Memo

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Date: November 15, 2016

To: Todd Taylor and John Lundgren (Sacramento County)

From: Honey Walters, Erik de Kok, and Dimitri Antoniou (Ascent Environmental, Inc.)

Subject: Sacramento County Climate Action Plan: Communitywide Greenhouse Gas Reduction & Climate Change Adaptation (Communitywide CAP)
Task 1 Technical Memorandum: 2015 Greenhouse Gas Emissions Inventory and Forecasts

INTRODUCTION

In 2009, Sacramento County (County) and the Sacramento Municipal Utility District (SMUD) completed a greenhouse gas (GHG) emissions inventory for the incorporated and unincorporated areas of the County, using 2005 as the emissions baseline year (Sacramento County 2009). The 2005 inventory included both emissions generated by the community and internal operations. In 2011, the County adopted a Climate Action Plan (CAP) Strategy and Framework Document (Phase 1 CAP), and in 2012 the County adopted a County Government Operations CAP document (Phase 2A CAP). In 2011, new data and methods were applied to some sectors in the 2005 inventory to update the 2005 emissions estimates. References to the original 2005 inventory data presented in this memo are based on the inventory results as presented in the 2011 Phase 1 and 2012 Phase 2A CAP documents.

Sacramento County is currently updating the 2005 inventory for baseline year 2015, as part of the current effort to prepare a comprehensive Communitywide CAP (Phase 2B) that will quantify and substantiate GHG reductions for both community sources in the unincorporated area and the County's internal operations. This initial phase in the preparation of the new Communitywide CAP includes: (1) updating the unincorporated County's community and internal operations GHG emissions inventory to 2015, and (2) preparing new GHG emissions forecasts for 2020, 2030, and 2050. This technical memorandum provides the results of the 2015 GHG emissions inventory update and future year emissions forecasts, including associated methods, assumptions, emission factors, and data sources.

The updated GHG emissions inventory and forecasts will provide a foundation for the forthcoming phases of work on the Communitywide CAP including the development of GHG emissions reduction targets, GHG emissions reduction measures, and an action plan to help the County achieve identified targets.

ORGANIZATION OF THIS MEMORANDUM

This memorandum consists of three main parts:

- **Section 1: Summary of Inventory Results** presents an overview of the updated 2015 GHG community and internal operations emissions inventory for each sector, including any new sectors not previously included in the 2005 inventory. Key components include:

- A summary of annual emissions by sector; and
- A general comparison to previous inventories.

- **Section 2: Data, Methods, and Assumptions** summarizes data, methods, and assumptions used in the 2015 inventory and provides a brief explanation regarding differences between the 2015 inventory and 2005 inventory on a sector-by-sector basis.

- **Section 3: Emissions Forecasts** summarizes the forecasted GHG emissions under a "business-as-usual" (BAU) scenario for future years 2020, 2030, and 2050.

1 SUMMARY OF INVENTORY RESULTS

1.1 2015 COMMUNITY INVENTORY RESULTS

Based on the modeling conducted, the unincorporated area of the County generated approximately 4,853,647 metric tons of carbon dioxide equivalent ($MTCO_2e$) in 2015. Major emissions sectors included residential and commercial/industrial building energy use, on-road vehicles, solid waste, off-road vehicles and equipment, agriculture, and high global warming potential gases. Table 1 and Figure 1 present the County's 2015 GHG emissions inventory by sector. A description of each emissions sector, including key sources of emissions, is provided in further detail in Section 2.2.1.

Table 1 2015 Unincorporated Sacramento County Community Greenhouse Gas Inventory

Sectors	2015 ($MTCO_2e$/year)	Percent of Total
Residential Energy	1,193,311	25%
Commercial/Industrial Energy	890,603	18%
Building Total	*2,083,914*	*43%*
On-Road Vehicles	1,671,596	34%
Off-Road Vehicles	196,769	5%
Transportation Total	*1,868,365*	*39%*
Solid Waste	352,909	7%
Agriculture	254,899	5%
High-GWP Gases	251,085	5%
Wastewater	27,253	<1%
Water-Related	15,222	<1%
Total	**4,853,647**	**100%**

Notes: Totals may not add due to rounding. $MTCO_2e$ = metric tons of carbon dioxide equivalent; GWP = Global Warming Potential

Source: Data compiled by Ascent Environmental in 2016.

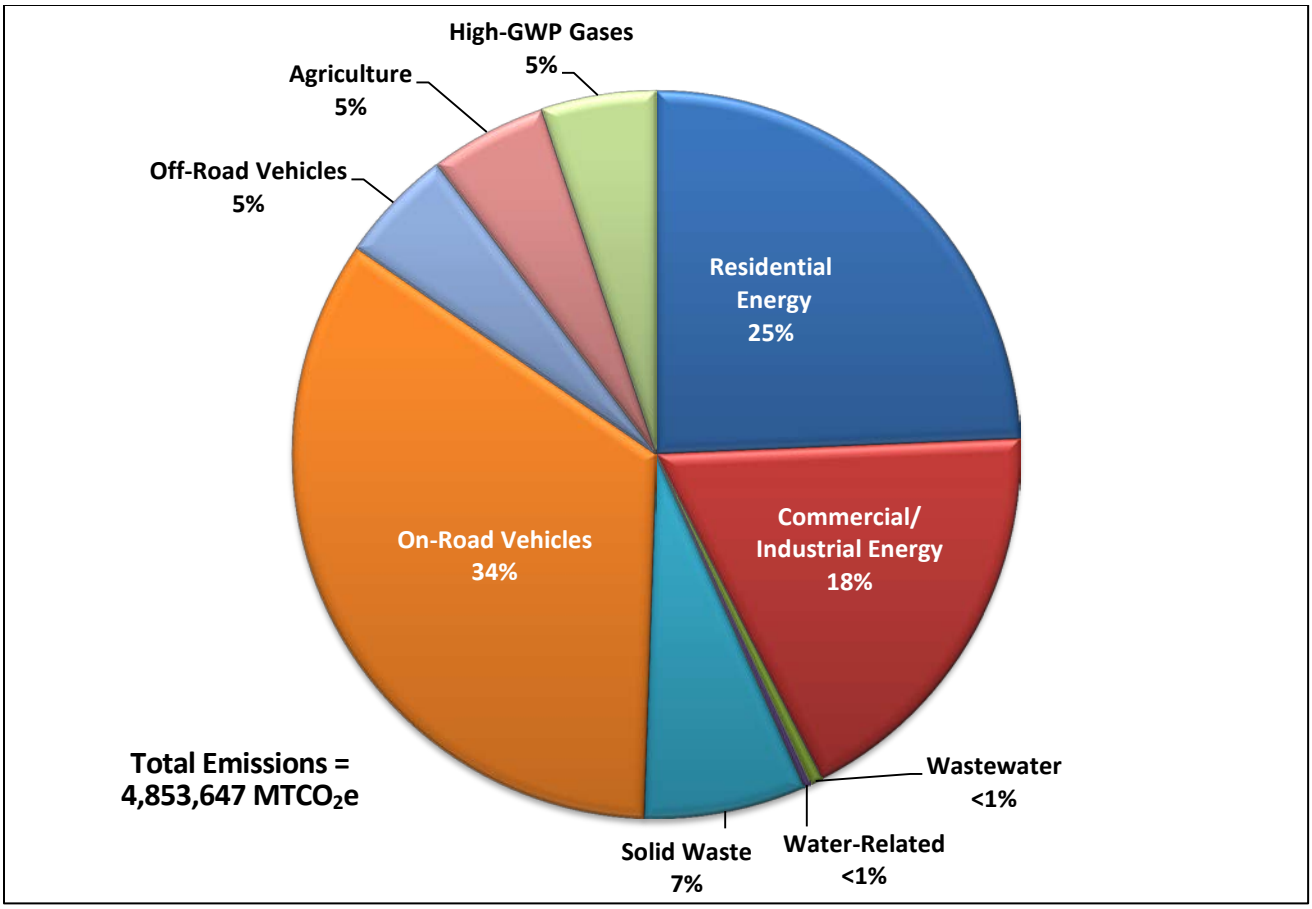

Figure 1 **2015 Unincorporated Sacramento County Community Greenhouse Gas Inventory**

Table 2 shows the 2005 community inventory for the unincorporated County alongside the updated 2015 results. In general, the organization of the updated 2015 community inventory is consistent with the 2005 inventory. Primary differences in the 2015 inventory were that energy use from the commercial and industrial sectors are now combined, and aircraft emissions at Sacramento International Airport (SMF) were excluded, as aircraft operations and emissions are not controlled or influenced by the County (See discussion in Section 2.2.2 regarding airport emissions for further details). For purposes of comparing the two inventories, emissions totals in Table 2 combine the industrial and commercial sectors from the 2005 inventory and do not include the aircraft emissions in the reported totals. Based on the modeling conducted, a 1.4 percent increase in emissions from the 2005 inventory was reported. Some sectors showed increases in emissions, while others showed decreases in emissions. Specific examples and further comparison between the two inventories is included in Section 2.2.1 on a per-sector basis. In general, differences in emissions between the two inventories can be explained by:

- the use of different Global Warming Potential (GWP) values between inventories (see Section 2.1 below for explanation of GWP values);
- adjustments in calculation methodologies (e.g., equations and emission factors);
- differences in data sources between the two inventories; and
- changes in actual activity levels within the County since 2005 (e.g., population increase, number of buildings, building energy use and vehicle travel).

Table 2 Comparison of Unincorporated Sacramento County Community Greenhouse Gas Inventories (2005 and 2015)

Sectors	2005 Inventory ($MTCO_2e$/year)	2015 GHG Inventory ($MTCO_2e$/year)	Difference ($MTCO_2e$/year)	Percent change from 2005
Residential Energy	1,033,142	1,193,311	+160,169	+16%
Commercial and Industrial Energy[1]	772,129	890,603	+118,474	+15%
On-Road Vehicles	2,066,970	1,671,596	-395,374	-19%
Off-Road Vehicles	236,466	196,769	-39,697	-17%
Solid Waste	201,350	352,909	+151,559	+75%
Water-Related	5,885	15,222	+9,337	+159%
Wastewater	70,662	27,253	-43,409	-61%
Agriculture	197,132	254,710	+57,578	+29%
High-GWP Gases	203,528	251,085	+47,554	+23%
Sacramento International Airport[2]	200,404	NA	NA	NA
Total[3]	**4,787,264**	**4,853,647**	**+66,383**	**+1.4%**

Notes: Totals may not add due to rounding; $MTCO_2e$ = metric tons of carbon dioxide equivalent; GWP = Global Warming Potential; NA = Not applicable

1. The 2005 Inventory separated Industrial and Commercial sectors, and thus they are combined here for comparison to the 2015 inventory, which did not separate industrial from commercial.

2. Aircraft emissions were not included in the 2015 Inventory, but they were included in the 2005 inventory and are included for reference purposes only.

3. Totals do not include aircraft emissions reported in the 2005 inventory.

Source: Sacramento County, 2011; 2015 inventory prepared by Ascent Environmental in 2016.

1.2 2015 INTERNAL OPERATIONS INVENTORY RESULTS

Based on the modeling conducted, the County's internal operations generated approximately 123,397 $MTCO_2e$ in 2015. Major emissions sectors included employee commute, buildings and facilities, vehicle fleet, and airport operations (e.g., ground support equipment and fleet only). Table 3 and Figure 2 present the County's 2015 GHG internal operations emissions inventory by sector. A description of each emissions sector, including key sources of emissions, is provided in further detail in Section 2.2.1.

Table 3 2015 Unincorporated Sacramento County Internal Operations Greenhouse Gas Inventory

Sectors	2015[1] ($MTCO_2e$/year)	Percent of Total (%)
Employee Commute	38,290	31%
Vehicle Fleet (on and off-road vehicles)	29,591	24%
Buildings and Facilities	28,247	23%
Airports (buildings and facilities)	18,310	15%
Water-Related	4,665	4%
Streetlights and Traffic Signals	3,729	3%
Wastewater	565	<1%
Total	**123,397**	100%

Notes: Totals may not add due to rounding.
$MTCO_2e$ = metric tons of carbon dioxide equivalent.
Source: Data compiled by Ascent Environmental in 2016.

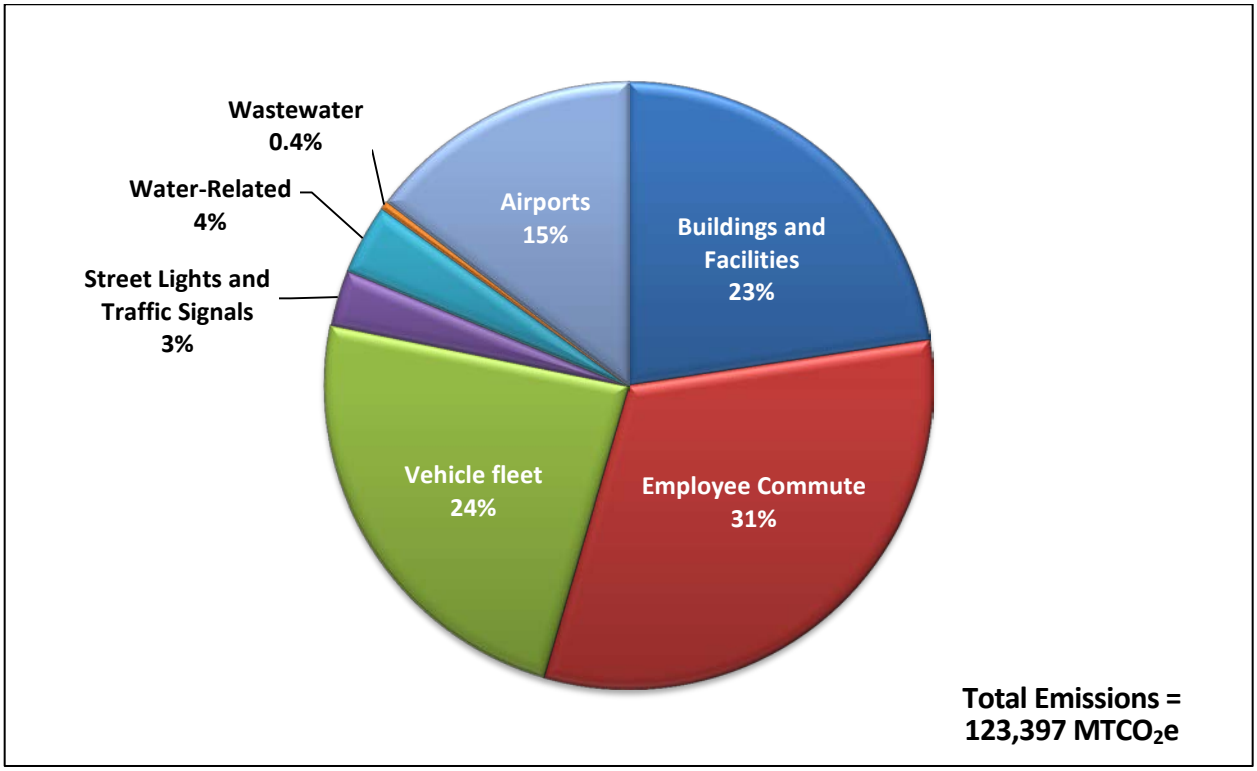

Figure 2 2015 Unincorporated Sacramento County Internal Operations Greenhouse Gas Inventory

Table 4 shows the 2005 inventory for the internal operations of the County alongside the updated 2015 internal operations inventory. In general, the organization of the updated 2015 community inventory is consistent with the 2005 inventory. One primary difference is that the 2015 update includes emissions associated with wastewater treatment and conveyance associated with County operations. All other sectors are the same as the 2005 inventory. Similar to the 2005 inventory, emissions associated with County airports were estimated separately. This sector includes emissions associated with airport buildings, facilities, and water-use. Airport fleet and employee commute emissions were not included in the airports sector, similar to the 2005 inventory, but are included in other applicable sectors.

For purposes of comparing the two inventories, emissions totals in Table 4 are summarized with and without the additional wastewater sector. Based on the modeling conducted, and considering emissions from the additional sector, an eight percent decrease in emissions from the 2005 baseline was reported. Some sectors showed increases in emissions, while others showed decreases in emissions. Specific examples and further comparison between the two inventories is included in Section 2.2.2 on a per-sector basis. In general, differences in emissions between the two inventories can be explained by;

- the use of different GWP values between inventories (see Section 2.1 below for explanation of GWP values),
- adjustments in calculation methodologies (e.g., equations and emission factors),
- differences in data sources between the two inventories, and

- changes in actual activity levels within the County since 2005 (e.g., increases in County employment, building energy use, and vehicle travel).

Table 4 Comparison of Unincorporated Sacramento County Internal Operations Greenhouse Gas Inventories (2005 and 2015)

Sectors	2005 Inventory Baseline ($MTCO_2e$/year)	2015 GHG Inventory ($MTCO_2e$/year)	Difference ($MTCO_2e$/year)	% change from 2005
Buildings and Facilities	35,870	28,247	-7,623	-21%
Employee Commute[1]	31,970	38,290	+6,320	+20%
Vehicle Fleet (on and off-road vehicles, County and airports)[2]	37,720	29,591	-8,129	-22%
Streetlights and Traffic Signals	8,810	3,729	-5,081	-58%
Water-Related	5,580	4,665	-915	-16%
Wastewater	NA	565	NA	NA
Airports (buildings, ground support)	14,980	18,310	+3,330	+22%
Total (excluding Wastewater)	**134,930**	**122,832**	**-12,098**	**-9.8%**
Total (including Wastewater)	**134,930**	**123,397**	**-11,533**	**-9.3%**

Notes: Totals may not add due to rounding. $MTCO_2e$ = metric tons of carbon dioxide equivalent; NA = Not applicable

1. Similar to the 2005 inventory, the 2015 employee commute sector includes airport employees

2. Similar to the 2005 inventory, the 2015 vehicle fleet sector includes airport fleet vehicles

Source: Sacramento County, 2012; 2015 inventory prepared by Ascent Environmental in 2016.

2 DATA, METHODS, AND ASSUMPTIONS

2.1 OVERALL ASSUMPTIONS AND DATA

2.1.1 Utility Emission Factors

Emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) per megawatt hour (MWh) or therm of natural gas vary greatly by location and from year to year depending on numerous factors. Best available utility-specific factors for GHG emissions were obtained and used throughout the inventory to estimate GHG emissions from electricity and natural gas consumption. Sources for electricity and natural gas emission factors are shown below.

- **Electricity:** Utility electricity emission factors for CO_2 were provided by SMUD and Pacific Gas & Electricity (PG&E) directly (SMUD 2016a, PG&E 2016). Electricity emission factors for CH_4 and N_2O were obtained from the U.S. Environmental Protection Agency's (EPA's) Emissions & Generation Resource Integrated Database (eGRID) 2012 GHG Annual Output Emission Rates (EPA 2015).

- **Natural Gas:** Utility natural gas emission factors for CO_2 were provided by PG&E directly. Emission factors for CH_4 and N_2O were obtained from the Climate Registry Emission Factors (2014). Specific factors used in the inventory calculations are shown below in Table 5.

Table 5 Unincorporated Sacramento County GHG Inventory Building Energy Emission Factors

Emission Factor	Unit	Source
SMUD- Electricity		
561.08	lb CO_2/MWh	SMUD, personal communication with Martha Helek
31,120	lb CH_4/MWh	EPA eGrid 2012 (updated 2015)
5,670	lb N_2O/MWh	EPA eGrid 2012 (updated 2015)
PG&E- Electricity		
429	lb CO_2/MWh	PG&E-provided energy data
31,120	lb CH_4/MWh	EPA eGrid 2012 (updated 2015)
5,670	lb N_2O/MWh	EPA eGrid 2012 (updated 2015)
PG&E- Natural Gas		
11.7	lb CO_2/therm	PG&E-provided energy data
0.11	lb CH_4/therm	2014 Climate Registry Emission Factors. Table 12.9.
0.002	lb N_2O/therm	2014 Climate Registry Emission Factors. Table 12.9.

Notes: CH_4 = methane; CO_2 = carbon dioxide; eGrid = Emissions & Generation Resource Integrated Database; GHG = greenhouse gas; GWh = gigawatt-hours; kg = kilograms; lb = pounds; MMBTU = million British thermal units; MT = metric tons; MWh = megawatt-hours; N_2O = nitrous oxide; PG&E = Pacific Gas and Electric; SMUD = Sacramento Municipal Utility District.

Source: Compiled by Ascent Environmental 2016.

2.1.2 Global Warming Potentials

GHG emissions other than CO_2 generally have a stronger insulating effect (e.g., ability to warm the earth's atmosphere or greenhouse effect) than CO_2. This effect is measured in terms of a pollutant's GWP. CO_2 has a GWP factor of one while all other GHGs have GWP's measured in multiples of one. The California Air Resources Board (ARB) currently uses GWP factors published in the Fourth Assessment Report (FAR) from the Intergovernmental Panel on Climate Change (IPCC), where CH_4 and N_2O have GWP's of 25 and 298, respectively (IPCC 2007). This means that CH_4 and N_2O would be 25 and 298 times stronger than CO_2, respectively, in their potential to insulate solar radiation within the atmosphere.

This inventory uses the same FAR GWP values. The 2005 inventory conducted for baseline year 2005 used GWPs from IPCC's Second Assessment Report, of 21 for CH_4 and 310 for N_2O. CH_4 emissions are typically higher from natural gas use than electricity and therefore, higher GWP values for CH_4 would result in higher emissions from natural gas use. Changes in GWP values used would also have a direct effect on emissions in the High-GWP Gases sector.

2.1.3 Population and Employment

Population data were available for the unincorporated County for 2013 (Sacramento County 2016a). Population, employment, and housing growth projection data were provided by County staff directly but sourced from the Sacramento Area Council of Governments (SACOG). Growth projections were used to obtain 2015 population data and to forecast future year emissions (See Section 3 for further details regarding growth factors used). The 2015 population for the unincorporated County that was used in this inventory is 576,007. Population data were used to estimate wastewater process and high-GWP emissions

for the community inventory. The total number of County employees was used for various sectors in the internal operations inventory to scale the emissions from the community inventory and to calculate employee commute emissions. County employee data were provided directly from County staff for 2015.

2.2 SECTOR-SPECIFIC ASSUMPTIONS AND METHODS

The 2015 inventory update includes several changes to the data sources and emission factors used in the 2005 inventory, along with changes in methods in some sectors. These differences were necessary in cases where the original data sources used in the 2005 inventory were no longer available or have been updated. New methods that provide more accurate emissions estimates are available for sectors such as the on-road vehicles and solid waste sectors. The general approach for both inventories is consistent with guidance from the Local Governments for Sustainability (ICLEI). Specifically, methods and assumptions were consistent with the U.S. *Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions (Community Protocol),* Version 1.0 (ICLEI 2012) and the *Local Government Operations Protocol (LGOP) for the Quantification and Reporting of Greenhouse Gas Emission Inventories*, Version 1.1 (ICLEI 2010).

The following summarizes data sources and methods used in estimating the unincorporated County's 2015 GHG emissions inventory. Further explanation of sector-specific methods is provided below.

- **Building Energy:** This sector was included in both the community and the internal operations inventory. Annual (2015) electricity and natural gas usage data for the unincorporated areas were obtained from PG&E's Green Communities report for Sacramento County. Annual (2015) electricity data for SMUD customers within the unincorporated County were obtained directly from SMUD (2016b). Account data for both SMUD and PG&E only included usage data for service accounts located within the unincorporated County boundaries.

- **Transportation (On-Road and Off-Road Vehicles):** This sector was included in both the community and the internal operations inventory. For the on-road vehicle sector, annual vehicle miles traveled (VMT) by speed bin (e.g., zero to five miles per hour) were obtained from SACOG for the unincorporated area, using the Senate Bill (SB) 375 Regional Technical Advisory Committee's (RTAC's) origin-destination method (established through SB 375). Vehicle emission factors were available from ARB's 2014 EMissions FACtor (EMFAC) model. Off-road vehicle emissions were estimated from ARB's OFFROAD 2007 model and scaled by population, jobs, or location of activity in the unincorporated area.

- **Solid Waste:** This sector was only included in the community inventory. Emissions associated with waste generated by residents and businesses in the incorporated County were estimated using disposal and landfill data provided by Sacramento County for Kiefer Landfill and disposal data available from the California Department of Resources Recycling and Recovery (CalRecycle) for other landfills receiving waste from the unincorporated County. Landfill gas (LFG) information was available from EPA.

- **Agriculture:** This sector was only included in the community inventory. Agricultural emissions were based on livestock and crop data from the County's 2015 Crop Report; pesticide use data from the California Department of Pesticide Regulation (DPR) (DPR 2014); fertilizer use from the California Department of Food and Agriculture (CDFA), ARB's GHG inventory, and University of California Davis Agricultural studies; diesel irrigation pump information from ARB; and open burning permit data from the Sacramento Metropolitan Air Quality Management District (SMAQMD).

- **High-GWP Gases:** This sector was only included in the community inventory. Estimates of high-GWP gases were available at the State level and were scaled from the Statewide GHG inventory to the unincorporated area by population.

- **Wastewater:** This sector was included in both the community and the internal operations inventory. Domestic wastewater emissions were calculated using population-based equations from the Community Protocol (ICLEI 2012). Emissions associated with wastewater conveyance/pumping were estimated based on wastewater pumping energy use data provided by Sacramento Area Sewer District (SASD) and Sacramento Regional County Sanitation District (Regional San) as well as total wastewater treatment volumes also provided by Regional San. Emissions were scaled to the unincorporated County population (community inventory) and employees (internal operations inventory).

- **Water-Related:** This sector was included in both the community and the internal operations inventory. Water-related emissions were estimated by using a region-specific energy intensity factor in combination with water consumption volumes compiled from the numerous water purveyors within Sacramento County. Water consumption volumes were estimated for the unincorporated County based on water purveyor service boundaries. Total water consumption volumes for individual water purveyors were apportioned based on the percent of service area located within unincorporated County. The energy intensity factor was also applied to County water use volumes that were available for owned buildings/facilities (internal operations inventory). Energy use was also available from Sacramento County Water Agency (SCWA) for water-related facilities. SMUD utility emission factors were used to estimate GHG emissions.

- **Airports:** This sector was only included in the internal operations inventory. Energy consumption data were provided by Sacramento County airports department. Data included building energy use, ground support equipment and airport vehicle fleet fuel usage. Note that airport fleets and employee commute emissions were included with total County fleet and employee commute sectors. Emissions associated with aircraft operations were not included because they are outside of the County's jurisdictional control.

- **Streetlights/Traffic Signals:** This sector was only included in the internal operations inventory. Electricity use was provided directly from Sacramento County for all streetlights and traffic signals.

2.2.1 Community Inventory

BUILDING ENERGY SECTOR

Based on GHG emissions modeling conducted, residential and non-residential building energy use in 2015 resulted in approximately 2,083,914 $MTCO_2e$. This sector comprised approximately 43 percent of the unincorporated County's emissions, resulting in the largest emissions sector in the inventory. These emissions were a result of electricity and natural gas energy use in buildings and other facilities, such as outdoor lighting, pumps, or other equipment. The building energy sector consumed approximately 5.5 million MWh of electricity and 100 million therms of natural gas. Water-related and wastewater conveyance energy was removed from this sector and are reported separately. SMUD is the primary electricity provider with PG&E supplying some electricity and all natural gas in the County.

Electricity accounted for approximately 67 percent of emissions from the building energy sector with 57 percent of total emissions coming from the residential sector. Table 6 presents building-energy use and associated emissions by fuel and source. Table 5, above, includes emission factors used to quantify emissions from electricity and natural gas use, which were also used to quantify emissions in other sectors, as discussed in applicable sectors below.

Table 6 Building Energy Use and GHG Emissions by Source

Source	Quantity	GHG Emissions	Percent
Electricity	**MWh/year**	**$MTCO_2e$/year**	**Sector/Energy Type**
Residential	2,804,198	716,128	51%
Commercial	388,871	98,884	7%
Industrial	2,267,601	579,646	42%
Electricity Total	5,460,669	1,394,658	100%
Natural Gas	**Therms/year**	**$MTCO_2e$/year**	**Sector/Energy Type**
Residential	69,610,572	477,183	69%
Commercial	30,412,628	208,479	30%
Industrial[2]	524,202	3,593	1%
Natural Gas Total	100,547,402	689,256	100%
Energy Combined		**$MTCO_2e$/year**	**Sector/Energy Type**
Residential	NA	1,193,311	57%
Commercial	NA	307,363	15%
Industrial	NA	583,240	28%
Total	NA	**2,083,914**	100%

Notes: Totals in columns may not add due to rounding. PG&E provided electricity and natural gas use for 2015 for unincorporated Sacramento County. SMUD provided electricity use for 2015 for unincorporated Sacramento County.

MWh = megawatt-hours; MT = metric tons; NA = not applicable; CO_2 = carbon dioxide; CO_2e = carbon dioxide equivalent; GHG=greenhouse gas.

Source: Data provided by Ascent Environmental in 2016 based on modeling using data provided by PG&E and SMUD.

In the 2005 inventory, emissions were quantified using ICLEI's Clean Air and Climate Protection (CACP) software. Default, statewide emission factors were replaced with emission factors from the California Climate Action Registry. Emissions were scaled by population data for the unincorporated County in 2005. The updated inventory used specific utility emission factors and energy use was provided directly from the utilities, as discussed above. The 2015 update combines commercial and industrial sectors into one. Emissions from wood-burning were not calculated separately for this inventory, as they were before. Increases in emissions in the building energy sector are likely due to increased population, economic growth, and higher GWP values used in the 2015 inventory update.

TRANSPORTATION SECTOR

On-Road Vehicles

Based on modeling conducted, on-road vehicle usage in the unincorporated County resulted in 1,671,596 $MTCO_2e$ in 2015, or 34 percent of the County's inventory. On-road vehicle emissions are primarily the result of exhaust from the combustion of gasoline and diesel fuels. To a smaller degree, emissions from on-road vehicles also result from upstream electricity generation for electric vehicles. Due to lack of available data, emissions from the combustion of natural gas and other non-electric alternative fuels in on-road vehicles were not included in the community inventory, and are assumed to have minimal contribution to total emissions.

SACOG is the regional Metropolitan Planning Organization responsible for developing a regional transportation plan (MTP) for Sacramento, Yolo, Yuba, Sutter, El Dorado, and Placer Counties. As discussed above, under Section 2.2, the California Sustainable Communities and Climate Protection Act of 2008 (SB 375) requires metropolitan planning organizations (MPOs) to develop a Sustainable Communities Strategy (SCS) as part of the MTP. SACOG provided vehicle travel information for the unincorporated County based on their regional travel demand model and consistent with planning years considered in their 2016 MTP/SCS. SACOG typically updates their regional growth and travel forecasts on a four-year cycle and therefore VMT data were available for SACOG MTP/SCS Plan years 2012, 2020, and 2036. Daily VMT data were interpolated between the available years based on a straight trend-line from 2012 to 2036. Consistent with ARB methodology for the quantification of GHG reduction measures, daily VMT was multiplied by 347 days per year to estimate annual VMT to account for lower VMT during weekends, holidays, and summer periods. Data provided did not include VMT associated with any of the SACOG-designated Sphere of Influence (SOI) areas within Sacramento County.

Total annual VMT in the unincorporated County were approximately 3,514,165,943 in 2015. This VMT estimate is associated with trips that begin or end in the unincorporated County. These vehicle trips included 100 percent of vehicle trips that both originate from and end in the unincorporated area (i.e., fully internal trips), 50 percent of trips that either end in or depart from the unincorporated area (i.e., internal-external or external-internal trips), and zero percent of vehicle trips that are simply passing through the area (i.e., external-external, or "pass-through", trips). This passenger vehicle trip accounting method is consistent with the RTAC method established through Senate Bill 375 and ARB recommendations.

SACOG provided VMT data by speed bin (e.g., zero to five miles per hour, five to ten miles per hour), which allowed for the use of detailed emission factors calculated for the same categories from EMFAC 2014. Although EMFAC provides CO_2 and CH_4 emissions data, direct N_2O emission factors were not available. Instead, N_2O emissions were calculated using ARB inventory methods that assume N_2O emissions are equal to 4.16 percent of NO_X emissions for gasoline vehicles and 0.3316 g N_2O per gallon fuel for diesel vehicles (ARB 2014a). Emissions from electricity use in electric vehicles were quantified based on total County electric vehicle VMT, as estimated by vehicle fuel type from EMFAC 2014, and scaled to the unincorporated County population. SMUD utility intensity factors, as described above, were applied to estimate emissions.

Methods described above are consistent with methods that were reported in the 2005 inventory for the unincorporated County. It is not known whether or not VMT data used in the 2005 inventory included the SOI areas or not. Decreases in this sector can likely be explained by increased vehicle efficiency over time and (potentially) previous data including VMT from areas located with SOI areas in the region.

Off-Road Vehicles

Based on modeling conducted, off-road vehicles operating in the unincorporated County emitted approximately 2196,769 $MTCO_2e$ in 2015, four percent of the County's 2015 inventory. These emissions were the result of fuel combustion in off-road vehicles and equipment used in construction, industry, and recreation and were available from ARB's OFFROAD 2007 model. Unfortunately, the OFFROAD 2007 model only provides emissions detail at the State, air basin, or county level. Sacramento County emissions data from OFFROAD 2007 were apportioned to the unincorporated area using custom scaling factors depending on the off-road fleet type. For example, due to the likely correlation between commercial activity and employment, the unincorporated portion of emissions from light commercial equipment in the County is assumed to be proportional to the number of jobs in the unincorporated County as compared to the County as a whole. Note that, although reported by the OFFROAD model, emissions from agricultural equipment are included separately in the agriculture sector and are excluded from the off-road vehicles sector. The estimated annual emissions and scaling factors used are presented in Table 7 below by fleet type.

Although ARB has released newer category-specific models designed to replace OFFROAD 2007, these newer models estimate statewide emissions without county-level detail and focus primarily on criteria pollutant emissions. ARB recommends using OFFROAD 2007 where desired information is unavailable from the newer off-road models (ARB 2015a). Notwithstanding ARB recommendations, OFFROAD 2007 model tends to overestimate emissions because it was developed prior to the 2009-2010 recession and, thus, presumes a higher growth rate in equipment population than what may have actually transpired in 2015 (ARB 2010). Additionally, the model does not include recent regulatory changes such as idling limits and newer engine tier requirements (ARB 2014b).

Table 7 2015 Unincorporated Sacramento County Community Off-Road Emissions by Fleet Type

Off-Road Fleet Type	$MTCO_2e$/year	Scaling Method
Airport Ground Support	4,633	population
Pleasure Craft	28,826	population
Construction and Mining Equipment	96,063	jobs
Transport Refrigeration Units	16,233	jobs
Industrial Equipment	10,627	jobs
Light Commercial Equipment	11,242	jobs
Lawn and Garden Equipment	12,145	population
Recreational Equipment	7,039	population
Oil Drilling	9,781	jobs
Entertainment Equipment	177	jobs
Railyard Operations	2	jobs
Total	196,769	

Notes: Totals may not add due to rounding. $MTCO_2e$ = = metric tons of carbon dioxide equivalent.

Source: Data provided by Ascent Environmental in 2016, based on modeling from OFFROAD 2007

Methods described above are consistent with methods that were reported in the 2005 inventory for the unincorporated County. However, in the 2015 inventory, some off-road sectors were scaled by jobs, whereas all sectors in the 2005 inventory were scaled by population. Further, for the 2015 inventory, farm-related off-road equipment emissions were included in the agriculture sector. Thus, if agriculture-related off-road equipment were added to this sector, reported increases would be higher and would show a 10 percent increase. Increases (if agriculture-related equipment were added) in this sector can be explained by population and economic growth. However, the rate of increase in emissions is not expected to be proportional to the increase in population/jobs, as off-road vehicle fuel efficiency and emissions have been improving over the years due to State regulations.

SOLID WASTE EMISSIONS

Based on modeling conducted, the solid waste sector was responsible for approximately 352,909 $MTCO_2e$, or seven percent of the County's 2015 GHG inventory. The ICLEI Community Protocol recommends that community GHG inventories include both "waste-in-place" emissions (i.e., methane emissions associated with existing waste already deposited since the first operational year of the landfill) and emissions associated with annual waste generated by the community in the inventory year. Waste-in-place emissions accounted for 212,239 $MTCO_2e$, or 60 percent of the emissions from the solid waste sector and community-generated waste in 2015 accounted for 140,650 $MTCO_2e$, or 40 percent of the solid waste sector. Table 8

summarizes emissions from the solid waste sector. Additional details regarding calculation methods and assumptions are discussed below.

Table 8 2015 Unincorporated Sacramento County Community Solid Waste Emissions by Source

Source	$MTCO_2e$
Fugitive CH_4 emissions	212,239
Stationary Combustion (excluding biogenic CO_2 from onsite waste-to-energy)	20
Total Waste-in-Place Emissions	**212,259**
Solid Waste generated by Unincorporated Sacramento County in 2015	140,650
Total	**352,909**

Notes: Totals may not add due to rounding; CO_2= carbon dioxide; CH_4= methane

Source: Waste-in-place emissions were obtained from Kiefer Landfill Mandatory Reporting to EPA for 2014 (EPA 2016). Community-generated waste emissions were estimated based on waste tonnage data provided by Sacramento County for Kiefer Landfill (2016b) and CalRecycle (2016) for all other landfills for waste generated in 2015.

Waste-in-Place

LFG is a mix of gases, primarily composed of CH_4, generated from decomposing organic waste and waste chemical reactions and evaporation in landfills (i.e., fugitive emissions). If a landfill has an impermeable membrane that covers a portion or all of the landfill (i.e., cover-and-capture), it can harvest the LFG and prevent CH_4 emissions from being released into the atmosphere. Once captured, a landfill can either convert the CH_4 to CO_2 through flaring or use it as a fuel for other energy-related applications.

Waste-in-place emissions were included for the Sacramento County Landfill (Kiefer) as this is the only active, public disposal facility within the unincorporated County boundaries. Consistent with ICLEI Community Protocol, if a community has a landfill subject to the EPA's Mandatory Reporting Rule (MRR), GHG emissions should be reported in the same manner they are reported to EPA, The Kiefer landfill is subject to the MRR, thus GHG emissions were summarized based on 2014 reporting data available through EPA's GHG Reporting Program (EPA 2016). In addition to fugitive CH_4 waste-in-place emissions, Kiefer landfill operates an onsite waste-to-energy facility, which uses LFG to generate electricity that is supplied back to the grid for community consumption. GHG emissions are emitted from the stationary internal combustion engine used to generate this electricity, and included in the inventory. Any CO_2 emissions from flaring are not reported to EPA and thus were not counted toward the County's inventory because IPCC and EPA considers any CO_2 emissions from flaring to be of biogenic origin and thus do not result in a net increase of CO_2 into the atmosphere (IPCC 2006a).

Note that waste-in-place CH_4 emissions occur from LFG generated at solid waste facilities and are calculated based on the accumulated waste disposed at the facility since the year that it began accepting waste. In comparison, emissions associated with community-generated waste are calculated based on the total waste generated by the community in the inventory year (i.e., 2015) at all landfills that waste is sent to. The methodology used to estimate emissions for the inventory year accounts for future emissions based on the waste disposed in 2015.

Community-Generated Waste in 2015

CH_4 emissions from decay of waste generated annually by residences and businesses in the unincorporated County accounted for 140,650 $MTCO_2e$, or 40 percent of emissions from the solid waste sector. A total of 416,740 tons of waste was reported for unincorporated Sacramento County in 2015 (CalRecycle 2016).

For emissions related to annual solid-waste generation from the community in the unincorporated County, CH_4 emissions are also generated from organic decomposition. The release of CH_4 from community-generated waste depends on the LFG management systems of the landfills at which the waste are disposed.

Community emissions associated with solid waste generation were estimated using ICLEI Community Protocol Equation SW.4.1 which calculates community-generated waste sent to landfills based on total tonnage disposed. Total waste disposed in 2015 by the unincorporated County, whether an LFG collection/control technology was in place or not, and waste characterization factors were used to estimate emissions.

Total solid waste generation by amount, type, and disposal landfill was available from CalRecycle. Information regarding the use of an LFG capture system was available for some landfills from EPA's GHG emissions database and EPA's Landfill Methane Outreach Program (LMOP). For landfills not included in this database, a review of available facility documentation and aerial imagery were used to determine if an LFG capture system was in place. Based on the review conducted, all facilities included an LFG capture system and therefore the default LFG collection efficiency, as recommended by the ICLEI Community Protocol, of 0.75 was used. Default waste characterization emission factors were used. Input disposal tonnage, by facility, is shown in Table 9 below.

Table 9 2015 Unincorporated Sacramento County Community Disposal Tonnage by Facility

Source	$MTCO_2e$
Landfills Receiving Waste from Sacramento County in 2015	**Total Tonnage Deposited in 2015**
Altamont Landfill & Resource Recovery	618
Anderson Landfill	5
Azusa Land Reclamation	50
Foothill Sanitary Landfill	35
Forward Landfill, Incorporated	70,527
Keller Canyon Landfill & Recycling Center	12
L and D Landfill	41,647
North County Landfill & Recycling Center	3,925
Potrero Hills Landfill	473
Recology Hay Road	239
Recology Ostrom Road	9
Sacramento County Kiefer Landfill	286,946
Western Regional Landfill	368
Yolo County Landfill	11,889
Total Waste Disposed (tons)	**416,740**

Notes: Totals may not add due to rounding; Data provided by Keith Goodrich, Sacramento County on June 1st, 2016(b) for Kiefer Landfill.

Source: CalRecycle 2016, compiled by Ascent Environmental, 2016.

In the 2005 inventory, emissions from this sector were quantified using the CACP software (waste-generation) and ARB's first order of decay (FOD) model (waste-in-place) for reporting year 2005. Waste-in-place emissions were not updated in the 2011 Phase 1 CAP and therefore a large increase is shown in this

inventory as a result of additional solid waste disposal at Kiefer Landfill from 2005 through 2014. These sectors are not completely comparable between inventories due to different methods used and the addition of waste at Kiefer Landfill from 2005 until 2014, which would increase CH_4 emissions.

AGRICULTURE

Based on modeling conducted, emissions from the agriculture sector accounted for approximately 254,899 $MTCO_2e$ from agricultural activity such as farm equipment operations, direct emissions from livestock, and fertilizer use, or five percent of the 2015 County inventory. Fuel combustion in farm equipment and CH_4 emissions from livestock made up 25 percent and 20 percent of total emissions from the sector, respectively. Other emissions estimated for this sector were from fertilizer use, lime application, burning of agricultural residue, and diesel-powered agricultural pumps. These emissions are summarized in Table 10 below.

GHG emissions associated with farming equipment were obtained from ARB's OFFROAD2007 model. ARB has a more recent off-road equipment model, the 2011 off-road inventory model, but it is limited to construction, industrial, and oil drilling equipment types and does not include agricultural equipment. In cases where the new model does not cover a desired category, ARB recommends using OFFROAD2007 for estimating emissions. Farming equipment emissions are assumed to occur entirely within the unincorporated County.

Table 10 2015 Unincorporated Sacramento County Community Agriculture Emissions by Source

Source	$MTCO_2e$/year
Farm Equipment	64,817
Enteric Fermentation from Livestock	50,402
Manure Management from Livestock	73,815
Fertilizer Use	34,402
Agricultural Irrigation Pumps	55,95
Residue Burning	1,314
Urea Fertilization	541
Lime Application	2.4
Pesticide Application	24,012
Total	254,899

Notes: Totals may not add due to rounding. $MTCO_2e$ = metric tons of carbon dioxide equivalent.

Source: Data compiled by Ascent Environmental, 2016.

With respect to livestock emissions, CH_4 and nitrous oxide emissions are released through enteric fermentation (a type of digestion process) and exposure of manure produced by these animals. The 2015 Sacramento County Crop Report provided estimates of total weight of cattle, lamb, and slaughter sheep in the County. Average weight per head of livestock were calculated by comparing historical County livestock population estimates from the California Agricultural Statistical Review and total livestock weights reported in the County crop reports in the same year. This was used to calculate livestock population needed for emissions estimates. All livestock-generated GHG emissions were estimated using population-based emission factors and quantification methods identical to those by ARB in the State inventory.

Emissions from fertilizer use vary by crop type and acreage. The acreage of crops cultivated in the County was based on the *2015 Sacramento County Crop and Livestock Report* (Sacramento County 2016c). The amount of fertilizer application for each crop type grown in the County was based on sample cost reports for each crop that are published by the University of California Cooperative Extension (UCCE). UCCE has special fertilizer reports available for wine grapes grown in the Sacramento region. Information about the mass amounts of urea and lime was provided in the Fertilizing Materials Tonnage Report for January to June of 2013. Emission factors and quantification methods for GHG emissions associated with urea and lime fertilizer application were obtained from IPCC (IPCC 2006b). These emission factors and quantification methods were also used by ARB in its development of the State GHG inventory and subsequent updates (ARB 2015a).

The GHG emission factor and quantification method for agricultural irrigation pumps and number of pumps were obtained from ARB reports on diesel irrigation pumps (ARB 2003, 2006). The latest reports provided total diesel pumps in SMAQMD's jurisdiction in 2006, but did not break down the inventory by county. However, pumps at both the county-level and air district-level were included in an older report. Assuming the ratio of pumps in the air district remained the same as in 2003, approximately 101 pumps were estimated to operate in Sacramento County in 2006. The County's pump inventory in 2015 was assumed unchanged from 2006. (ARB 2006: Table D-2).

Residue burning refers to the burning of croplands after they are harvested to clear the land of residual vegetation. The GHG emissions from residue burning in Sacramento County were based on Bay Area Air Quality Management District (BAAQMD) emissions inventory methods for open burning (emissions per ton of material burned), and 2015 open burning permit data submitted to the air district (ton or cubic yard of material burned) (BAAQMD 2014, SMAQMD 2015). SMAQMD provided the permit information in response to a public records request. However, the air district had not yet quantified emissions from open burning for the 2015 calendar year. The permit data provided total acres (e.g. orchard pruning) burned by material category. Thus, it was necessary to calculate emissions separately. In Sacramento County, over 864 acres, or 32 percent, of material openly burned in Sacramento County consisted of fruit and nut tree prunings. SMAQMD open burn permits also included burning of debris associated with flood control, forest management, and fire-fuel management-related burns. Although these are not necessarily agricultural-related emissions, they were included in the residue burning sub-sector to facilitate a more complete inventory.

A common pesticide that is also categorized as a GHG is methyl bromide. Based on the published factors from IPCC's Fifth Assessment Report, methyl bromide is assumed to have a GWP factor of 2. However, according to the California Pesticide Information Portal, no methyl bromide was used in the County in 2014. 2015 information was not available, but no changes in methyl bromide use are expected.

In the 2005 inventory, all agriculture emissions were calculated using the CACP software. Similar data sources were used previously as were in the 2015 update inventory. The 2005 inventory did not include farm-related off-road equipment in the agriculture sector. Considering that the 2015 update inventory did include farm-related off-road equipment, agriculture emissions associated with enteric fermentation of cattle and swine, manure management from dairy cows, enteric fermentation and manure management from dairy cows, and N_2O emission from fertilizer have gone slightly down since the 2005 inventory. This is likely due to conversion of agriculture land over the past years and overall reductions in agriculture productivity due to the drought and other factors. Specifically, the 2015 Sacramento County Crops and Livestock Report showed an overall six percent decrease in total crop production and 10 percent decrease in cattle production from 2014 (Sacramento County 2016).

HIGH-GWP GASES

High-GWP gases accounted for 251,085 $MTCO_2e$, or approximately five percent of total emissions in 2015. This sector includes emissions from various high-GWP gases including hydrofluorocarbons (HFCs), perfluoroethers (PFEs), and perfluorocarbons (PFCs). HFCs and CFCs are generally emitted into the atmosphere through off-gassing, leakage, or direct emissions of refrigerants, solvents, aerosols, foams, and fire protection suppression chemicals. Other high-GWP gases are used in specific industrial applications like semiconductor manufacturing or make up less than one percent of the overall State's emissions inventory (ARB 2015b).

Estimates of high-GWP gases were calculated based on ARB's 2014 State GHG inventory. 2014 State per-capita emission factors were calculated from the most recent California 2014 inventory. These emission factors were then scaled to 2015 assuming that per capita emissions would increase by five percent between 2014 and 2015, consistent with increases between the 2013 and 2014 inventory data. The final 2015 emission factors were applied to the known population of the unincorporated County to obtain County-level emissions. Emissions from High GWP gasses are summarized below in Table 11 by emissions source and application.

In the 2005 inventory, statewide high GWP GHG emissions trends were mapped from 1990 to 2004 and the resulting trend line (showing an average annual rate of growth of approximately 10 percent) was used to estimate emissions in 2005. This approach is similar to what was done for the 2015 inventory. However, the ARB inventory was used rather than the estimate from the California Energy Commission, as was done in the 2005 inventory. Increases in emissions are explained by population increases from 2005.

Table 11 2015 Unincorporated Sacramento County Community High GWP Gases by Application

Emissions Source and Application	Unincorporated Sacramento County Emissions ($MTCO_2e$/yr)
Commercial	**117,677**
Aerosols	2413
Fire Protection	471
Foams	2,385
Refrigeration and Air Conditioning	112,407
Industrial	**38,671**
Aerosols	410
Fire Protection	118
Foams	11,715
Refrigeration and Air Conditioning	24,864
Solvents	1,564
Residential	**42,419**
Aerosols	9,287
Foams	4,263
Refrigeration and Air Conditioning	28,869
Transportation	**52,317**
Aerosols	2,645
Refrigeration and Air Conditioning	49,673
Grand Total	**251,085**

Note: Totals may not add due to rounding. MT = metric tons, CO_2e = carbon dioxide equivalents; GWP=global warming potential

Source: Source: ARB 2015b, IPCC 2007: Table 2.14, IPCC 2013; data compiled by Ascent Environmental in 2016.

WASTEWATER EMISSIONS

Based on modeling conducted, wastewater generation in 2015 resulted in emissions of approximately 27,253 $MTCO_2e$, less than one percent of total emissions, primarily from fugitive CH_4. Wastewater emissions were estimated in two components: (1) pumping-related energy for wastewater conveyance from the source to the treatment facility, and (2) wastewater treatment process emissions. Each is discussed separately below.

Wastewater Conveyance

SASD and Regional San are the primary agencies responsible for sewer conveyance and wastewater treatment within the unincorporated County. Service areas for SASD and Regional San also include the cities of Citrus Heights, Rancho Cordova, Elk Grove, Folsom, Sacramento, and West Sacramento in Yolo County.

Within Regional San's service area, wastewater is collected from customers' homes and businesses via sewer collection pipes operated by SASD, City of Sacramento Department of Utilities, City of Folsom Sewer District, or City of West Sacramento Public Works. Wastewater is then conveyed and pumped through a network of lower lateral and main pipes owned and operated by SASD. Finally, SASD pipes are connected to larger interceptor pipelines owned and operated by Regional San, which convey the wastewater to the Sacramento Regional Wastewater Treatment Plant (WWTP) near Elk Grove.

Emissions associated with wastewater conveyance are directly related to the energy required to convey the wastewater and the volume of water conveyed/pumped. To estimate GHG emissions, a regional wastewater conveyance energy intensity factor was calculated from total pumping energy data within SASD and Regional service area and total wastewater treated in 2015. SASD pumping data were provided directly by SASD. Regional San pumping energy and treatment effluent volumes were provided directly by Regional San (pers. Comm. Steve Nebozuk, Regional San. 2016). Because pumping energy was specific to SASD and Regional San (excluding local sewer districts within SASD and Regional San's service area), but wastewater effluent data represented the entire SASD and Regional San service area (e.g., unincorporated County and cities), the effluent volumes were adjusted down by 25 percent to exclude the portion of wastewater generated by incorporated cities (pers. Comm. Salam Khan, SASD. 2016). Effluent volume was apportioned to the unincorporated County population and the calculated energy intensity factor was applied to obtain total wastewater conveyance-related energy. GHG emissions were estimated using the same emissions factors described for the building sector. Similar to methods used in the 2005 inventory, wastewater-related energy use data were subtracted from the building sector based on applicable North American Industry Classification System (NAICS) codes to avoid double-counting.

According to the ICLEI Community Protocol, wastewater discharge and treatment energy intensities associated with septic tanks and other on-site systems are assumed negligible. Hauling emissions associated with maintenance of septic tanks are captured in the on-road vehicle sector and not included in this sector.

Wastewater Treatment Process Emissions

Wastewater generated by the unincorporated County is treated at the Regional San WWTP. Treatment process emissions at the WWTP include electricity consumption for treatment, process N_20, wastewater effluent containing N_20, and emissions from biogas combustion. Wastewater treatment process emissions for Regional San were calculated in accordance with LGOP, Version 1.1. Specifically the following equations/methods were used to capture all emission types that occur at the treatment plant.

- Annual electricity consumption for the Regional San WWTP adjusted for the unincorporated County population and SMUD utility intensity factors described in the building sector.

- Equation 10.10 from LGOP for process N_2O emissions from effluent discharge.
- Equation 10.3.2.2 from the LGOP for process N_2O emissions from wastewater treatment without nitrification/denitrification.
- Equation 10.2 from the LGOP for direct emissions from combustion of digester gas.

It was assumed that the entire unincorporated County population is served by the Regional San WWTP. As such, process wastewater emissions may be slightly over estimated as some portion of the unincorporated County use onsite septic tanks for wastewater treatment. Emissions from wastewater treatment are summarized below in Table 12.

Table 12 2015 Unincorporated Sacramento County Community Wastewater Emissions

Wastewater Emission Type	$MTCO_2e$/year
Wastewater Conveyance	2,088
Wastewater Treatment	25,166
Total Wastewater Emissions	**27,253**

Notes: Totals may not add due to rounding. MT = metric tons; CO_2e = carbon dioxide equivalent.

Source: Modeled by Ascent Environmental in 2016.

In the 2005 inventory, emissions from this sector were quantified using statewide, per-capita emissions estimated by ARB for 2004 and were scaled to the unincorporated County population. As described above, the 2015 inventory update uses process-specific data and equations to estimate wastewater process emissions and uses region-specific energy intensity factors and effluent volumes to estimate emissions associated with wastewater conveyance. The decrease in emissions in this sector is likely due to the more refined and region-specific methodology used in this inventory. It is important to note that SRCSD also recycles water for use in irrigation and landscaping. However, the use of recycled water would translate to reductions in potable water consumption. Wastewater-related emissions are associated with the actual quantities of water conveyed and treated and therefore accurately reflect energy and water use in 2015.

WATER-RELATED EMISSIONS

Based on modeling conducted, water-related emissions accounted for 15,222 $MTCO_2e$ in 2015, less than one percent of the County's 2015 GHG inventory. GHG emissions associated with water consumption occur from the indirect use of energy associated with water treatment and pumping energy required to distribute water to the point of use (e.g., residence, business). Water-related emissions were estimated by using an energy intensity factor (i.e., the total amount of energy required to produce a unit of water for a particular use), and applied to total water consumption for Sacramento County in 2015. GHG emissions were estimated by applying SMUD utility intensity factors, as described for the building sector. The methods used are explained in more detail below.

Energy Intensity Factor

An energy intensity factor, with regard to water-related emissions, is defined by the amount of energy (electricity, natural gas and oil) required to produce a unit of water for a particular use. Electricity is the primary source of energy used for water treatment and conveyance in the Sacramento region (SMUD 2014). Other energy sources may include diesel pumps for onsite water wells and back-up generators at treatment plants. It is likely that the vast majority of diesel pumping occurs on agricultural land or other unincorporated lands with private onsite pumps. GHG emissions from agricultural-related pumps were accounted for in the

agriculture sector, discussed below in this section. Other diesel pumps that may occur were considered negligible. With regard to natural gas use for water treatment and conveyance, total industrial/commercial land uses (the land uses likely to include water-related energy use) accounted for 10 percent of the total community energy, and it is likely that most (if not all) of this is associated with building energy use. Thus, for purposes of this analysis, energy intensity is based on electricity use only, and is expressed as kilowatt-hours per million gallons (kWh/MG).

In 2013, SMUD and the Regional Water Authority published the Assembly Bill (AB) 32 Water Energy Assessment and Savings Demonstration Project (SMUD 2014). This was a comprehensive study completed for the purpose of identifying opportunities to reduce GHG emissions through water system and energy facility improvements. Part of the study included an assessment of existing water supplies, water conveyance volumes, and energy use by individual water suppliers within Sacramento County. The study estimated energy intensity factors based on available energy consumption and water volume conveyed for all water suppliers that participated in the study, as well as a regional average intensity factor (i.e., 1,062 kWh/MG).

A review of all water purveyors in Sacramento County was conducted and compared to the water purveyors included in the SMUD study discussed above. Some of the water purveyors included in the calculation for the regional intensity factor discussed above do not provide water to the unincorporated County. Thus, a weighted specific energy intensity factor was calculated based on the energy intensities for the water purveyors that do provide water to the unincorporated County, weighted by the percent of total water provided by each purveyor (methods used to obtain total water volumes are discussed below). This resulted in a specific intensity factor of 1,215 kWh/MG for the unincorporated County.

Water Consumption

To estimate water-related emissions, total water consumption volumes were estimated and applied to the energy intensity factor discussed above. Based on a review of available Sacramento County Geographic Information System (GIS) data, the SMUD study, and the California Department of Water Resources (DWR), there are 25 individual water purveyors in Sacramento County, some of which entirely serve unincorporated areas and others that serve both incorporated cities and the unincorporated County (e.g., City of Folsom, San Juan Water District). As such, water consumption data were not readily available from any one source.

Water consumption volumes were compiled for all water purveyors identified within the unincorporated County. Water consumption volumes were available for many of the 25 water purveyors. However, no water volume data were available for some smaller purveyors. These included Clay Water District, Galt Irrigation District, Natomas Central Municipal Water Company, and Omochumne-Hartnell Water District. Based on a review of aerial imagery and GIS layers for these districts, it was determined that these districts serve primarily agriculture land uses. In addition, per California Water Code 10617, an “urban water supplier” is defined as a supplier, either publicly or privately owned, providing water for municipal purposes either directly or indirectly to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually,” and would be required to prepare an Urban Water Management Plan to DWR. Thus, because no water consumption data were available through DWR, it is likely that these water purveyors represent small portion of total water consumption in the County and were therefore determined to not contribute substantially to the overall water consumption and energy demand in the unincorporated County.

Water volumes were compiled for all other 21 purveyors within Sacramento County from available online sources such as the SMUD study and DWR. Total water use from each purveyor was apportioned to the unincorporated County based on the percentage of each purveyor’s service area acreage within the unincorporated County. Water service boundaries for all water purveyors were available from the County’s online GIS database.

Total estimated water consumption for unincorporated County was multiplied by the calculated energy intensity factor and GHG emissions were estimated based on SMUD utility factors, as described in the building sector. Similar to methods used in the 2005 inventory, water-related energy use data were subtracted from the building sector based on applicable NAICS codes (i.e., water pumping, irrigation, and treatment for agriculture, commercial, and industrial land uses) to avoid double-counting. Results are shown below in Table 13.

Table 13 2015 Unincorporated Sacramento County Community Water-Related Emissions Summary

Water Suppliers	Quantity
Total Water Delivered	49,009 MG/year
Total Energy Consumption	5,947 MWh/year
Total Water-Related GHG Emissions	15,222 $MTCO_2e$/Year

Notes: Totals may not add due to rounding. MG= million gallons; MWh = megawatt-hours; MT = metric tons; CO_2e = carbon dioxide equivalent; GHG=greenhouse gas.
Source: Data compiled by Ascent Environmental in 2016.

In the 2005 inventory, emissions from this sector were quantified based on energy use provided by SCWA only. As discussed above, the 2015 inventory update uses regional-specific energy intensity factors and water consumption volumes to estimate emissions associated with water treatment and conveyance for the entire unincorporated County, which explains the large increase over the 2005 inventory.

2.2.2 Municipal Operations Inventory

EMPLOYEE COMMUTE

Employee commute accounted for 38,290 $MTCO_2e$, or approximately 31 percent of total emissions in 2015. This sector estimated GHG emissions associated with fuel use and VMT traveled for Sacramento County employees commuting to and from work. Employee work and home zip code information was available for all County employees in 2015. Annual VMT for all employee work commute trips was calculated based on mileage from the center of each work zip code to the associated home zip code. Similar to methods used in the 2005 inventory, total annual VMT was adjusted based on County average vacation time and a 9/80 work week, where employees complete 80 hours of work in a 9-day period and have the 10th day off, which eliminates one roundtrip commute every two weeks. Further, emissions were reduced based on available results of a County employee commute survey conducted in 2010 for the 2005 inventory, which indicated that approximately 14 percent of travel by County employees consisted of carpooling, public transit, bicycle, or walking. Emissions were estimated using emission factors derived from EMFAC 2014, as discussed in Section 2.2.1.

The primary difference between emissions reported in this sector is that the 2011 Phase 1 CAP updated the 2005 inventory based on an employee commute survey that was conducted in 2010. Emissions were back-casted to 2005 to update the baseline inventory. Based on available data in this survey, total annual employee VMT in the 2005 inventory was lower than what was estimated for the 2015 inventory; that is, total employee annual VMT was estimated at approximately 73 million as compared to 108 million in the 2015 inventory update. In addition, the employee commute survey estimated that the County had 11,000 employees in December 2005, as compared to 11,933 in December 2015.

VEHICLE FLEET

County-owned vehicle fleet emissions accounted for 29,591 $MTCO_2e$, or approximately 24 percent of total emissions in 2015. Vehicle fleet fuel consumption data for 2015 (e.g., mileage, fuel consumption) was provided for all County-owned vehicles. This sector includes emissions estimated from on-road and off-road vehicles owned and operated by the County. Airport fleet emissions were also included in this sector. Emissions were estimated using emission factors derived from EMFAC 2014 (on-road vehicles) and published emissions factors from the Climate Registry (2014) for off-road vehicles.

Similar data and methods were used for this sector in the 2005 inventory. Decreases in emissions for this sector are likely due to County staff deliberately purchasing more fuel-efficient and lower-emission vehicles as part of the regular fleet replacement to reduce fleet-related GHG emissions.

BUILDINGS AND FACILITIES

County buildings and facilities accounted for 28,247 $MTCO_2e$, or approximately 23 percent of total emissions in 2015. This sector includes energy (e.g., electricity and natural gas) use for all County buildings and facilities, excluding airport buildings/facilities which are included as part of the airports sector (see below). Energy use data were provided for 2015 by individual County departments (e.g., General Services, Transportation, Parks and Recreation). Buildings include County-owned and leased buildings. Infrastructure and facilities include energy use at park/golf buildings, park/golf lighting and irrigation controllers, and other facilities such as movable access gates and communications towers. GHG emissions were estimated using the same methods and emission factors as described in Section 2.2.1.

Data and methods used for this sector are similar to those used in the 2005 inventory. Decreases in emissions for this sector are likely due to deliberate actions on the part of County staff to reduce energy usage by retrofitting many County facilities to be more energy efficient, construction of new buildings to LEED standards, increase in the use of on-site renewable energy systems such as installing solar panels on buildings/facilities, as well as utility energy intensity factors improving, likely due to SMUD's increased renewable energy portfolio.

AIRPORTS

Emissions from County airports accounted for 18,310 $MTCO_2e$, or approximately 15 percent of total emissions in 2015.The GHG emissions associated with airport facilities are broken out separately from other County facilities. The reported emissions are associated with energy used for the County's ground operations (i.e., airfield and landside maintenance equipment, roadways, parking) and buildings. Aircraft emissions and airline-owned ground support equipment are excluded because the County does not have control over those operations.[1] Airline ground support equipment is included in the community inventory off-road sector, as discussed above in Section 2. Also, the airport fleets and airports employee commute data were not broken out for this inventory; those emissions are included in emissions shown for the vehicle fleet and commute categories. This sector includes emissions associated with building energy and ground operations at Sacramento International (SMF), Mather, and Sacramento Executive Airports.

Increased emissions in this sector are likely due to the recent airport expansion of Terminal B at SMF, which was opened in 2011 and is approximately three times larger than the terminal it replaced.

[1] Aircraft are owned and operated by private airline companies and are not considered to be part of the Sacramento County's Airport System's internal operations. Regulatory authority for GHG emissions associated with aircraft operations rests with the Federal Aviation Administration and EPA.

WATER CONSUMPTION

Water-related activities in the County's internal operations resulted in 4,665 $MTCO_2e$, or approximately four percent of total GHG emissions in 2015. Similar to the 2005 inventory, water-related emissions were estimated based on energy used to operate water delivery facilities under the jurisdiction of SCWA. In addition, water consumption volumes were available for County-owned buildings and facilities. The calculated water energy intensity factor, described in Section 2.2.1, was applied to water consumption data, to obtain water-related energy use, and summed with available energy data from SCWA. As such, this inventory provides additional detail and a slightly more complete picture with regard to water-related GHG emissions, as compared to the 2005 inventory. GHG emissions were estimated using SMUD utility emission factors.

Methods used in this inventory were similar to methods previously used. However, additional water consumption volumes were available for County-owned buildings. Despite additional water-consumption data, emissions reported were lower in comparison to the 2005 inventory. Decreases in emissions are likely due to deliberate actions on the part of County staff to reduce water use by replacing existing fixtures with water conserving fixtures, reducing landscape watering, and training employees, as well as by utility energy intensity factors improving as a result of increased renewable energy sources and reductions in community water usage due to recent drought conditions and mandatory reductions that were in place throughout California in 2015.

STREET LIGHTS/SIGNALS

County streetlights and traffic signals accounted for 3,729 $MTCO_2e$, or approximately three percent of total emissions in 2015. This sector includes emissions associated with electricity consumption to power County-owned traffic signals and street lights. In addition, energy consumption associated with Smart Meter Communication devices installed on County streetlights and illuminated street name signs are also captured in this sector. GHG emissions were estimated using SMUD utility emission factors.

Data and methods used for this sector are similar to those used in the 2005 inventory. Decreases in emissions for this sector are likely due to deliberate actions on the part of County staff to reduce energy usage by replacing existing street and parking lot light fixtures with LED lights, as well as by utility energy intensity factors improving as a result of SMUD's increased renewable energy sources.

WASTEWATER

Wastewater emissions associated with County-owned buildings and facilities were not included in the 2005 inventory. Although the County has no direct control over wastewater-related emissions, the generation and treatment of wastewater by activities in County-owned buildings and eventual treatment of those emissions can be accounted for as a subset of community wastewater emissions. Additionally, water conservation measures could result in emissions reductions from this sector.

Wastewater treatment and conveyance emissions associated with County buildings and facilities accounted for 565 $MTCO_2e$, less than one percent of total emissions in 2015. Emissions from wastewater conveyance and treatment were estimated separately for this inventory. Similar to the community inventory, emissions for this sector were based on total population served by the Regional San WWTP and total effluent volume treated. To estimate emissions associated with wastewater treatment at Regional San, total County employment data were used. Methods are identical to what was described in Section 2.2.1. To estimate emissions associated with wastewater conveyance, the community effluent data, as described in Section 2.2.1, was scaled to the total number of employees of Sacramento County (i.e., 11,933) and applied to the

wastewater conveyance energy intensity factor that was calculated for the community inventory, as discussed in Section 2.2.1. GHG emissions were estimated using SMUD utility emission factors.

SECTORS NOT INCLUDED IN THE INVENTORY

Emissions associated with solid waste generation attributable to County owned and operated buildings are not included in the baseline emissions inventory shown above due to unavailability of data. Emissions associated with operation of the County-owned Kiefer Landfill are also not included in the inventory due to the community nature of the solid waste sector and uncertainty regarding the allocation of responsibility between the County and other jurisdictions that contribute refuse to the landfill. All solid waste emissions, including emissions associated with waste generation by County residents in the unincorporated area, is discussed in the Community inventory in Section 2.2.1 above.

3 GHG EMISSIONS FORECASTS TO 2020, 2030, AND 2050

BAU emissions forecasts provide the County with an assessment of how the County's emissions would change over time without further action from federal, State, or local regulation.. Forecasts for the community inventory and internal operations inventory were done separately. This section discusses methods used for each. BAU forecasts described in this section for 2020, 2030, and 2050 are generally based on the State's GHG reduction target years established in key State legislation and policies, including AB 32 (Pavley, Statutes of 2006), SB 32 (De Leon, Statutes of 2016), and Executive Orders B-30-15 and S-3-05. The Statewide GHG reduction targets are as follows:

- 1990 levels by 2020 (AB 32);
- 40 percent below 1990 levels by 2030 (SB 32 and EO B-30-15); and,
- 80 percent below 1990 levels by 2050 (EO B-30-15 and S-3-05)

For the community inventory, estimated BAU emissions forecasts were based on predicted growth in existing demographic forecasts, including population, jobs, and household growth between 2012 and 2036 for the unincorporated Sacramento County, as provided by SACOG. Population and dwelling units are expected to increase annually by one percent, while employment is expected to increase annually by 1.9 percent. These growth factors were used to forecast BAU emissions for 2020, 2030 and 2050 for most sectors in the inventory. SACOG also provided annual VMT growth projections for the years 2012 through 2036. Based on this data, annual VMT is projected to increase one percent annually. VMT projections were used to scale emissions from the on-road vehicle sector. The same annual growth rates were applied to years beyond 2036. In addition, the community inventory includes emissions from agriculture activities in the County, which were scaled based on anticipated changes in future agriculture land, as evaluated in the Sacramento County General Plan Final Environmental Impact Report (FEIR) which estimated that approximately 412 acres of agriculture land would be lost every year, or 0.1 percent of total agriculture land (Sacramento County 2010). BAU forecasts for the internal operations inventory were based on projected employment increases for the County, as discussed above.

Table 14 shows baseline emissions in 2015 and BAU emissions forecasts for 2020, 2030, and 2050.

Table 14 Unincorporated Sacramento County Emissions Inventory and BAU Forecasts ($MTCO_2e$/year)

Sector	2015	2020	2030	2050
2015 Community Inventory				
Residential Energy	1,193,311	1,254,182	1,385,397	1,690,448
Commercial/Industrial Energy	890,603	978,487	1,181,128	1,720,999
On-Road Vehicles	1,671,596	1,765,579	1,969,694	2,451,443
Off-Road Vehicles	196,769	214,146	253,855	357,866
Solid Waste	352,909	372,751	4,15,844	517,551
Agriculture	254,899	253,627	251,102	246,128
High-GWP Gases	251,085	265,202	295,861	368,223
Wastewater	27,253	28,785	32,113	39,967
Water-Related	15,222	16,078	17,937	22,323
Total	**4,853,647**	**5,148,836**	**5.802,930**	**7,414,948**
2015 Internal Operations Inventory				
Employee Commute	38,290	42,068	50,781	73,991
Vehicle Fleet	29,591	32,511	39,244	57,182
Buildings and Facilities	28,247	31,034	37,461	54,584
Airports (buildings and facilities)	18,310	20,117	24,283	35,382
Water-Related	4,665	5,125	6,187	9,015
Streetlights and Traffic Signals	3,729	4,097	4,945	7,206
Wastewater	565	621	749	1,092
Total	**123,397**	**135,574**	**163,651**	**238,452**

Notes: Total may not add due to rounding. BAU = Business as usual, CO_2e = carbon dioxide equivalents, NA = Not Available, GWP = Global Warming Potential, MT = metric tons

Source: Ascent Environmental, 2016

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