pattern of daily behavior and depends on the activity participation of individuals. Travel is derived from participation in activities and depends on the organization of those activities, rather than just the desire to travel. SANDAG ABM broadly includes five steps: a population synthesizer, long-term choice, day-level activity, tour-level and trip-level models. Within these steps, there are many sub-models. SANDAG used the ABM to assess the long-term needs of the region's transportation system such as roadways,

---

[11] TransCAD is a computer software package specifically designed for transportation planning and analysis.

transit planning, and goods movement. It is also used to conduct GHG analyses under SB 375 and perform federally required air quality conformity.

SANDAG's ABM has improved the representation of demographic and socio-economic characteristics including age, gender, household structure, and income. This has enhanced SANDAG's capabilities to analyze the activity patterns of different household groups and the impact of policies on specific sub-groups of the population (e.g., impact of gas price rise on low income groups). SANDAG has also improved the spatial and temporal (30 minute interval) resolution of the analysis. This provides detailed inputs for corridor level analysis and intersection design. Further, the ABM better represents bike and walk trips and is more sensitive to these modes.

Data Collection

SANDAG's ABM requires large amounts of data to capture the travel behavior of each individual person and household in the region. Therefore, SANDAG has undertaken efforts to improve the data collection for model calibration and validation. For example, SANDAG conducted the 2010-2011 Parking Behavior Survey and the 2009-2010 Parking Inventory. The parking behavior survey captures peoples' choice on parking location and the parking inventory provides all available parking facilities and charges. In addition, the SANDAG 2006 Household Interview Survey and the 2009 Transit On-Board Survey were used for mode choice estimation. The household interview survey provides the distribution of travel modes such as transit trip and bicycle trip share. The on-board survey provides demographic and socio-economic information of the transit rider. SANDAG participated in the 2012 California Household Travel Survey which can provide more recent data for the ABM.

Model Description

A population synthesizer is the first step of the model which converts the forecasted socio-economic and housing information at the regional level into a detailed record for each individual person in the household with information such as age, gender, and income. This becomes a key input to the other steps of the SANDAG's ABM model. The long term decision model predicts primary work/school location, car ownership for each household, availability of free parking for workers, and transponder ownership. Long term decisions are then fed into the short term decision model to capture the complex aspects of travel decisions such as mode, time of travel, frequency, and other individual decision-making processes of travel choices. The daily activity-travel pattern model captures the behavioral aspects and travel decisions at each level.

SANDAG's ABM uses a nested logit model structure to forecast the main tour mode, from the tour origin to the primary destination, and back to the origin. Once the daily

activity pattern has been estimated for each person, the model schedules the tours he or she would be expected to take. The tour-level mode choices include drive alone, shared ride (2 persons and 3 or more persons), drive-to-transit, walk-to-transit, park-and-ride, kiss-and-ride[12], bike and walk. The model further splits the auto mode into free or pay, and transit into specific modes (local bus, express bus, bus rapid transit, commuter rail, light rail transit). The model also allows travelers to use walking as a mode for any trip in a tour, and allows travelers to switch between transit and auto modes. The tour mode choice model utilizes variables such as household size, car ownership, in-vehicle travel time, other travel time, cost, initial wait time, transfer wait time, number of transit transfers, intersection density, employment density and dwelling unit density. This model was developed based on the SANDAG 2006 Household Travel Behavior Survey and the 2009 Transit On-Board Survey.

The model structure of both trip-level stop location and mode choice sub-models are consistent with that of the tour-level models. The stop distance on a tour is observed to make a significant contribution in locating each trip on a tour. In the trip-level mode choice model, the coefficients of in-vehicle time and other travel times have correct signs and values are within the reasonable ranges as stated in the FHWA guidelines. They are generally greater in absolute value than those estimated in the tour mode choice models, indicating higher elasticities with respect to time and cost for each trip mode given the tour mode.

The trip assignment step of SANDAG's ABM is performed by converting person-tours to vehicle trips by mode and time period, aggregating those trips with internal-external, commercial, and air passenger trips, and assigning them to the highway and transit networks. SANDAG's ABM runs over five time periods using multi-class user equilibrium to assign vehicle trips on the transportation network for drive alone, shared rides, and all other vehicles. When all trips are assigned to a network, it estimates the total number of trips by mode, and the volume of vehicle traffic in each link. It also predicts the congested travel time in the entire transportation system by considering roadway capacity. SANDAG estimates effective roadway capacity of each facility by considering facility type and area type. This allows for consideration of priority lanes for shared rides and no-truck routes. Transit assignment is predicted by accounting for the congested travel time from the highway assignment. The time taken to access, egress, and transfer from one transit vehicle to another are weighted twice that of the travel time in the general purpose lane.

---

[12] Kiss-and-ride refers to informal trips where a driver picks up or drops off additional passengers, not associated with park-and-ride facilities.

ARB staff evaluated the structure and variables used in the various sub-models of ABM, and whether the model followed the state of the practice[13]. ARB staff also evaluated average distance between home and work, home and school/college, and county-to-county work/school trips. Overall, the modeled tours by person types closely follow the observed data. Auto ownership, demographics, and accessibility variables strongly influence the number and the duration of tours. The signs and coefficients of each variable in the ABM model seem reasonable.

Model Validation

Model validation, usually the last step in developing any regional travel demand model, reflects how well the model estimates match with observed data. The California Transportation Commission (CTC) Regional Transportation Guidelines suggests validation for a travel model should include both static and dynamic tests. The static validation tests compare the model's base year traffic volume estimates to traffic counts using the statistical measures and the threshold criteria. Testing the predictive capabilities of the model is called dynamic validation and it is done by changing the input data for future year forecasts. SANDAG validated its ABM using traffic counts from CalTrans, PeMS Traffic Research Associates and local jurisdictions. Transit boardings by time of day and route from SANDAG's Passenger Counting Program are used for the transit validation.

CTC recommends using volume-to-count ratios, correlation coefficient[14] and root-mean squared error[15] for daily traffic assignment. Further, SANDAG's ABM has a correlation coefficient of 0.99 between the modeled and the observed volumes, indicating that the model closely follows observed data. Table 2 is a summary of SANDAG ABM validation results comparing to CTC guidelines.

---

[13] The state of the practice indicates the methods used by most MPOs in developing their travel demand models.

[14] Correlation coefficient estimate the correlation between the actual traffic counts and the estimated traffic volumes from the model

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

Table 2: SANDAG ABM Validation Summary

Validation Item	SANDAG Model	CTC Guideline Criteria for Acceptance
Percent of links with volume-to-count ratios within Caltrans deviation allowance	91%	At Least 75%
Correlation Coefficient	0.99*	At Least 0.88
Percent Root Mean Squared Error (RMSE)	28.6%	Below 40%

*Calculated from observed and estimated daily traffic at key locations from 2012 model calibration and validation report.

3. EMFAC Model

ARB's Emission Factor model (EMFAC 2014) is a California-specific computer model which calculates weekday emissions of air pollutants from all on-road motor vehicles including passenger cars, trucks, and buses for calendar years 2000 to 2050. EMFAC2014 is used to support ARB's regulatory and air quality planning efforts and to meet the Federal Highway Administration's transportation planning requirements. SANDAG ran its activity based travel demand model for the RTP/SCS scenarios for the region and converted the estimated passenger vehicle VMT and speed profiles into EMFAC 2014 inputs. SANDAG then calculated per capita CO_2 emissions by using residential populations and estimated CO_2 emissions for passenger vehicles in 2020, and 2035.

ARB staff developed a *Methodology to Calculate CO2 Adjustment to EMFAC Output for SB 375 Target Demonstrations* to allow MPOs to adjust the calculation of percent reduction in per capita CO2 emissions used to meet the established targets when using a different version of EMFAC for the second RTP/SCS. This adjustment factor neutralizes the changes in fleet average emission rates between the version of EMFAC used for the first RTP/SCS and the version used for the second RTP/SCS. The goal of the methodology is to hold each MPO to the same level of stringency in achieving their targets, regardless of the version of EMFAC used for its second RTP/SCS. SANDAG followed the methodology and their CO2 per capita reductions results were adjusted accordingly.

4. Off-Model Adjustments

SANDAG made off-model adjustments to estimate GHG emissions reductions from some transportation system management (TSM) and transportation demand management (TDM) strategies to which its ABM and land use model are not sensitive. These off-model adjustments are based on local knowledge and data collection which

demonstrate the potential for GHG emissions reductions from several SCS strategies, including carpool, carshare, charging for electrical vehicles, and vanpool programs.

Carpool:

SANDAG plans to dedicate $100,000 each year from 2015 to 2050 to encourage solo commuters to carpool to work. The program subsidizes new carpools through a $30 gift card for the first three months to each participant. It is estimated that 488 new carpools could be incentivized through this program each year[16].

SANDAG assumes there are about 2.1 persons per carpool, and that participation will stabilize at about 1,300 carpools per year. The average commuter distance of 26 miles was used to calculate the total annual reduction of VMT from the carpool program. SANDAG estimated a daily VMT reduction of 36,986 in 2020 and 2035, which is equivalent to a 0.04 percent reduction of per capita VMT by 2020 and 2035.

Car sharing:

Car sharing is a short-term vehicle use program in which participants rent cars for short periods of time, often by the hour. Car sharing provides a flexible transportation alternative to vehicle ownership for people that use a vehicle only occasionally. SANDAG's 2015 RTP allocates $37 million for the car share program and expects it will achieve a 0.4 percent per capita reduction in VMT by 2020 and a 1.1 percent per capita reduction by 2035. SANDAG estimates emission reduction benefits for the program based on the estimated reductions in car share member VMT compared to non-car share members.

Electric Vehicles:

The SANDAG Plug-in Electric Vehicle (PEV) Readiness Plan (including Zero-Emission Vehicles and Plug-In Electric Vehicles) was developed to support the development of PEVs fleet share and address the challenges of deploying charging infrastructure. The 2015 RTP/SCS allocates $15 million for the 2014-2035 time frame to fund charger installation incentives. As of 2015, the SANDAG region has over 16,000 plug-in electric vehicles and over 500 public charging stations. SANDAG estimates the PEV program will reduce 96,654 and 478,565 pounds of daily passenger vehicle CO_2 emissions by 2020 and 2035, respectively, by extending the VMT fueled by electricity by 10 percent. The net daily CO_2 reduction from this program is approximately 78,785 and 390,027

---

[16] Carpool subsidy: ($30 gift card + $2.50 activation fee per card) x 3 months x 2.1 people

pounds by 2020 and 2035, respectively, after considering the CO2 emissions from electricity generation.

Vanpool:

The SANDAG Regional Vanpool Program is designed to reduce commute hour congestion on the roadways in the region. The 2015 RTP/SCS allocates $282 million in the Regional Vanpool Program to encourage new vanpool participants through a subsidy of $400 per month per vanpool. SANDAG assumes 80 percent of the yearly projected vanpools would be 8-passenger vans, and the other 20 percent would be 10-passenger vans. Additionally, SANDAG assumes an average round-trip per vanpool of 113 miles. As a result, the daily VMT reduction is 678,339 and 972,797 by 2020 and 2035, respectively, which is equivalent to a 0.8 and 1 percent reduction of VMT by 2020 and 2035.

ARB staff reviewed assumptions used in SANDAG's strategy analysis, for example, population, VMT, and the method used to calculate the GHG emissions reductions from each strategy. SANDAG's method and baseline assumptions appear reasonable.

Overall Off-Model Reduction

SANDAG used off-model adjustments to estimate the GHG reductions that would result from strategies such as carpooling, car sharing, vehicle charging systems for electric vehicles, and vanpooling. The assumptions associated with these strategies were based on case studies and observed data collected from existing programs. Overall, these off-model strategies contribute to an approximately 1.34 and 2.52 percent reduction in VMT in the SANDAG region in 2020 and 2035, respectively, which translates to an approximately 1.46 and 3.10 percent reduction in GHG emissions in 2020 and 2035.

Table 3: Overall Off-Model Per capita GHG Reduction

Off Model Strategy	2020	2035
Carpool	0.05%	0.05%
Carshare	0.50%	1.3%
PEV	0.01%	0.6%
Vanpool	0.90%	1.2%
Total Reduction of Per Capita CO2	**1.46%**	**3.10%**

5. Planned Model Improvements

MPOs continually improve their models. SANDAG has planned and allocated funding for a variety of model improvement projects. Aside from continuously maintaining and enhancing existing models and tools, SANDAG is in the final stage of developing new land use, economic, and transportation modeling tools. In addition, planned model improvements include the land use editing tool update, active transportation enhancement, and dynamic traffic assignment which will help to better assess the impact of strategies and their GHG emissions.

ARB staff recommends that SANDAG should consider using the latest version of the California Household Travel Survey. They should revisit and recalibrate the mode choice model using the latest household travel survey data.

ARB staff recommends that SANDAG should consider conducting stated preference surveys of households and firms to improve the location choice model of their ABM. Further, SANDAG should collect floor space rent data to improve the economic characteristics of land use model.

As part of the next phase of the model improvements, SANDAG should consider integrating the land use and ABM into single modeling system to improve the interactions between the land use and transportation models to capture synergetic effects. Integrated land use and transportation models will improve the representation of long-term choices such as residential and employment locations.

D. Model Sensitivity Analysis

ARB staff reviewed the results of SANDAG's sensitivity analyses to assess whether the model was generally sensitive to changes in transportation related variables by verifying that the direction of change was consistent with the relevant empirical literature. Staff also assessed whether the magnitude of the changes observed was appropriate (otherwise known as "appropriately sensitive"), based on elasticities discussed in ARB policy briefs and corresponding technical background documents[17]. An "elasticity" is an economic concept that quantifies the relationship between the choices people make and the cost of those choices. In transportation, this concept is used to quantify how changes in the cost of travel influence an individual's choice about the amount they will

---

[17] These policy briefs and technical background documents, which seek to identify the impacts of key transportation and land use policies on vehicle use and GHG emissions, based on the scientific literature, can be found at http://arb.ca.gov/cc/sb375/policies/policies.htm.

travel. Elasticities can also be used to describe the relationships between changes in land use or transportation variables other than cost, and their likely impact on travel behavior.

1.   Auto Operating Cost

Auto operating cost is a major assumption in travel demand modeling which influences travelers' choice on auto use. It is expected that when the auto operating cost increases, less VMT will be generated since travelers are likely to choose less expensive means of travel such as transit. Conversely, when auto operating cost decreases, more VMT will be generated since the travelers are expected to drive more.

SANDAG defines auto operating cost in two categories: fuel cost and non-fuel-related costs. The base year fuel cost was set during SANDAG's model calibration process. The non-fuel-related costs include vehicle maintenance and tire costs. The auto operating cost is estimated as a cost per mile multiplied by the trip distance. SANDAG designed four scenarios to test the model's responsiveness to auto operating cost changes: 50 percent decrease, 25 percent decrease, 25 percent increase and 50 percent increase.

As expected, the model shows a decrease in VMT when auto operating cost increases. The percentage of VMT change from the base case in each scenario ranged from -1.6 percent to 2.5 percent. Table 4 summarizes the results of the auto operating cost sensitivity scenarios with comparisons to the ranges from the empirical literature. The modeled VMT for each of the scenarios changed in the expected direction and falls within the expected short-run VMT ranges. However, the modeled VMT falls slightly outside the expected long-run VMT ranges, which might be due to the reported elasticities being derived from studies in regions different from SANDAG.

Table 4: Auto Operating Costs - Sensitivity Results

Test	Modeled VMT	Expected VMT (Short-Run)	Expected VMT (Long-Run)
50% Decrease from Base Case	81,525,803	80,349,768 - 88,702,962	83,929,708 - 93,078,444
25% Decrease from Base Case	80,424,737	79,951,997 - 84,128,594	81,741,967 - 86,316,335
Base Case (2012)	79,554,226	--	--
25% Increase from Base Case	78,781,407	74,979,858 - 79,156,455	72,792,117 - 77,366,485
50% Increase from Base Case	78,317,785	70,405,490 - 78,758,684	66,030,008 - 75,178,744
Source: -0.026 (Small and Van Dender, 2010) , -0.195 (Burt and Hoover, 2006), and -0.091 to -0.093 (Boilard, 2010) for short-run; -0.131 (Small and Van Dender, 2010), and -0.29 to -0.31 (Goodwin et al., 2004) for long-run.

2.   Transit Fare

Changes in transit fare will affect traveler's choice on travel mode and therefore, influence VMT. The expectation is that decreasing transit fare results in increased transit boarding and increasing transit fare results in decreased transit boarding.

SANDAG designed four scenarios to test the model's responsiveness to transit fare changes: 50 percent decrease, 25 percent decrease, 25 percent increase and 50 percent increase. As expected, the model shows a decrease in transit boarding when transit fare increases (Figure 15). The percentage of transit boarding changes from the base case in each scenario ranged from -29 percent to 46 percent.

Figure 15: Transit Fare - Sensitivity Results
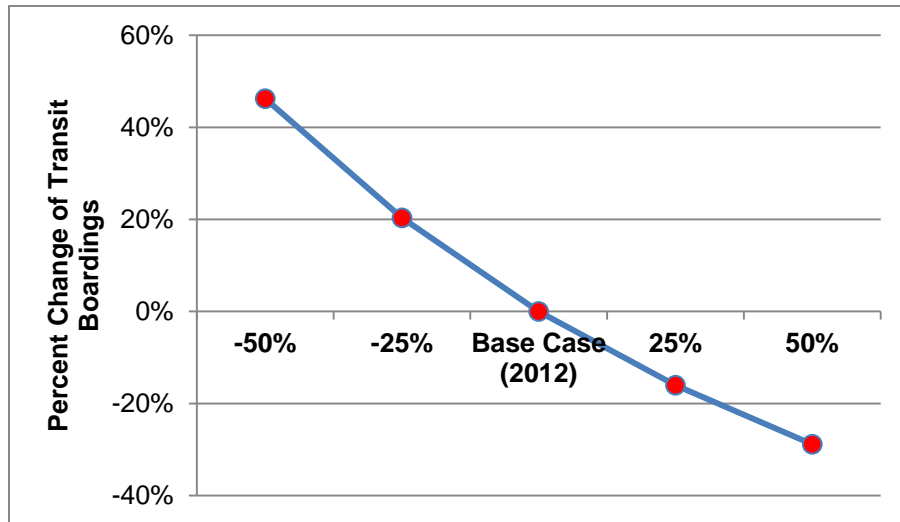
3.   Transit Frequency

Transit frequency is an indicator of the supply side of transit. When the transit frequency increases, the transit service operates more and therefore, supplies more. When transit frequency decreases, the transit boarding will be decreased since less transit supply is offered and travelers must choose other modes of transportation.

SANDAG designed four scenarios to test the model's responsiveness to transit frequency changes: 50 percent decrease, 25 percent decrease, 25 percent increase and 50 percent increase. As expected, the model shows an increase in transit trips when transit frequency increases (Figure 16). The percentage of transit trips changes from the base case in each scenario ranged from -12 percent to 27 percent.

Figure 16. Transit Frequency - Sensitivity Results
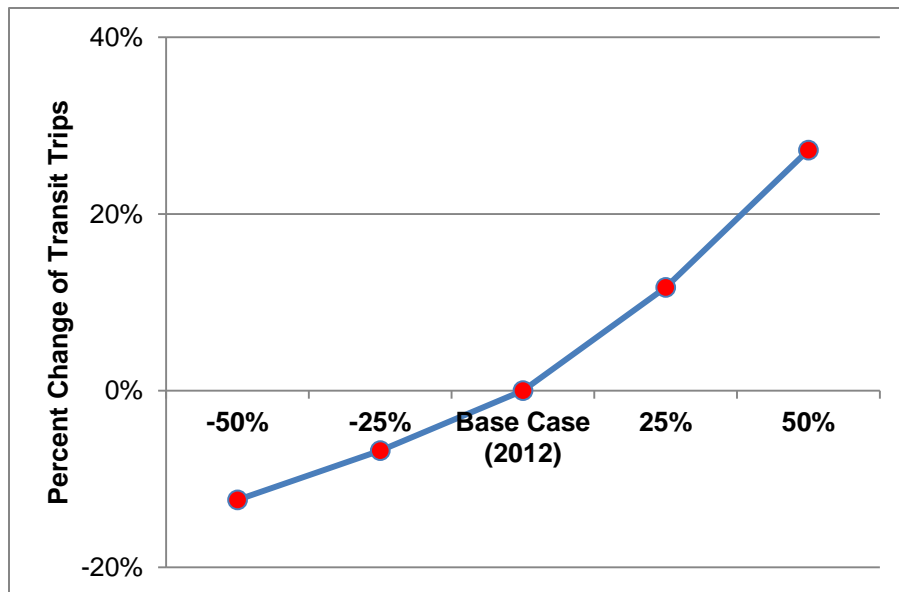
4.   Land Use Density

Land use density changes will affect VMT since higher density of housing units and employment correspond to reduced trip frequency and trip length, and therefore, reduced VMT. It is expected that when land use density increases, the corresponding VMT output from SANDAG ABM should decrease.

SANDAG used 2035 revenue constrained network with Series 13 Regional Growth Forecast and alternative land use scenarios to test the model response of land use density changes. SANDAG combined both residential and employment density. The two sensitivity tests involved a 3 percent increase and 7 percent increase in residential and employment densities. Changes to residential and employment density were focused on the existing and planned smart growth areas for one scenario, and around high quality transit fixed-route stops[18] for the other scenario. Table 5 shows the VMT changes resulting from running the two land use scenarios. As expected, the increased density scenarios result in less VMT compared to the baseline providing evidence that the model is sensitive directionally to residential density changes. Compared to empirical literature, the increase in land use density seems to have a greater impact on reducing VMT in the SANDAG region.

---

[18] High quality transit is defined as routes with peak and midday frequency more than15 minutes.

Table 5: Land Use Density - Sensitivity Results

Test	Modeled VMT	Expected VMT
Base case (2035)	60,989,959	--
3% Increase from Base Case	60,647,442	60,770,395 - 60,898,474
7% Increase from Base Case	59,833,247	60,477,643 - 60,776,494
Source: Boarnet and Handy (2013) The Impacts of Population Density on VMT range from -0.05 to -0.12.		

5. Household Income

SANDAG used the cross-sectional approach adopted by the Metropolitan Transportation Commission (MTC), to examine the relationship between VMT and household income. Cross-sectional tests are used to provide better information when testing the interaction of socioeconomic and transportation variables, which are difficult to model independent of one another. Cross-sectional testing uses statistics to help sort out the relationships between multiple input and output variables. SANDAG conducted a regression analysis with a typical weekday VMT against household income for each full-time and part-time worker using the 2012 ABM model outputs. The resulting elasticity of VMT was 0.1. The elasticity shows that the model is directionally sensitive to changes in household income levels (i.e. VMT increases as incomes increases, and vice versa), but the degree of change cannot be evaluated since no elasticities specific to income were identified in the empirical literature.

VII. Conclusion

This report documents ARB staff's technical evaluation of SANDAG's adopted 2015 RTP/SCS. This evaluation affirms that the SCS, if implemented, would meet the Board adopted per capita GHG emissions reduction targets of 7 percent reduction in 2020 and 13 percent reduction in 2035 from a base year of 2005.

VIII. References

Boarnet, Marlon G., and Susan Handy. 2014. "Impacts of Residential Density on Passenger Vehicle Use and Greenhouse Gas Emissions, Policy Brief." 30 September 2014. http://arb.ca.gov/cc/sb375/policies/policies.htm

Boarnet, Marlon G., and Susan Handy. 2014. "Impacts of Bicycling Strategies on Passenger Vehicle Use and Greenhouse Gas Emissions, Policy Brief." 30 September 2014. http://arb.ca.gov/cc/sb375/policies/policies.htm

Boarnet, Marlon G., Gil Tal, and Susan Handy. 2013. "Policy Brief on the Impacts of Transit Access (Distance to Transit) Based on a Review of the Empirical Literature." December 2013. http://www.arb.ca.gov/cc/sb375/policies/transitaccess/transit_access_brief120 313.pdf

Brownstone, David and Thomas Golob. 2009. The Impact of Residential Density on Vehicle Usage and Energy Consumption. *Journal of Urban Economics* 65: 91-98.

California Air Resources Board. 2011. Description of Methodology for ARB Staff Review of Greenhouse Gas Reductions from Sustainable Communities Strategies (SCS) Pursuant to SB 375. July 2011. http://www.arb.ca.gov/cc/sb375/scs_review_methodology.pdf

California Department of Finance, Report P-1 (County): State and County Total Population Projections, 2010-2060. Sacramento, California, 2014. http://www.dof.ca.gov/research/demographic/reports/projections/P-1/

California Department of Transportation. 2015. Fiscal Year 2015-2016 Caltrans Sustainable Transportation Planning Grant Awards. http://www.dot.ca.gov/hq/tpp/documents/AwardList.pdf

California Department of Transportation. 2015. Transit and Intercity Rail Capital Program (TIRCP) Project Awardee Summaries. http://www.dot.ca.gov/hq/MassTrans/Docs-Pdfs/TIRCPAwardSummary06302015.pdf

California Transportation Commission. 2010. Regional Transportation Plan Guidelines. http://www.catc.ca.gov/programs/rtp/2010_RTP_Guidelines.pdf

Litman, Todd. 2013. Understanding Transport Demands and Elasticities: How Prices and Other Factors Affect Travel Behavior. Victoria Transport Policy Institute. http://www.vtpi.org/elasticities.pdf

SANDAG. See San Diego Association of Governments.

San Diego Associations of Governments. 2015. 2050 Regional Transportation
Plan/Sustainable Communities Strategy Commitments Progress Report, April
2015. http://www.sandag.org/uploads/projectid/projectid_349_18981.pdf

San Diego Association of Governments. 2015. About SANDAG: History.
http://www.sandag.org/index.asp?fuseaction=about.history (Accessed October
2015)

San Diego Association of Governments. 2015. San Diego Forward: The Regional Plan.
http://www.sdforward.com/regionalplan

San Diego Association of Governments. 2015. Transnet Smart Growth and Active
Transportation Grant Programs.
http://www.sandag.org/index.asp?classid=12&projectid=491&fuseaction=projects
.detail (Accessed October 2015)

San Diego Association of Governments. 2010. Riding to 2050: San Diego Regional
Bike Plan. http://www.sandag.org/uploads/projectid/projectid_353_10862.pdf

Transportation Research Board. 2012. Travel Estimation Techniques for Urban
Planning. National Cooperative Highway Research Program (NCHRP) Report
716. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_716.pdf

U.S. Census Bureau. 2014. American Community Survey 2006-2014.
https://www.census.gov/programs-surveys/acs/

APPENDIX A. SANDAG's Modeling Data Table

Modeling Parameters	2012 (base year)	2020 With Project	2020 Without Project	2035 With Project	2035 Without Project	RTP/SCS Chapter-Page(s) or Data Source(s)
DEMOGRAPHICS						
Total population	3,143,429	3,435,713	3,435,713	3,853,698	3,853,698	
Group quarters population	103,492	145,623	145,623	161,796	161,796	
Total employment	1,450,913	1,624,123	1,624,123	1,769,939	1,769,939	
Uniformed Military	103,944	103,944	103,944	103,944	103,944	
Average unemployment rate (%)	9.2	5.9	5.9	5.8	5.8	
Total number of households	1,103,034	1,178,090	1,178,090	1,326,446	1,326,446	
Persons per household	2.76	2.79	2.79	2.78	2.78	
Auto ownership per household	1.74	1.73	1.74	1.71	1.73	SANDAG, SDF Final, ABM residents travel model
Median *Household* income (Year 2010 $)	$ 67,148	$ 70,050	$ 70,050	$ 76,497	$ 76,497	
LAND USE						
Total acres						
Total resource area acres (CA GC Section 65080.01)	1,528,424	1,528,439	1,528,439	1,526,905	1,526,905	
Total farmland acres (CA GC Section 65080.01)	51,874	51,874	51,874	51,874	51,874	
Total open space acres (Open Space only; habitat and farmland excluded)	1,362,654	1,365,376	1,365,376	1,366,353	1,366,353	

Total developed acres	846,884	919,178	919,178	1,014,477	1,014,477	
Total commercial developed acres	39,434	42,288	42,288	42,252	42,252	
Total residential developed acres	337,033	401,983	401,983	494,207	494,207	
Total housing units	1,165,818	1,249,684	1,249,684	1,394,783	1,394,783	
Housing vacancy rate (%)	5.4%	5.7%	5.7%	4.9%	4.9%	
Total single-family housing units	703,101	731,693	731,693	758,622	758,622	
Total multi-family housing units	420,147	477,258	477,258	597,762	597,762	
Total mobile home units & other	42,570	40,733	40,733	38,399	38,399	
Average residential density - housing units per developed residential acre	3.5	3.1	3.1	2.8	2.8	
Net residential density	6.4	6.5	6.5	6.8	6.8	
Net residential density - Incorporated Cities	7.9	7.9	7.9	8.4	8.4	
Total housing units within 1/4 mile of high frequency transit stations and stops	223,555	468,932	265,733	621,351	326,768	HF stations/stops are defined as stops of routes with peak and midday frequency <=15 mins
Total housing units within 1/2 mile of high frequency transit stations and stops	347,794	650,549	410,487	832,983	484,209	
Total employment within 1/4 mile of high frequency	358,322	812,221	440,501	1,013,537	491,923	Straight line distance buffer

transit stations and stops						
Total employment within 1/2 mile of high frequency transit stations and stops	512,216	1,004,476	620,026	1,231,643	692,091	
TRANSPORTATION SYSTEM						
Total lane miles						
Freeway (lane miles)	2462	2495	2473	2560	2473	
Highway / Expressway (lane miles)	626	654	654	659	654	
HOV (lane miles)	91	145	118	297	118	
Arterial (lane miles)	4187	4568	4543	4793	4543	
Collector (lane miles)	4745	4861	4855	4903	4855	
Local (lane miles)	1990	2007	2005	2043	2005	
Freeway-Freeway *Interchange* (lane miles)	129	131	130	155	130	
Regular transit bus operation miles	75,194	97,473	75,204	131,077	75,204	
Bus rapid transit bus operation miles	N/A	23,598	11,136	62,903	11,152	
Commuter / Light Rail operation miles	11,515	14,035	13,349	29,238	13,349	
Transit total daily vehicle seat miles	4,628,843	7,354,235	5,455,349	12,410,663	5,456,075	
Bicycle and pedestrian trail/lane miles						
Class I	159	181	181	227	186	
Class II	891	903	903	909	907	

52

Vanpool (total riders per weekday)	N/A	6,814	N/A	9,772	N/A	
TOUR & TRIP DATA						
Number of Tours (by tour purpose)	4,185,191	4,506,081	4,570,013	4,865,387	5,106,931	
Work	1,309,523	1,370,476	1,401,174	1,442,970	1,552,587	SANDAG, SDF Final, ABM residents travel model
School	719,675	807,565	809,459	898,596	905,282	
Escort	559,008	614,163	622,338	631,264	671,148	
Personal Business	466,473	499,540	505,959	553,969	577,610	
Shopping	448,468	477,755	484,300	526,189	548,812	
Meal	120,294	129,515	130,597	145,236	151,051	
Social/Recreation	561,750	607,067	616,186	667,163	700,441	
Home						
Number of trips (by trip purpose) per day	10,705,644	11,476,370	11,635,337	12,359,924	12,969,518	
Work	1,501,768	1,570,757	1,605,416	1,655,209	1,779,291	
School	719,675	807,565	809,459	898,596	905,282	
Escort	1,161,442	1,246,561	1,263,583	1,292,474	1,364,862	
Personal Business	946,564	1,004,808	1,016,936	1,102,076	1,152,102	
Shopping	968,727	1,025,978	1,040,374	1,109,619	1,161,840	
Meal	459,266	490,736	495,501	535,962	558,594	
Social/Recreation	886,477	954,340	967,137	1,039,204	1,089,116	
Home	4,061,725	4,375,625	4,436,931	4,726,784	4,958,431	
Average trip distance (miles) by mode						
Drive alone	7.96	7.91	7.91	7.75	7.64	

Shared ride (2 persons)	5.16	5.07	5.06	4.82	4.94
Shared ride (3+ persons)	4.20	4.10	4.09	4.01	3.98
School bus	5.30	5.46	5.47	5.48	5.48
Drive-to-transit	9.92	10.60	10.57	11.03	10.86
Walk-to-transit	6.17	6.63	6.50	6.95	6.66
Bicycle	2.31	2.28	2.30	2.31	2.25
Walk	0.76	0.75	0.75	0.74	0.74
All modes	5.82	5.70	5.70	5.55	5.52
Average trip distance (miles) by trip purpose	5.82	5.70	5.70	5.55	5.52
Average work trip length	9.06	9.15	9.11	8.89	8.73
Average school trip length	4.32	4.07	4.09	4.17	4.17
Average escort trip length	5.27	5.14	5.12	4.99	4.95
Average personal business trip length	5.07	4.92	4.90	4.76	4.71
Average shopping trip length	4.09	4.02	4.01	3.88	3.87
Average meal trip length	4.48	4.37	4.35	4.26	4.25
Average social/recreation trip length	5.31	5.13	5.12	5.01	4.97
Average home trip length	5.89	5.78	5.78	5.64	5.62
Average trip duration (minutes) by mode					

Drive alone	15.54	15.85	16.00	15.63	16.09
Shared ride (2 persons)	10.35	10.39	10.48	10.21	10.58
Shared ride (3+ persons)	8.76	8.74	8.79	8.62	8.85
School bus	11.68	12.13	12.23	12.47	12.83
Drive-to-transit	36.21	35.69	36.35	32.45	37.08
Walk-to-transit	45.71	44.40	45.09	41.07	45.42
Bicycle	11.54	11.40	11.52	11.53	11.27
Walk	15.23	14.95	15.05	14.82	14.85
All modes	13.55	13.69	13.76	13.70	13.91
Average trip duration (minutes) by trip purpose					
work trip duration	19.04	19.75	19.90	19.55	20.07
school trip duration	13.44	13.24	13.24	13.76	13.90
escort trip duration	12.18	12.22	12.29	12.20	12.42
personal business trip duration	11.83	11.82	11.86	11.79	11.88
shopping trip duration	10.19	10.30	10.35	10.27	10.38
meal trip duration	10.44	10.48	10.55	10.53	10.67
Social/Recreation trip duration	12.25	12.25	12.29	12.35	12.42
home trip duration	13.77	13.90	13.96	13.95	14.12
MODE SHARE					
Vehicle Mode Share (AM Peak Period)					
Drive alone (% of trips)	43.1%	41.3%	41.5%	41.0%	41.6%
Shared ride (2 persons) (% of trips)	25.6%	26.0%	26.0%	25.5%	25.8%

Shared ride (3+ persons) (% trips)	15.9%	16.6%	16.6%	15.8%	15.9%
School Bus (% trips)	1.1%	1.3%	1.3%	1.4%	1.3%
Drive-to-transit (% trips)	0.1%	0.2%	0.2%	0.3%	0.2%
Walk-to-transit (% of trips)	1.6%	1.9%	1.8%	2.6%	1.9%
Bike (% of trips)	1.0%	1.0%	1.0%	1.0%	1.0%
Walk (% of trips)	11.6%	11.7%	11.6%	12.3%	12.2%
Vehicle Mode Share (PM Peak Period)					
Drive alone (% of trips)	43.0%	41.4%	41.6%	40.9%	41.4%
Shared ride (2 persons) (% of trips)	26.5%	26.6%	26.5%	26.4%	26.5%
Shared ride (3+ persons) (% of trips)	18.3%	19.2%	19.2%	18.6%	18.9%
School Bus (% trips)	0.1%	0.1%	0.1%	0.1%	0.1%
Drive-to-transit (% trips)	0.1%	0.2%	0.2%	0.3%	0.2%
Walk-to-transit (% of trips)	1.5%	1.8%	1.7%	2.5%	1.8%
Bike (% of trips)	1.1%	1.1%	1.1%	1.1%	1.1%
Walk (% of trips)	9.5%	9.6%	9.6%	10.1%	10.0%
Vehicle Mode Share (Whole Day)					
Drive alone (% of trips)	44.9%	42.9%	43.1%	42.4%	43.0%
Shared ride (2 persons) (% of trips)	24.3%	24.7%	24.7%	24.3%	24.5%
Shared ride (3+ persons) (% trips)	16.8%	17.6%	17.6%	16.9%	17.0%

School Bus (% trips)	1.2%	1.4%	1.4%	1.6%	1.5%
Drive-to-transit (% trips)	0.2%	0.3%	0.3%	0.3%	0.3%
Walk-to-transit (% of trips)	1.6%	2.0%	1.8%	2.7%	2.0%
Bike (% of trips)	1.0%	1.0%	1.0%	1.0%	1.0%
Walk (% of trips)	10.0%	10.1%	10.1%	10.7%	10.6%
Transit Boardings	356,417	513,146	449,222	774,727	546,400
TRAVEL MEASURES*					
Vehicle Miles Traveled (typical weekday, all vehicles, all miles)	79,289,103	84,596,338	85,233,966	90,407,068	92,733,448
Vehicle Miles Traveled (typical weekday, all vehicles, SB-375 miles (e.g., minus XX))	74,321,791	79,077,123	79,778,595	83,587,467	86,124,155
Total SB-375 VMT per weekday for passenger vehicles (ARB vehicle classes of LDA, LDT1, LDT2 and MDV) (miles)	74,930,581	79,755,332	80,457,603	84,337,983	86,873,815
Total II (Internal) VMT per weekday for ARB vehicle classes (miles)	64,199,680	67,262,876	67,964,746	70,336,427	72,810,653
Total IX/XI VMT per weekday for ARB vehicle classes (miles)	10,122,111	11,814,247	11,813,848	13,251,040	13,313,502
Total XX VMT per weekday for ARB vehicle classes (miles)	608,790	678,209	679,008	750,516	749,660

Congested Peak Hour VMT on freeways (Lane Miles, V/C ratios >0.75)	10,847,500	12,391,937	12,750,900	13,265,414	14,847,008
Congested Peak VMT on all other roadways (Lane Miles, V/C ratios >0.75)	875,126	825,652	894,964	839,411	1,036,846
CO2 EMISSIONS*					
Total CO2 emissions per weekday for all vehicle classes all miles (tons)	41,195	36,260	36,482	27,299	27,716
Total CO2 emissions per weekday for passenger vehicles (SB 375 VMT) - not including off-model adjustments (ARB vehicle classes LDA, LDT1, LDT2, and MDV) (tons)	36,459	37,821	38,233	39,672	41,088
Total II (Internal) CO2 emissions per weekday for ARB vehicle classes (tons)	31,237.93	31,896.65	32,296.79	33,085.88	34,436.83
Total IX / XI trip CO2 emissions per weekday for ARB vehicle classes (tons)	4,925.16	5,602.42	5,613.93	6,233.22	6,296.81
Total XX trip CO2 emissions per weekday for ARB vehicle classes (tons)	296.22	321.61	322.66	353.04	354.56

INVESTMENT (Millions)						
Total RTP Expenditure (YOE$)	$0	$15,392		$75,442		
Highway capacity expansion (2014$/$YOE)	$0	$2,119/ $2,253		$10,377/ $14,316		
Other road capacity expansion (YOE$)	$0	$3,164		$11,737		
Roadway maintenance (YOE$)	$0	$1,357		$6,019		
Transit capacity expansion (2014$/$YOE)	$0	$3,146 / $3,204		$12,559 / $17,694		Ch. 2, 3; Appendix A, O
Transit operations (YOE$)	$0	$2,923		$16,191		
Bike and pedestrian projects (2014$/$YOE)	$0	$538 / $588		$1,693 / $2,304		
Other (Complete Streets – maintain and sustain existing infrastructure) (YOE$, millions)	$0	-		-		
TRANSPORTATION USER COSTS						
Vehicle operating costs (Year 2010 $ per mile)	$0.198	$0.240	$0.240	$0.267	$0.267	
Gasoline price (Year 2010 $ per gallon)	$3.64	$4.11	$4.11	$4.87	$4.87	SANDAG UEC
Average transit fare (Year 2010 $)	Varies ($1.0 to $5.0)	Varies ($1.0 to $8.0)	Varies ($1.0 to $5.0)	Varies ($1.0 to $8.0)	Varies ($1.0 to $5.0)	

Parking cost (Year2010 $)	Varies ($0.004/hour to $8/hour, or $0.25/day to $30/day)	Varies ($0.004/hour to $8/hour, or $0.25/day to $30/day)	Varies ($0.004/hour to $8/hour, or $0.25/day to $30/day)	Varies ($0.004/hour to $8/hour, or $0.25/day to $30/day)	Varies ($0.004/hour to $8/hour, or $0.25/day to $30/day)	
NOTES:						

* GHG emissions and VMT outputs do not include post-processors including the EMFAC 2007-EMFAC 2014 adjustment

**Tour/Trip Purpose definitions:

    Work (full time or part time)

    School (k12, college, university, or other education)

    Personal Business (e.g. medical appointments)

    Shopping

    Meal (i.e. having a meal outside of the home)

    Social/Recreation (e.g. going to gym, visiting a friend or family member

    Escort (i.e. accompanying another person to an activity they are engaging in (carpooling), e.g. a parent driving a child to school or sports team event)

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

This appendix lists the requirements in the California Transportation Commission's (CTC) Regional Transportation Planning (RTP) Guidelines that are applicable to the SANDAG regional travel demand model, and which SANDAG followed. In addition, listed below are the recommended practices from the CTC RTP Guidelines that SANDAG incorporated into its modeling system.

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.
- 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.
- Each MPO shall quantify the reduction in greenhouse gas emissions projected to be achieved by the SCS.
- 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.
- The metropolitan transportation plan shall include the projected transportation demand of persons and goods in the metropolitan planning are over the period of the transportation plan.
- These regions 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.
- Land use, population, employment, and other network-based travel model assumptions shall be documented and based on the best available information.
- 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.
- A capacity-sensitive assignment methodology shall be used, and emissions estimates shall be based on a methodology which differentiates between peak- and off-peak link volumes and speeds and uses speeds based on final assigned volumes.
- Zone-to-zone travel impedances 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.
- Network-based travel models shall be reasonably sensitive to changes in the time(s), cost(s), and other factors affecting travel choices.

- 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.
- Highway Performance Monitoring System (HPMS) estimates of vehicle miles traveled (VMT) shall be considered the primary measure of VMT within the portion of the nonattainment or maintenance area and for the functional classes of roadways included in HPMS, for urban areas which are sampled on a separate 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 §93.105(c)(1)(i).

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 model 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 model should address changes in regional demographic patterns.
- Geographic Information Systems (GIS) capabilities should be developed in these counties, leading to simple land use models in a few years.
- All natural sources data should be entered into the GIS.
- Parcel data should be developed within a few years and an existing land use data layer created.
- For the current RTP cycle (post last adoption), MPOs should use their current travel demand model for federal conformity purposes, and a suite of analytical tools, including but not limited to, travel demand models, small area modeling tools, and other generally accepted analytical methods for determining the emissions, VMT, and other performance factor impacts of sustainable communities strategies being considered pursuant to SB 375.
- 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.

- For models with a mode choice step, if the travel demand model is unable to forecast bicycle and pedestrian trips, another means should be used to estimate those trips.
- 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.
- 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.
- The travel model set should be run to a reasonable convergence towards equilibrium across all model steps.
- Simple land use models should be used, such as GIS rule-based ones, in the short term.
- Parcel data and an existing urban layer should be developed as soon as is possible.
- A digital general plan layer should be developed in the short-term.
- 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.
- The carpool mode should be included, along with access-to-transit sub modes.
- 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.
- These regions should monitor the large RTPAs and MPOs, in *E* below, as they develop tour/activity-based travel models.
- 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.
- Travel demand processes should incorporate freight movement. Information from the statewide freight model, when available, local trip-based truck demand models, or more advanced commodity flows models could be used.