Appendix A

Regional Greenhouse Gas Inventory for the Tahoe Basin

A Regional Greenhouse Gas Inventory For the Lake Tahoe Basin

Final Report

January 2013

Prepared by Sonoma Technology, Inc. (STI)
and the Tahoe Basin Greenhouse Gas Work Group

A Regional Greenhouse Gas Inventory For the Lake Tahoe Basin

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Prepared by

Erin K. Pollard
Stephen B. Reid
John C. Stilley

Sonoma Technology, Inc.
1455 N. McDowell Blvd., Suite D
Petaluma, CA 94954-6503

Contributing Author

Tricia York
California Tahoe Conservancy
1061 Third Street
South Lake Tahoe, CA 96150

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Cover graphic illustrates the Lake Tahoe shoreline.

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1. Introduction

This report documents the methods used to develop baseline and future-year regional greenhouse gas (GHG) emissions inventories for the Lake Tahoe Basin. This work was funded and managed by the California Tahoe Conservancy (CTC), and GHG emissions estimates were developed by Sonoma Technology, Inc. (STI) under subcontract to the University of California at Davis (UCD).

1.1 Background

In 1997, the Lake Tahoe Environmental Improvement Program (EIP) was created to better implement projects and programs designed to achieve and maintain the Basin's environmental quality standards. Recently, EIP stakeholders and partners identified a fundamental knowledge gap regarding the direct and indirect[1] emissions of GHGs in the Lake Tahoe region. To address this gap, the CTC, an EIP partner agency, funded the development of a regional GHG emissions inventory designed to establish a baseline of information on current and forecasted GHG emissions by source sector so planning agencies can set emissions reduction targets, develop mitigation strategies, and establish incentive programs within the regional planning process.

In addition, the results of the GHG inventory project will provide essential information to EIP agencies and stakeholders as they seek to comply with California GHG regulations, such as California Assembly Bill 32 (AB 32, or the Global Warming Solutions Act), which requires statewide GHG emissions to return to 1990 levels by 2020. Under AB 32, Tahoe planning agencies are required to meet regional GHG reduction targets through integrated land use and transportation planning as part of Senate Bill 375 (SB 375), the Sustainable Communities and Climate Protection Act.

1.2 Technical Issues

1.2.1 Overview

The greenhouse effect is a natural process that traps radiant heat in the Earth's lower atmosphere, making the planet habitable. The Earth's surface absorbs sunlight and emits infrared radiation (heat) to the atmosphere, a portion of which is absorbed and re-emitted by GHGs such as carbon dioxide (CO_2),[2] capturing heat that would otherwise escape into space. Over time, human activities have added to the naturally occurring levels of GHGs in the atmosphere, thereby enhancing the greenhouse effect.

A GHG emissions inventory provides a detailed estimate of the amount of GHGs emitted into the atmosphere annually by various emissions sources across a given geographic area.

[1] Direct emissions are emitted by sources located within the region of interest, while indirect emissions are emitted by sources outside the region of interest but result from activities occurring within the region (e.g., electricity consumption).
[2] The six "Kyoto" GHGs are CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

This quantification of GHG emissions from various source sectors is the first step toward developing strategies for reducing such emissions over time.

In general, GHG emissions are calculated by quantifying the intensity of emissions-producing activities and then applying appropriate emission factors to the activity data. Emission factors represent the amount of a given pollutant emitted per unit of activity, and for CO_2, emission factors are generally derived from the characteristics of the fuel combusted. For a given fuel, a CO_2 emission factor is calculated using the fuel's carbon coefficient and heat content and an oxidation factor that accounts for the fraction of carbon that may not be oxidized during combustion, as shown in **Equation 1** (California Climate Action Registry, 2009).

$$EF = \text{Heat Content} \times \text{Carbon Coefficient} \times \text{Oxidation Factor} \times 44/12 \qquad \textbf{(1)}$$

Where

EF = CO_2 emission factor (kg CO_2/gallon)
Heat Content = energy per unit volume (BTU/gallon)
Carbon Coefficient = mass of carbon (C) per energy unit (kg C/BTU)
Oxidation Factor = fraction of carbon oxidized (default = 1.0)
44/12 = ratio of the molecular weight of CO_2 to that of carbon

GHG emissions inventory methods and protocols providing guidance on activity data and emission factors have been established by the Intergovernmental Panel on Climate Change (2006), the California Climate Action Registry (2009), the U.S. Energy Information Administration (2008), and the U.S. Environmental Protection Agency (2009). We based the inventory methodologies for this project on these established protocols.

1.2.2 Key Inventory Steps

In keeping with established methods and protocols, the inventory development process involved a number of key decisions and steps:

- **Engaging project stakeholders** – At the outset of the project, CTC and STI convened a GHG inventory work group consisting of staff from local planning agencies and research institutions (see Acknowledgements). The work group provided guidance in selecting inventory years, identifying available data, and coordinating the project with other planning efforts for the Basin.
- **Establishing inventory boundaries** – The geographic scope of this inventory is defined by Tahoe Regional Planning Agency's (TRPA) jurisdictional boundaries, which lie within the borders of both California and Nevada. The California side of the Basin includes portions of Placer and El Dorado counties and all of the City of South Lake Tahoe, while the Nevada side includes portions of Douglas County, Washoe County, and Carson City[3] (see **Figure 1-1**). Because of the multiple entities present within the Basin, the GHG emissions estimates developed during the project were geographically disaggregated so the contributions of individual counties and cities could be assessed.

[3] The portion of Carson contained in the Basin is forested land with no human population; therefore the only GHG emissions for this uninhabited area are related to on-road motor vehicle traffic.

- **Selecting inventory years** – In consultation with the GHG inventory work group, CTC selected 2005 as the baseline inventory year on the basis of data availability and the compatibility of 2005 with other planning efforts (e.g., 2005 is also the baseline year for regional GHG reduction targets being developed for the Basin in response to SB 375). CTC also requested that emission estimates be prepared for 2010 to quantify the impact of the recent economic downturn on GHG emissions in the Basin. Future-year emissions estimates were prepared for 2020 and 2035, which also align with SB 375 target years and other regional planning efforts.
- **Identifying emissions sources** – STI and CTC worked with the GHG inventory work group to identify the emissions sources to be included in the inventories (see **Table 1-1**). The Tahoe Basin includes source categories that are typically not of concern in municipal GHG inventories (e.g., forestry, wildfires, and recreational boats), and also lacks industrial facilities that would normally be included in GHG inventories (e.g., cement production and iron and steel manufacturing).
- **Collecting activity data** – STI and CTC worked with the GHG inventory work to identify and review available data for characterizing baseline and future-year GHG emissions in the Basin. On the basis of this review, we compiled a list of primary data sources recommended for GHG emissions estimation, as well as secondary sources of data that could be used if primary data were not available for years of interest (Reid et al., 2011). Data sets used to estimate and forecast emissions for specific source categories are documented in Section 2 of this report.
- **Prioritizing source sectors –** To allocate available resources appropriately, we made an initial estimate of GHG emissions associated with key source sectors and with source sectors that are not well-characterized in existing emissions inventories for the Basin. On the basis of this analysis, we prioritized several source categories (e.g., on-road motor vehicles, electricity usage, residential wood combustion, and recreational boats) and determined that other source categories were unlikely to be significant sources of GHG emissions in the Basin (e.g., construction equipment and lawn and garden equipment) and could therefore be addressed with readily available data.

More detailed information about the data and methods used to estimate GHG emissions for the Tahoe Basin is provided in Section 2 of this report.

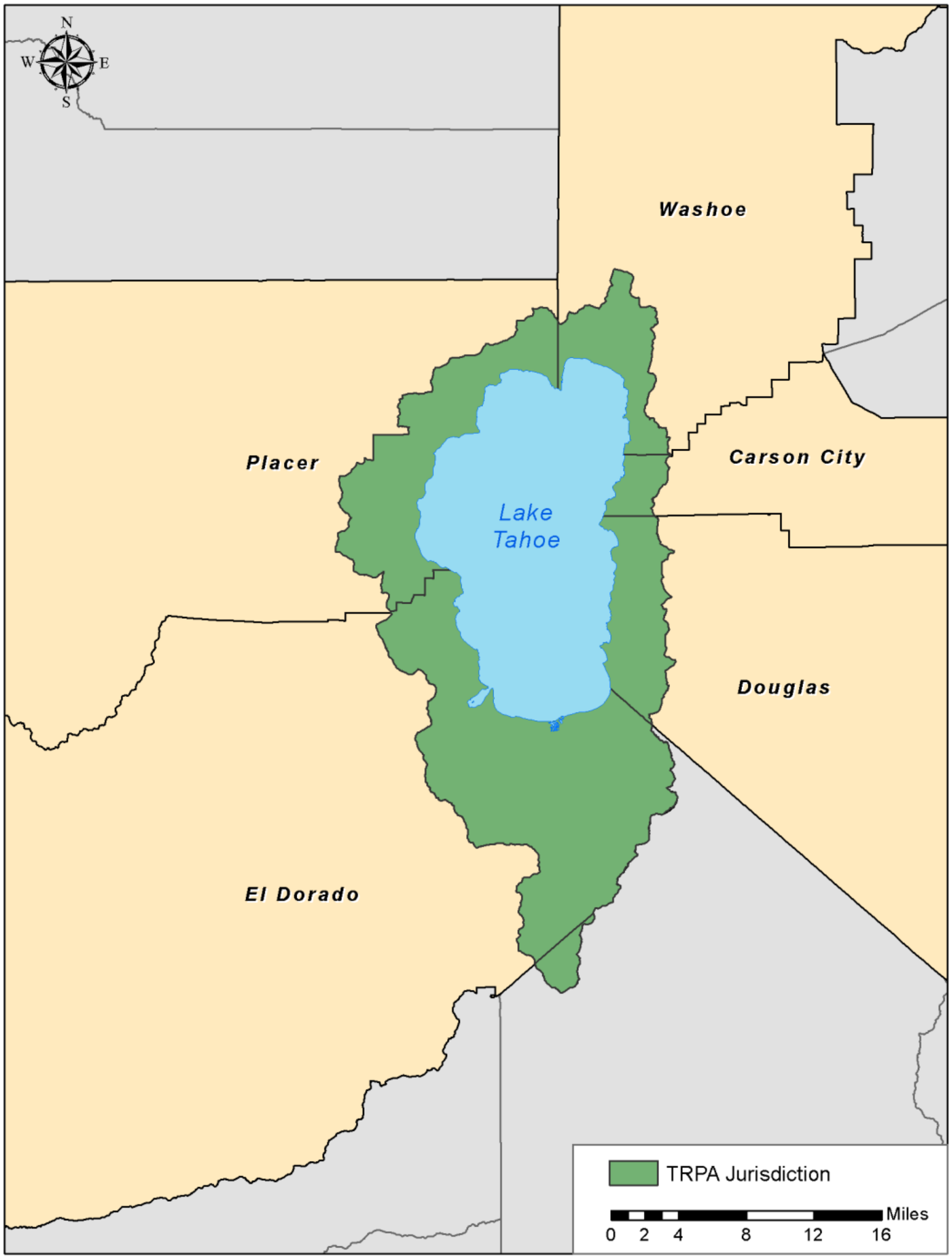

Figure 1-1. Map of TRPA's jurisdictional boundaries around Lake Tahoe Basin.

Table 1-1. Source categories included in the GHG emissions inventories for the Lake Tahoe Basin.

Emissions Type	Source Sector	Source Category
Direct[a]	Transportation	On-road mobile sources (motor vehicles: passenger cars, trucks, buses)
		Off-road vehicles (boats, snowmobiles, lawn and garden equipment, construction equipment, etc.)
	Fuel combustion	Wood combustion (campfires, fireplaces, stoves)
		Natural gas combustion (residential and commercial)
		Other fuel combustion
	Fires	Wildfires and prescribed burns
	Land use	Livestock
		Forestry carbon stock
	Waste	Wastewater treatment
Indirect[b]	Energy	Electricity consumption
		Wastewater treatment
	Transportation	Aircraft
	Waste	Municipal solid waste
		Wastewater treatment

[a] Direct, or "Scope 1," emissions are emitted by sources located within the region of interest.
[b] Indirect emissions are emitted by sources outside the region of interest but result from activities within the region. "Scope 2" indirect emissions are associated with electricity consumption, and all other indirect emissions (e.g., transport-related activities, waste disposal) are classified as "Scope 3" (California Air Resources Board et al., 2010).

1.3 Emissions Summary

The Lake Tahoe Basin generated approximately 1,363,734 metric tons of CO_2-equivalent[4] (CO_2e) emissions in 2005 and approximately 1,433,374 metric tons of CO_2e emissions in 2010. Electricity consumption is the largest source of emissions, producing 487,553 metric tons of CO_2e in 2005 and 562,543 metric tons of CO_2e in 2010 (see **Table 1-2**). These emission levels represent over 36% the total CO_2e emissions in each year, as shown in **Figure 1-2**). The transportation sector was the next largest source, accounting for 30% of total CO_2e emissions in 2005 and 27% of total CO_2e emissions in 2010. The third largest source is fuel combustion, which includes wood, natural gas, and other fuel combustion sources. Fuel combustion in the Basin accounts for over 25% of total CO_2e emissions in 2005 and 2010. The other source sectors (fires, land use, and waste) account for only about 8% of the total CO_2e emissions in 2005 and 2010.

[4] Emissions for non-CO_2 GHGs are converted to CO_2-equivalent values based on each GHG's global warming potential (GWP). GWP is an index that quantifies the radiative forcing effects of a given GHG using CO_2 as the reference gas (California Climate Action Registry, 2013).

Table 1-2. Basin-wide CO_2e emissions by source sector and category (metric tons/year).

Type	Source Sector	Source Category	2005	2010
Direct	Transportation	On-road mobile sources	325,282	304,348
		Recreational boats	22,403	15,994
		Other off-road equipment	53,860	58,751
	Fuel combustion	Wood combustion	97,700	104,297
		Natural gas combustion	236,232	243,075
		Other fuel combustion	5,858	6,161
	Fires	Wildfires and prescribed burns	4,284	91,652
	Land use	Livestock	12,734	12,734
	Waste	Wastewater treatment	57	62
Indirect	Energy	Electricity consumption	487,553	562,543
		Wastewater treatment[a]	2,115	2,300
	Transportation	Aircraft	5,131	4,739
	Waste	Municipal solid waste	110,512	26,704
		Wastewater treatment[a]	12	12
Total Emissions			**1,363,734**[b]	**1,433,374**

[a] The indirect components of wastewater treatment account for wastewater processed outside the Basin in Truckee. A portion of the electricity consumed by the Truckee facility is treated as an indirect source for the Basin-wide GHG inventory, as well as a portion of nitrous oxide emissions from the facility.
[b] CO_2e are rounded to the nearest whole number. Many values were less than 1 and were not included in the table Total CO_2e was calculated using decimals and unlisted values less than 1.

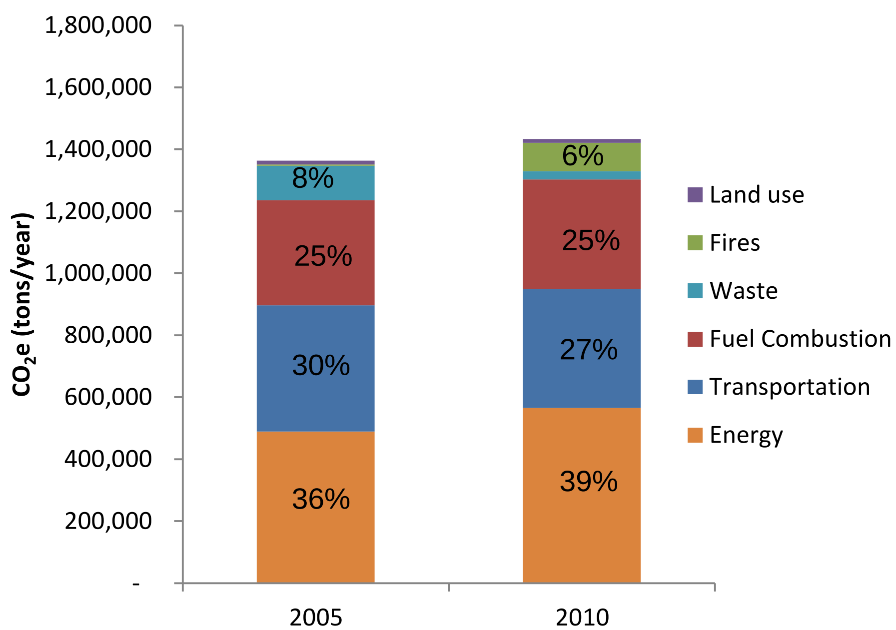

Figure 1-2. Basin-wide CO_2e emissions breakdown by source sector for 2005 and 2010.

In the remainder of this document, we further describe the data sources and methods used to develop GHG emissions estimates for the Lake Tahoe region for the baseline and future years. We also discuss the key findings and results of the emissions inventories for the baseline and future years, and present recommendations for improving these inventories.

2. Technical Approach

For the GHG inventory, emissions were calculated from emission factors and activity data. Emission factors represent the amount of a given pollutant emitted from a source per unit of activity (e.g., grams of CO_2 per gallon of fuel burned); for CO_2, emission factors are derived from the characteristics of the fuel combusted. For a given fuel, a CO_2 emission factor is calculated using the fuel's carbon coefficient and heat content and an oxidation factor that accounts for the fraction of carbon that may not be oxidized during combustion, information that is readily available from GHG reporting protocols (California Climate Action Registry, 2008).

Activity data represent the intensity of an emissions-producing activity or process (e.g., fuel consumption or product output). For the Tahoe Basin GHG inventory, activity data was collected for the source sectors listed in Table 1-1. Required activity data for the Basin include annual vehicle miles traveled (VMT), electricity consumption in megawatt-hours (MWh), total fuel consumption by residences and businesses (wood, natural gas, etc.), and prescribed burning acreages.

The following sections summarize the technical approach used to estimate GHG emissions for each source category in the baseline inventories, as well as the methods used to project the baseline emissions to 2020 and 2035. More detailed information on the emission factors and activity data used to estimate GHG emissions for each category is provided in **Appendix A**.

2.1 Source Categories

2.1.1 On-Road Motor Vehicles

CO_2 emissions, which represent the majority of GHG emissions from motor vehicles, are directly related to the quantity of fuel combusted. For a regional inventory, it is very difficult to convert available fuel sales data into estimates of fuel consumed within the study area. First, fuel sales are typically tracked at the state or county level and are not readily apportioned to sub-county areas like those in the Basin. Also, fuel sold within the Basin is consumed in areas outside the Basin, just as fuel sold outside the Basin is consumed within the Basin. Therefore, the preferred approach is to develop VMT estimates from available traffic counts and travel demand model outputs and convert those VMT data to fuel consumption using fuel economy estimates for vehicles in the region of interest.[5] In addition, VMT data are required to estimate CH_4 and nitrous oxide (N_2O) emissions from motor vehicles; these emissions depend on vehicle control technologies and are therefore based on vehicle characteristics and distance traveled (California Climate Action Registry, 2008).

Vehicle activity data was available from TRPA's TransCAD travel demand model (see **Figure 2-1** for network coverage). TransCAD is a geographic information system (GIS)-based traffic model for which development began in 2004. For the Basin, TransCAD was informed by

[5] For CO_2 emissions calculations, VMT data were converted to fuel consumption estimates using vehicle classifications and fuel economy data from the California Air Resources Board's (ARB's) EMFAC2011 on-road mobile source emissions model (see Appendix A).

a travel survey that collected data from over 1,200 households (Tahoe Regional Planning Agency, 2008). To calculate GHG emissions, VMT outputs from TransCAD must be classified by the following vehicle trip types:

- Internal: trips begin and end within the Basin.
- Internal-external: trips begin in the Basin and end outside the Basin, or vice versa.
- External-external: trips begin and end outside the Basin (i.e., pass-through trips).

The requirement to classify the VMT outputs is driven by SB 375, which requires local planning agencies to meet regional GHG reduction targets through integrated land use and transportation planning. According to SB 375 guidance documents, VMT totals for estimating GHG emissions in a given region should include all internal trips, half of the internal-external trips, and none of the external-external trips (Regional Targets Advisory Committee, 2009). For the base years, this formula results in GHG VMT estimates for the basin of 1,539,088 miles per day for 2005 and 1,459,299 miles per day for 2010.[6]

These VMT data were converted to fuel consumption estimates using fuel economy data derived from the California Air Resources Board's (ARB) EMFAC2007 model.[7] The resulting fuel consumption estimates were combined with CO_2 emission factors to estimate CO_2 emissions. For CH_4 and N_2O, VMT data were combined directly with emission factors to estimate emissions. Emissions were allocated to various jurisdictions within the Basin (i.e., counties and the City of South Lake Tahoe) based on the distribution of VMT data across TRPA's transportation network. Additional details on these calculation steps are provided in Appendix A.

[6] Total VMT for the Basin, including external-external trips, is summarized in Appendix A.

[7] These methods, including the use of EMFAC2007, are consistent with the approach used to estimate GHG emissions from on-road vehicles for the Final Environmental Impact Statement (FEIS) prepared for the Lake Tahoe Regional Plan Update (Ascent Environmental, 2012). We compared the on-road GHG estimates in Table 1-2 against the values reported in Table 3.5-3 of the FEIS and verified that 2010 Basin-wide estimates were consistent in both inventories. For 2005, the FEIS reported only on-road GHG emissions for vehicles subject to SB 375 regulations (i.e., automobiles and light trucks on the California side of the basin), so this estimate is not directly comparable to Table 1-2.

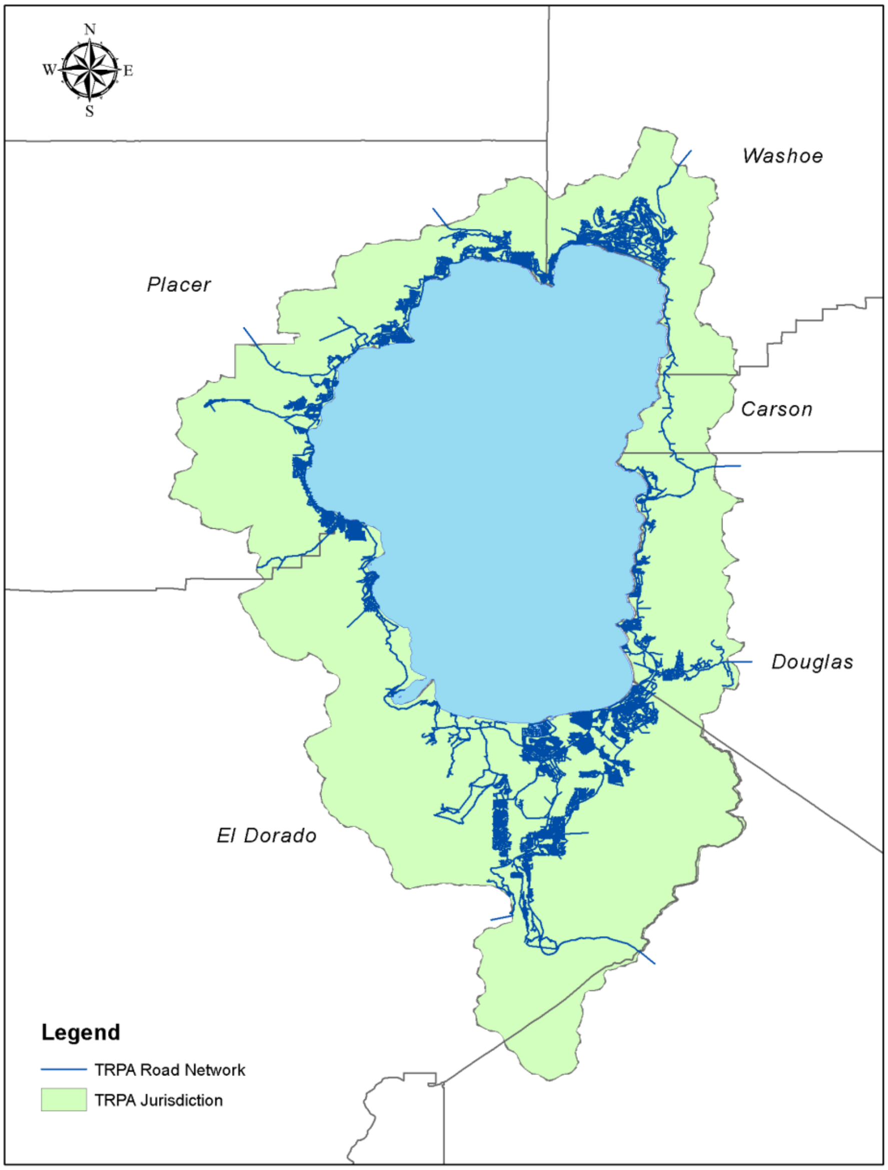

Figure 2-1. TRPA road network.

2.1.2 Recreational Boats

For recreational boats operating in Lake Tahoe, baseline emissions were estimated using fuel consumption activity from TRPA and relevant emission factors from the California Climate Action Registry's general and local reporting protocols (California Climate Action Registry, 2008; California Air Resources Board et al., 2010). TRPA developed estimates of annual launches, fuel consumption, and emissions as part of the development of an environmental impact statement (EIS) for the Lake Tahoe Shorezone (Tahoe Regional Planning Agency, 2006). These estimates included fuel use and hours of operation estimates for recreational boats for 2004 and 2010 (2005 was estimated by interpolating between 2004 and 2010), as well as activity forecast data for various scenarios for 2014 and 2027. Fuel consumption estimates were summed by engine type and fuel type (gasoline and diesel) and then multiplied by appropriate emissions factors.

The Basin-wide emissions for recreational boats were allocated to the county and city level using boat launch locations provided in the Shorezone study (see **Table 2-1**). The Shoreline study provided a list of existing marinas and boat ramps in the Basin and each marina was assigned to the appropriate county.

Table 2-1. County-level locations of boat launches.

<table>
<tr><th>County</th><th>% of Total Launches</th><th>Lake Area (km^2)[1]</th><th>% of Total Area[a]</th></tr>
<tr><td>El Dorado</td><td>10%</td><td rowspan="2">142.57</td><td rowspan="2">31%</td></tr>
<tr><td>South Lake Tahoe</td><td>22%</td></tr>
<tr><td>Placer</td><td>36%</td><td>203.49</td><td>44%</td></tr>
<tr><td>Douglas</td><td>18%</td><td>65.53</td><td>14%</td></tr>
<tr><td>Washoe</td><td>14%</td><td>54.65</td><td>12%</td></tr>
</table>

[a] Note that the lake area and percentage of total area values were not used in the GHG emissions estimation process and are shown here only as a point of comparison with the percentage of total launches by county and city.

2.1.3 Aircraft (Indirect)

Aircraft emissions were estimated for the Lake Tahoe airport using fuel data collected for 2010 and fuel combustion emissions factors from the California Climate Action Registry's general reporting protocol (California Climate Action Registry, 2008). Fuel consumption for jet fuel and aviation gasoline was provided by the airport's fuel vendor for 2009 and 2010 (Golden, 2011). In 2005, the airport used a different fuel vendor and the fuel consumption data were unavailable; therefore, 2005 fuel consumption was estimated by scaling the 2010 fuel consumption using airport traffic activity from the Federal Aviation Administration (FAA)[8].

Since the airport lies in the jurisdiction of the City of South Lake Tahoe, all emissions from the airport were geographically allocated to South Lake Tahoe/El Dorado County (see **Figure 2-2**).

[8] Airport traffic activity data available from the FAA website (http://aspm.faa.gov/main/taf.asp).

Figure 2-2. Location of the Lake Tahoe Airport.

2.1.4 Other Off-Road Equipment

Emissions for all other off-road equipment were estimated using emissions and fuel consumption output from ARB's OFFROAD2007 model. The OFFROAD2007 model addresses a wide variety of off-road equipment types, including recreational vehicles, lawn and garden equipment, and construction equipment. The model relies on county-level equipment populations and activity data (e.g., annual hours of operation) to estimate emissions and fuel consumption. we used the model to estimate emissions for off-road equipment in the California portion of the Basin, except for off-road sources for which more refined local estimates are available (e.g., recreational boats). In keeping with previous emissions inventory development for the Basin conducted by the Desert Research Institute (DRI) (Gertler et al., 2008), emissions for the California side were scaled up to account for the Nevada side of the Basin using the ratio of Basin-wide population for California and Nevada to the population of the California side of the Basin only. This step was performed to provide a complete inventory that includes both the California and Nevada sides of the Basin.

2.1.5 Wood Combustion

Wood fuel combustion was calculated using wood burning activity estimates from a local wood burning survey, the number of Basin-wide households and visitors, and emission factors from the California Climate Action Registry's general reporting protocol (California Climate Action Registry, 2008). TRPA and researchers from the University of California, Riverside (UCR) conducted wood burning surveys in 2002, collecting information on residential wood combustion during winter months and campfire wood combustion during summer months (Fitz and Lents, 2004). UCR researchers used results of these surveys to estimate the distribution of wood-burning appliances (e.g., woodstove, fireplace with insert, fireplace without insert, and pellet stove) in the region, the type of wood burned (hardwood versus softwood), and the average quantity of wood burned per day. In 2004, the UCR results were revisited and updated by researchers at DRI as part of the development of an improved particulate matter (PM) emissions inventory for the Tahoe Region (Kuhns et al., 2004).

These updated activity data for 2004 were used to represent 2005 activity levels for wood combustion. To account for changes in activity levels between 2005 and 2010, the 2004 wood combustion data were adjusted based on the change in total households between 2004 and 2010. The resulting emission estimates derived from these activity data were allocated to jurisdictions across the Basin using census data[9] (U.S. Census Bureau, 2000) representing the number of households that use wood as their primary home heating source (see **Table 2-2**).

Table 2-2. Households in the Basin that use wood as their primary home heating source (from the 2000 U.S. Census).

County	Households	Percentage
El Dorado County (including South Lake Tahoe)	503	50%
Placer	403	40%
Douglas	68	7%
Washoe	35	3%
Basin Total	**1,009**	**100%**

2.1.6 Natural Gas Fuel Combustion

Natural gas fuel combustion emissions were calculated using fuel consumption activity from local utilities and emission factors from the California Climate Action Registry's general reporting protocol (California Climate Action Registry, 2008). We acquired 2005 and 2010 activity data for total fuel consumption from the local utilities.[10]

- For most of the Basin, Southwest Gas, the primary provider of natural gas to residential and commercial customers, provided activity data for total consumption for residential and commercial gas use.
- For areas not covered by Southwest Gas data (i.e., the unincorporated portion of El Dorado County) residential natural gas consumption rates derived from the Southwest Gas data were applied to the number of households in these areas to estimate residential fuel usage.

[9] Note that the American Community Survey (ACS) conducted by the U.S. Census Bureau also contains information on household fuel types, but fewer households are sampled during this survey than during the full census. However, geographic distributions between the ACS data and the full census are very similar.
[10] Southwest Gas provides service to Placer, Washoe, and Douglas counties, as well as the City of South Lake Tahoe. Pacific Gas and Electric (PG&E) serves the unincorporated areas of El Dorado County.

- For the unincorporated portion of El Dorado County, commercial fuel use was derived based on the ratio of residential to commercial usage from the data provided by Southwest Gas. This step was required because PG&E did not provide activity data for this portion of El Dorado County in time for use in this inventory.

Figure 2-3 provides a summary of natural gas usage (in million metric British Thermal Units [MMBtu]) for 2005 and 2010 for the Basin.

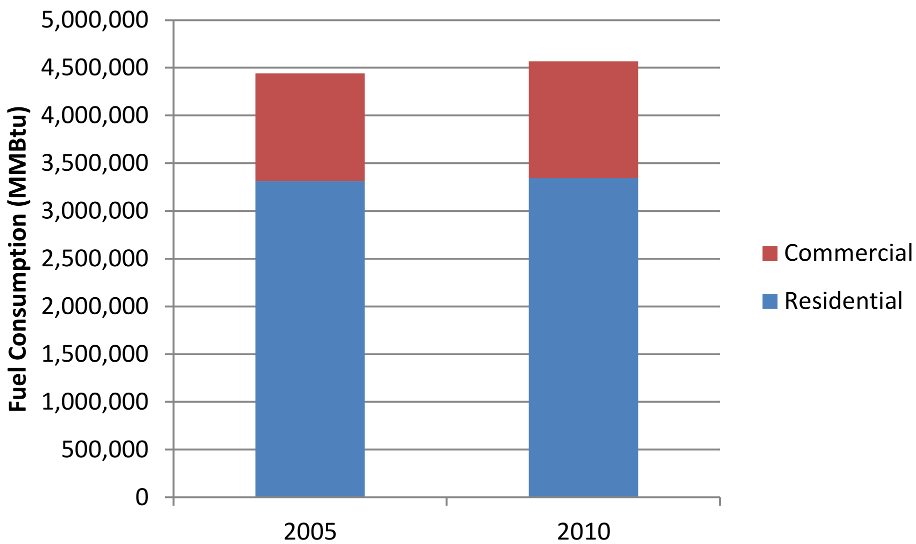

Figure 2-3. Basin-wide natural gas usage for residential and commercial use.

2.1.7 Other Fuel Combustion

Emissions from the combustion of propane (liquefied petroleum gas [LPG]) and distillate oil were calculated based on (1) number of households using these fuels for home heating and (2) emission factors from the California Climate Action Registry's general reporting protocol (California Climate Action Registry, 2008). Since propane is an unregulated fuel in California, no data are collected on sales or usage. In a guidance document for regional GHG inventories, EPA recommends that, in the absence of detailed consumption data, consumption be estimated based on the number of heating degree days (HDDs)[11] in the region for the year of interest, the number of households using LPG as heating fuel, and an average household consumption rate of 11,647 British Thermal Units (Btu per HDD (U.S. Environmental Protection Agency, 2009). We applied this methodology using census data on home heating fuels and annual average heating degree day values for 2005 and 2010 from the Western Regional Climate Center (Western Regional Climate Center, 2012).

[11] HDDs provide a representation of how cold a region's average temperature was over some period of interest and are calculated as the difference between a day's average temperature and some base temperature (e.g., 65° F).

Resulting emissions estimates were assigned to geographic jurisdictions based on census-tract-level information on the number of households using propane or distillate oil as their primary home heating fuel (see Appendix A).

2.1.8 Wildfires and Prescribed Burns

Emissions from wildfires and prescribed burns are a function of the type and amount of vegetation consumed by each fire event. Previously, STI generated a national inventory of CO_2 emissions from fires using the BlueSky Smoke Modeling Framework, a system developed by STI and the USDA Forest Service (Raffuse et al., 2008). The BlueSky system reconciles satellite fire detections with ground-based reports to estimate the area burned by each fire event, then uses detailed land cover data, fuel consumption algorithms, and emission factors to calculate the type and amount of vegetation burned and the resulting emissions. The BlueSky system includes the SmartFire model (Raffuse et al., 2009), a geospatial processing tool that aggregates and reconciles information about when and where fires occur.

In addition, the California Department of Forestry and Fire Protection (CalFire) maintains a GIS database of fire history as part of its Fire and Resource Assessment Program (FRAP). The CalFire data is available for years back to 1990 and were used to verify BlueSky data and evaluate fire trends.

The BlueSky/SmartFire system was the most complete data set available (i.e., it includes fires not included in the CalFire database) and was used to develop activity data for 2005 and 2010 for major wildfires and large prescribed burns. For smaller prescribed fires (e.g., pile burns) that are not captured by SmartFire, activity data were derived from the Lake Tahoe Fuel Reduction Plan (USDA Forest Service, 2007) and other sources that describe forest management and fire activities in the Basin. Those sources include the Lake Tahoe Basin Management Unit of the United States Department of Agriculture (USDA) Forest Service website (USDA Forest Service, 2012) and local newspaper articles (Osborn, 2012).

These data indicate that wildfire and prescribed burning activities vary greatly from year to year within the Basin, as shown in **Figure 2-4**. Between 2001 and 2010, according to CalFire, all prescribed burning activities occurred in 2006, while wildfires predominantly occurred in 2007. For 2005, activity data was low since there were no wildfires and less prescribed burning. For 2010, fire activity was higher since there was a recorded wildfire and increased prescribed burning.

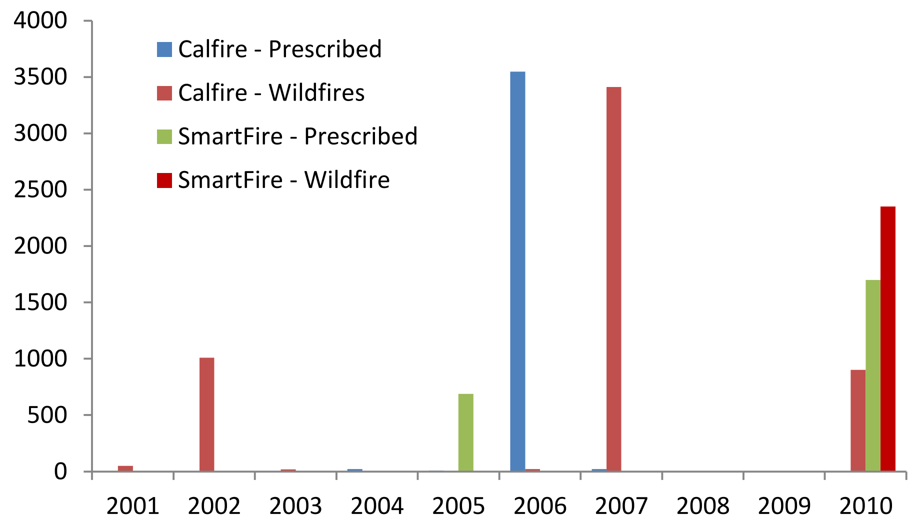

Figure 2-4. Summary of acres burned by wildfire and prescribed burns in the Lake Tahoe Basin, 2001–2010.

2.1.9 Livestock

Emissions from livestock were based on ARB estimates of animal populations in the Basin and emission factors for each animal type from EPA GHG guidance documents (U.S. Environmental Protection Agency, 2009). ARB produces refined livestock population estimates by county and air basin (Reid et al., 2008). These estimates combine statewide summaries of livestock populations from the annual Agricultural Resource Directory for dairy and beef cows published by the California Department of Food and Agriculture and the Agricultural Census developed by the USDA, providing populations for other animal types (e.g., swine, sheep, horses, and goats). The most recent population numbers (which are from 2003) were downloaded from ARB's website. These numbers were held as being constant for 2005 and 2010.

2.1.10 Solid Waste (Indirect)

GHG emissions from solid waste are a result of methane generation from the anaerobic decomposition of organic wastes deposited in a landfill. Because of this process, emission rates are a function of the amount of waste generated and type of waste generated (e.g., paper products, food waste, plant debris, wood/textiles) within the region of interest. In addition, methane recovery systems at regional landfills must be taken into account where applicable.

Because emissions from landfills continue for many years after waste disposal, two methods exist for estimating GHG emissions from this source. The Waste-in-Place method quantifies the annual amount of methane emitted by a given landfill, regardless of when the waste was disposed. The Methane Commitment method calculates emissions resulting from waste disposed in a given year, regardless of when the emissions occur. The former method requires historical waste disposal information and is not sensitive to source reduction or recycling activities. Moreover, waste from the Tahoe Basin is sent to Lockwood Regional

Landfill in Storey County, Nevada, so the actual methane emissions are occurring outside the Basin at a facility that Basin agencies have no direct control over. Therefore, the Methane Commitment method was used to estimate emissions for waste generated in the Basin during 2005 and 2010, and these emissions are treated as an indirect source in the inventory.

Emissions estimates for solid waste were calculated using data on solid waste generation from local utilities (South Tahoe Refuse and Tahoe Truckee Sierra Disposal) and the solid waste module in the International Council for Local Environmental Initiative's (ICLEI) Clean Air and Climate Protection (CACP) software. The CACP solid waste module is based on EPA's Waste Reduction Model (WARM); it calculates methane emissions based on the amount and type of waste generated in a given year and the capture efficiency of the methane recovery system at the landfill in question.

For the Basin, 165,460 tons of solid waste were generated in 2005 and 159,915 tons were generated in 2010. These totals were broken down into waste types (e.g., paper, food, etc.) using waste composition percentages developed by the California Integrated Waste Management Board (CalRecycle) (Cascadia Consulting Group, 2009). Because Lockwood Landfill did not have a methane recovery system prior to 2009 (Ling-Barnes, 2010), emissions estimates for 2005 (110,512 tons of CO_2e) are much higher than for 2010 (26,704 tons of CO_2e) (see **Figure 2-5**).

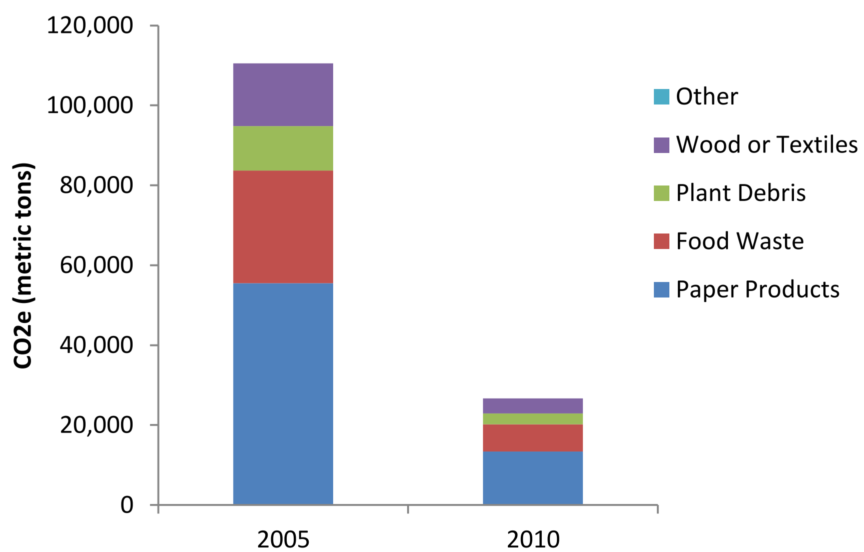

Figure 2-5. CO_2e emissions by type of waste for 2005 and 2010.

2.1.11 Wastewater Treatment

Three wastewater treatment plants currently operate in the Basin. They are managed by the South Lake Tahoe Public Utilities District, Douglas County Sewer Improvement District #1, and Incline Village General Improvement District (see **Figure 2-6**). In addition, a portion of the wastewater from Tahoe's north shore is sent to a treatment plant in Truckee operated by the

Tahoe-Truckee Sanitation Agency. these facilities we contacted and provided information on annual wastewater throughput, wastewater treatment methods, and any control systems for methane that may be in use.

The wastewater treatment method is an important consideration, as anaerobic methods rely on bacterial processes that are carried out in the absence of oxygen and produce methane emissions. On the other hand, aerobic treatment systems, which are generally used at smaller-scale facilities, do not produce methane emissions and produce only small amounts of nitrous oxide (N_2O) emissions. We found that all four facilities identified above treat their wastewater aerobically; therefore no methane emissions are produced at these facilities. For N_2O, emissions were calculated using a population-based method from the Intergovernmental Panel on Climate Change (IPCC) guidance (2006).

To estimate direct GHG emissions for the three facilities in the Basin, emissions were assigned to each facility based on the population of the area it serves (see Figure 2-6). For the Truckee facility, which lies outside the Tahoe Basin, a portion of: (1) N_2O emissions; and (2) GHG emissions resulting from electricity consumption at that facility were treated as indirect sources for the Basin-wide inventory. The portion of the Truckee facility's emissions included as an indirect source in the inventory was based on the percentage of the facility's annual waste that comes from the Basin (35%). This percentage and annual electricity consumption at the Truckee treatment plant were obtained from staff at that facility.

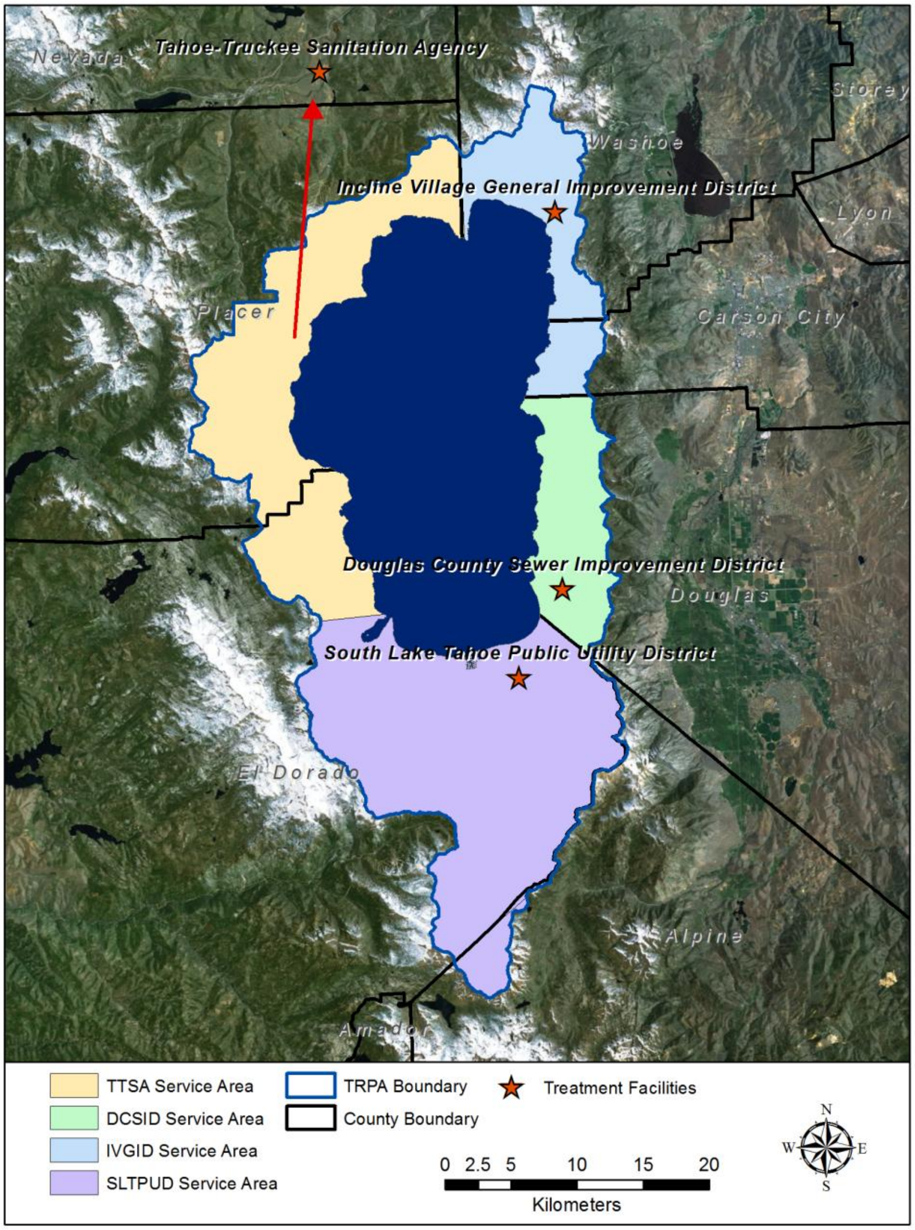

Figure 2-6. Locations of wastewater treatment plants that service the Basin.

2.1.12 Electricity Consumption (Indirect)

Emissions from electricity consumption were calculated using activity information from local utilities (Nevada Energy and Liberty Energy) and emission factors from local utilities and the California Climate Action Registry's general reporting protocol (California Climate Action Registry, 2008). Electricity consumption data was acquired (in megawatt-hours [MWh]) for commercial, government, and residential activity from Liberty Energy, which services the California side of the Basin, and residential and commercial activity from Nevada Energy, which services the Nevada side of the Basin. **Figure 2-7** summarizes the total energy consumption by county and type. To reflect the mix of fuels used to generate the electricity, the utilities provided emission factors for 2005 and 2010 for CO_2.[12] For methane and nitrous oxide, emissions factors from the California protocol were used.

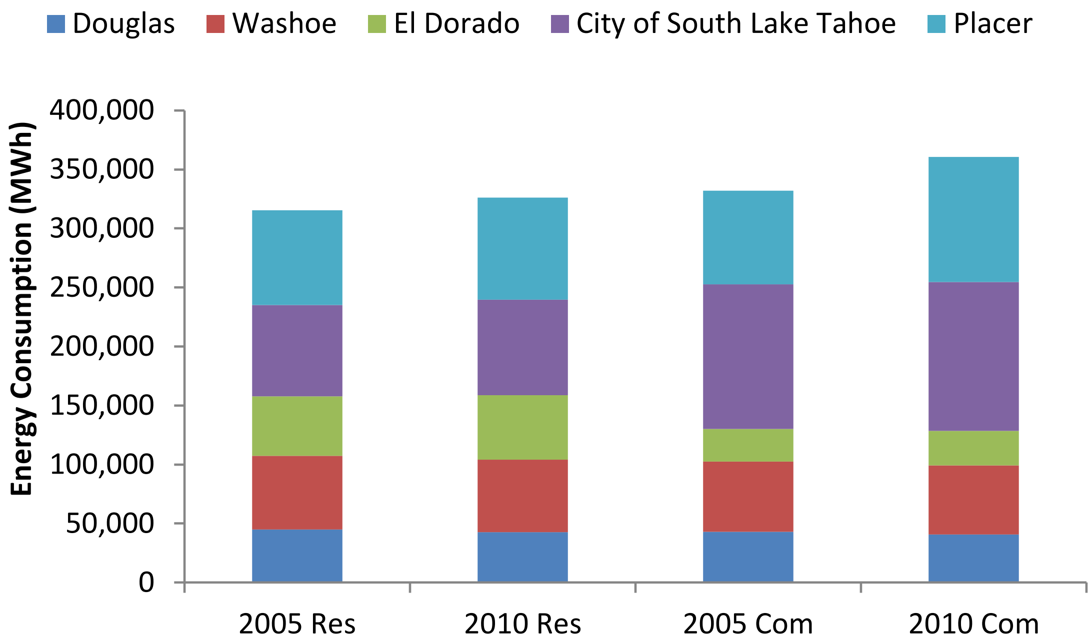

Figure 2-7. Commercial and residential energy consumption (MWh) in 2005 and 2010 for the Basin (provided by Liberty Energy and Nevada Energy).

2.1.13 Forestry Carbon Stocks

Removal of CO_2 from the atmosphere by forests can represent a significant emissions sink for heavily-forested regions like the Tahoe Basin. According to EPA estimates, forests sequestered the equivalent of 10.6% of nationwide GHG emissions in 2006; however, the amount of carbon sequestered by forests at a regional level can vary greatly depending on the mix of tree species in the region (U.S. Environmental Protection Agency, 2009). In addition, protocols have been developed for assessing the impact of forestry projects (e.g., reforestation, improved forest management) on net GHG emissions. Recommended methods include procedures for assessing the risk that carbon sequestered by a project may be released back into the atmosphere within a defined timeframe (Climate Action Reserve, 2010).

Because the Lake Tahoe region is heavily forested, we developed estimates of baseline carbon stocks associated with forested lands. These baseline values can be used to develop future carbon sequestration estimates associated with any changes to forest management practices in the region. To develop these baseline estimates, we relied on the Carbon Online

[12] Emission rates depend on the electricity generation methods (e.g., natural gas combustion, renewables, etc.); the mix of methods can change over time.

Estimator v2 (COLE2) database, which is maintained by the Forest Inventory and Analysis (FIA) program as a record of the health of forests in the United States.

The number and size of the trees in various forests are recorded into the COLE2 database by manual surveys of the forests. Due to resource limitations, these plots are usually subdivided and only a portion of the plot is surveyed during a select year; then the data for that parcel are used to estimate the carbon stock of rest of the plot. For the next year, another portion of the plot may be estimated and those results are used to make a new estimate of the carbon stock for the plot (which could vary significantly from the previous year due to fires or other activity in the plot).

Because of this process, the tree carbon data for plots in the Basin obtained from the COLE2 database were averaged over a 10-year period to create a single baseline scenario. The tree carbon data were converted to CO_2 stock in metric tons by multiplying total carbon by 3.76, which is the ratio of the molar weight of CO_2 to the molar weigh of carbon. **Table 2-3** summarizes the 10-year average tree carbon (metric tons) and resulting CO_2 (metric tons) for the Basin by geographical jurisdictions.

Table 2-3. Ten-year average tree carbon (metric tons) and CO_2 (metric tons) for the Basin.

Region	Tree Carbon	10-Year Average
Carson	32,777	123,242
Douglas	117,240	440,822
Washoe	2,422	9,107
El Dorado (unincorporated)	392,749	1,476,736
South Lake Tahoe	-	-
Placer	138,246	519,805
Nevada Total	152,439	573,171
California Total	530,995	1,996,541
Basin Total	**683,434**	**2,569,712**

2.2 Forecasting GHG Emissions

GHG emissions inventories for 2020 and 2035 were developed using the Tahoe Metropolitan Planning Organization (TMPO) alternative growth scenarios for the Basin from the draft Regional Transportation Plan (RTP) 2035 (Tahoe Metropolitan Planning Organization, 2012a) and draft EIS for 2035 (Tahoe Metropolitan Planning Organization, 2012b). The RTP integrates land use and transportation strategies to allow the Basin to achieve targets for reducing GHG emissions by 2035. The TMPO report provides projections of 2020 and 2035 Basin-wide and statewide population (see **Table 2-4**), employment (see **Table 2-5**), and VMT (see **Table 2-6**) totals for each of the following five alternatives:

- Alternative 1 – No Project, which represents the business-as-usual (BAU) case
- Alternative 2 – Low Development, Increased Regulation
- Alternative 3 – Low Development, Highly Incentivized Redevelopment
- Alternative 4 – Reduced Development, Incentivized Redevelopment
- Alternative 5 – Rate of Development and Regulatory Structure Similar to 1987 Regional Plan

Table 2-4. Population by TMPO alternative growth scenario for 2020 and 2035.

Region	2020					2035				
	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
California	41,709	42,735	43,934	43,737	44,277	42,005	44,102	45,468	45,950	44,227
Nevada	13,423	13,475	14,115	13,582	13,619	13,682	13,711	14,897	13,823	15,725
Total	**55,132**	**56,210**	**58,049**	**57,319**	**57,896**	**55,687**	**57,813**	**60,365**	**59,773**	**59,952**

Table 2-5. Employment by TMPO alternative growth scenario for 2020 and 2035.

Region	2020					2035				
	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
California	12,365	12,674	12,587	12,933	13,127	12,723	12,946	12,946	13,170	13,393
Nevada	10,370	10,630	10,556	10,847	11,010	10,670	10,858	10,858	11,045	11,233
Total	**22,735**	**23,304**	**23,143**	**23,780**	**24,137**	**23,393**	**23,804**	**23,804**	**24,215**	**24,626**

Table 2-6. VMT to calculate GHG emissions[13] and total Basin VMT by TMPO alternative growth scenario for 2020 and 2035.

Region	2020				
	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
California	928,908	944,010	925,150	963,786	981,457
Nevada	448,828	443,676	450,370	463,344	472,743
GHG Total	**1,377,736**	**1,387,686**	**1,375,520**	**1,427,130**	**1,454,200**
Basin Total	2,015,976	1,990,698	2,033,362	2,095,270	2,117,242
	2035				
California	989,899	1,004,890	1,017,955	1,068,686	1,095,393
Nevada	580,555	547,780	567,380	581,888	604,996
GHG Total	**1,570,454**	**1,552,670**	**1,585,335**	**1,650,574**	**1,700,389**
Basin Total	2,141,100	2,094,300	2,131,000	2,244,800	2,321,100

[13] VMT used to calculate GHG emissions include VMT from internal-internal trips and half of the VMT from internal-external trips.

In order to estimate future-year emissions, some source category activity data or emissions are forecasted using other socioeconomic categories (households and visitors). The socioeconomic categories were developed from the 2005 baseline estimates and were grown to future-year estimates using population growth rates for each of the five alternatives (see **Tables 2-7 and 2-8**).

Table 2-7. Households by TMPO alternative growth scenario for 2020 and 2035.

Region	2020					2035				
	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
California	16,204	16,521	17,062	16,847	17,017	16,367	16,992	17,742	17,568	17,621
Nevada	6,033	6,151	6,353	6,273	6,336	6,094	6,327	6,606	6,541	6,561
Total	**22,238**	**22,673**	**23,414**	**23,120**	**23,353**	**22,462**	**23,319**	**24,348**	**24,110**	**24,182**

Table 2-8. Number of visitors by TMPO alternative growth scenario for 2020 and 2035.

Region	2020					2035				
	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
California	41,728	42,544	43,936	43,383	43,820	42,148	43,757	45,689	45,240	45,376
Nevada	15,948	16,259	16,791	16,580	16,747	16,108	16,723	17,461	17,290	17,342
Total	**57,675**	**58,803**	**60,727**	**59,963**	**60,567**	**58,256**	**60,480**	**63,150**	**62,531**	**62,718**

For most of the source sectors, TMPO-based socioeconomic data were used to forecast the activity data or emissions to 2020 and 2035. However, future-year emissions from aircraft and recreational boats were estimated using other sources of forecast data. For aircraft, the FAA provides estimates of future-year airport operations (number of flights) and this data was used to scale 2005 baseline emissions to 2020 and 2035. For recreational boating, the Lake Tahoe Shorezone study (Tahoe Regional Planning Agency, 2006) included boat trips and fuel consumption forecast for various Shorezone buildout alternatives for 2014. During discussions with the work group, it was decided to use the “no build” scenario, which uses existing Shorezone ordinances (adopted in 1987) and prohibits construction of Shorezone structures in prime fish habitat areas. The Shorezone study provided fuel use for 2004 and estimates for 2027. Fuel estimates were interpolated between these two years to provide estimates for 2020 and 2035, which were then used to estimate the emissions from recreational boating.

Table 2-9 lists each source category and corresponding growth activity used to develop the future-year emissions inventories. Note that for on-road mobile sources, future-year emissions estimates are impacted not only by changes in VMT, but also by changes to the vehicle fleet over time (e.g., improving fuel economy standards).

Table 2-9. Growth activity for each of the source sectors in the inventory.

Sector	Source Category	Growth Activity
Transportation	On-road mobile sources	TMPO VMT
	Recreational boats	Forecasted fuel use from the Shorezone study
	Other off-road equipment	Population and employment
	Aircraft	FAA forecast activity
Fuel combustion	Wood combustion	Household and visitor
	Natural gas combustion	Household and employment
	Other combustion	Household
Fires	Wildfires and prescribed burns	Average annual activity
Land use	Livestock	Held constant
Waste	Municipal solid waste	Population
	Wastewater treatment	Population
Energy	Electricity consumption	Household and employment
	Wastewater treatment	Population

3. Summary of Results

Greenhouse gas emissions inventory estimates were produced for the Lake Tahoe Basin for the base years of 2005 and 2010 and the future years of 2020 and 2035 (BAU and four additional growth scenarios). The results of the emissions inventories are presented by Basin (regional), state (CA and NV), and local government jurisdiction. Emissions totals for CO_2e are presented below and emission totals for CH_4 and N_2O are presented in **Appendix B**.

3.1 Baseline Basin-Wide Emissions

Basin-wide CO_2e totals by year and source sectors are shown in **Figure 3-1** and **Table 3-1**. In 2005, the direct and indirect emissions from the Basin amounted to approximately 1,363,000 metric tons of CO_2e, and total CO_2e emissions increased by about 5% in 2010 to 1,433,000 metric tons. For both years, the energy sector is the largest source of CO_2e emissions, accounting for 36% of total emissions in 2005 and 39% in 2010.

In addition, the top three source sectors (energy, transportation, and fuel combustion) account for 91% of total CO_2e emissions for 2005 and 2010. Transportation-related emissions decreased about 6% from 2005 to 2010 due to a decrease in Basin-wide VMT, while emissions from solid waste decreased by 76% over that timeframe due to the implementation of a methane recovery system at Lockwood Landfill in 2009. Due to an increased amount of prescribed burning and wildfires occurring in the Basin, emissions from fires increased by 21% between 2005 and 2010. As shown in Table 3-1, the California side of the Basin produces the majority of the GHG emissions, accounting for 69% and 73% of the total emissions for 2005 and 2010, respectively.

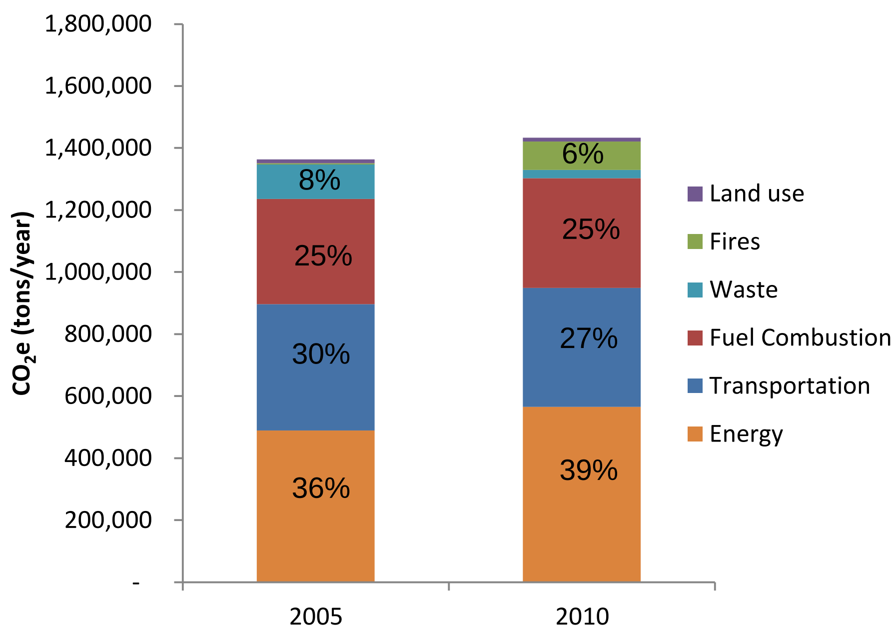

Figure 3-1. Baseline Basin-wide CO_2e emissions by source sector.

Table 3-1. Baseline CO_2e emissions (metric tons/year) by state and Basin-wide.

Type	Source Sector	Source Category	2005			2010		
			CA	NV	Basin	CA	NV	Basin
Direct	Transportation	On-road mobile sources	200,727	124,555	325,282	189,616	114,731	304,348
		Recreational boats	15,151	7,251	22,403	10,817	5,177	15,994
		Other off-road equipment	40,803	13,057	53,860	44,509	14,243	58,751
	Fuel combustion	Wood combustion	87,726	9,973	97,700	93,651	10,647	104,297
		Natural gas combustion	171,435	64,797	236,232	181,256	61,819	243,232
		Other combustion	3,970	1,888	5,858	4,317	1,844	6,161
	Fires	Wildfires and prescribed burns	3,083	1,201	4,284	79,650	12,002	91,652
	Land use	Livestock	12,734	-	12,734	12,734	-	12,734
	Waste	Wastewater treatment	39	18	57	44	18	62
Indirect	Energy	Electricity consumption	329,627	157,926	487,553	395,998	166,545	562,543
		Wastewater treatment	2,115	-	2,115	2,300	-	2,300
	Transportation	Aircraft	5,131	-	5,131	4,739	-	4,739
	Waste	Municipal solid waste	71,595	38,917	110,512	19,956	6,748	26,704
		Wastewater treatment	12	-	12	12	-	12
Total			**944,149**	**419,585**	**1,363,734**	**1,039,600**	**393,774**	**1,433,530**

3.2 Baseline Emissions by Geographic Jurisdiction

GHG emissions were estimated for the portion of the five counties (Placer, El Dorado, Washoe, Douglas, and Carson) that lie inside the TRPA jurisdiction, as well as the City of South Lake Tahoe. **Figures 3-2 and 3-3** and **Tables 3-2 and 3-3** show baseline emissions by source sector for each local government jurisdiction. Jurisdiction total emissions are also shown proportionally to each other, with the size of the "pie" representing the magnitude of emissions for a given area. For both years, the City of South Lake Tahoe accounts for about 29% of total emissions, followed closely by Placer County, which contributes about 24% to the overall inventory in both 2005 and 2010. Contributions to the baseline GHG inventories from unincorporated El Dorado County and Nevada counties range from 1% to 17%.

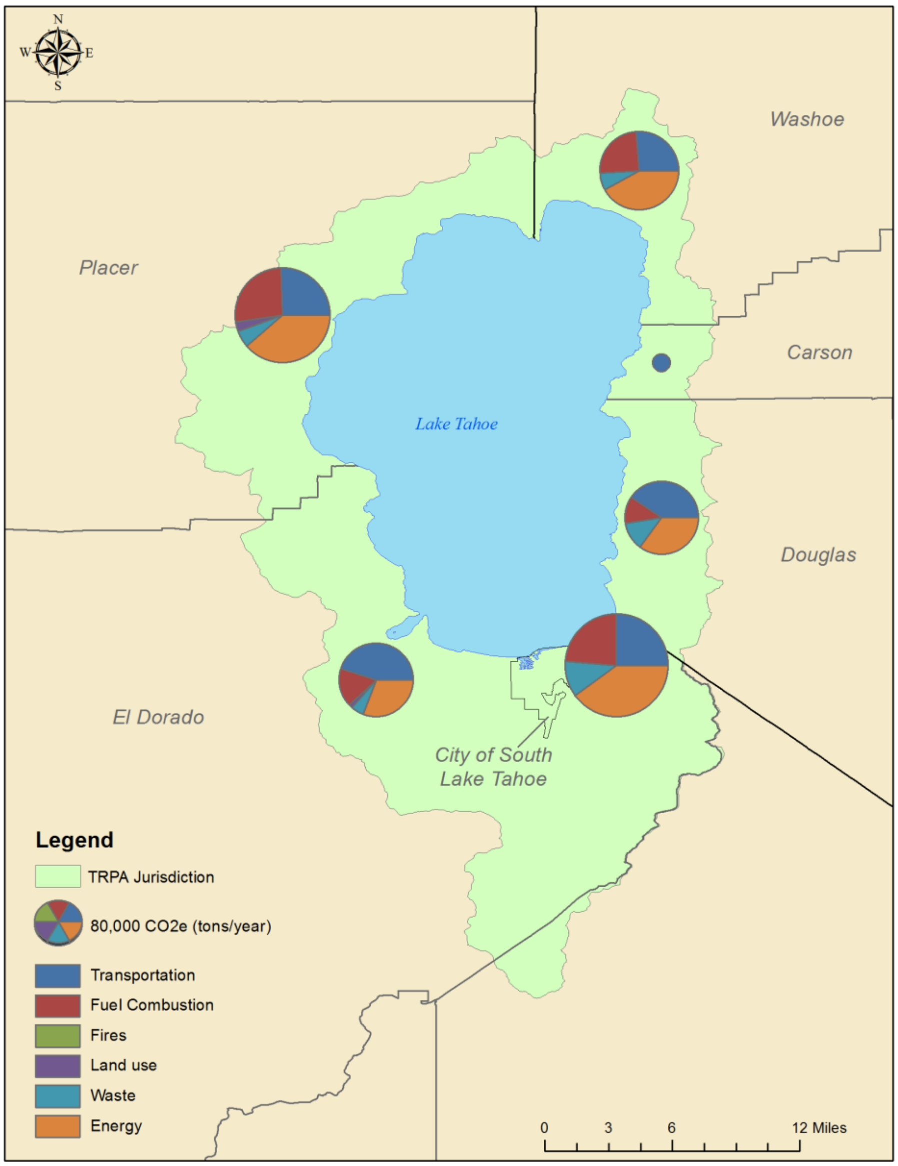

Figure 3-2. Baseline CO_2e emissions for 2005 by source sector and geographic jurisdiction (note that the size of each "pie" is proportional to the amount of total emissions).

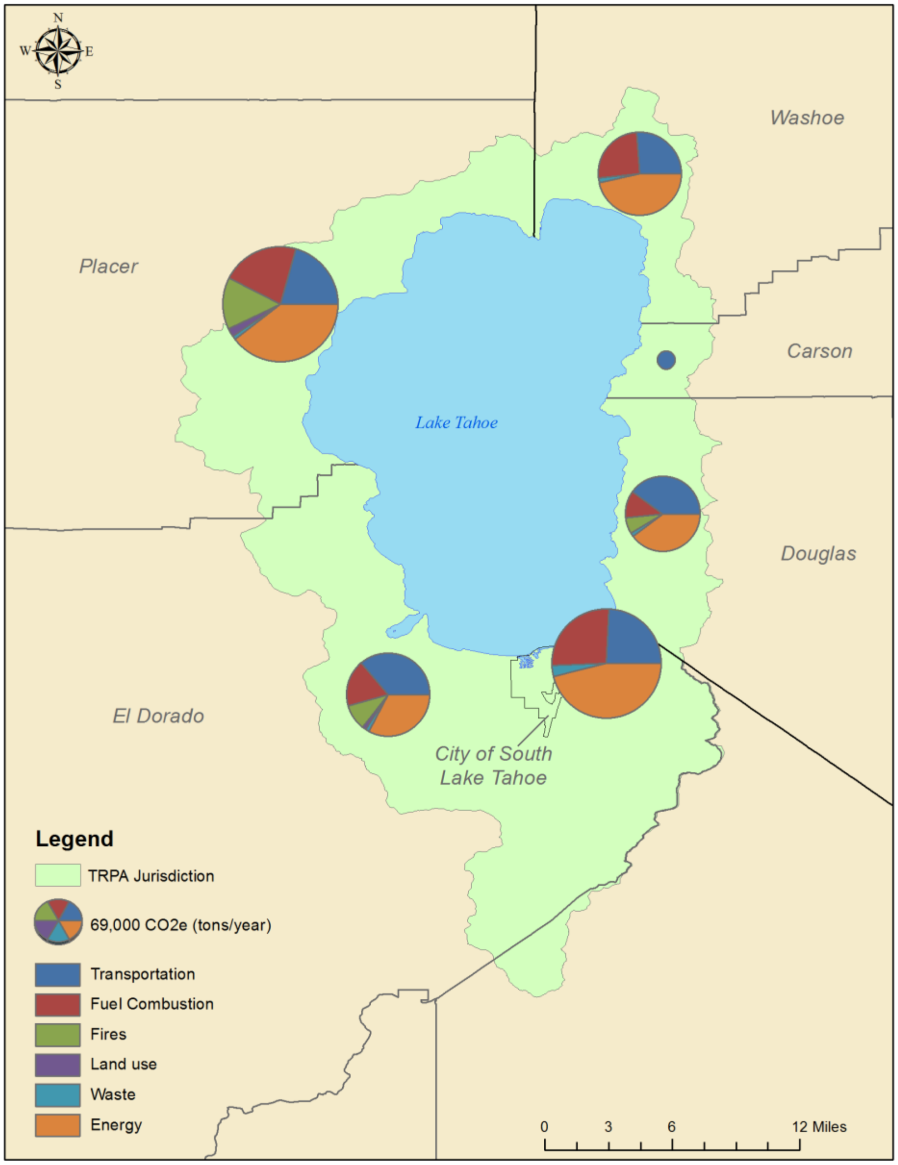

Figure 3-3. Baseline CO_2e emissions for 2010 by source sector and geographic jurisdiction (note that the size of each "pie" is proportional to the amount of total emissions).

Table 3-2. Baseline CO_2e emissions for 2005 by source sector and geographic jurisdiction.

Type	Source Sector	Source Category	Geographic Jurisdiction					
			Placer	El Dorado (unincorporated)	South Lake Tahoe	Washoe	Carson	Douglas
Direct	Transportation	On-road mobile sources	62,904	75,752	62,071	46,397	11,206	66,952
		Recreational boats	8,001	2,329	4,821	3,200	-	4,051
		Other off-road equipment	9,602	8,274	22,026	8,100	-	5,857
	Fuel combustion	Wood combustion	39,022	13,299	35,405	3,389	-	6,584
		Natural gas combustion	44,792	18,128	108,515	50,235	-	14,563
		Other combustion	1,073	747	2,150	418	-	1,470
	Fires	Wildfires and prescribed burns	1,345	1,738	-	-	-	1,201
	Land use	Livestock	9,809	2,925	-	-	-	-
	Waste	Wastewater Treatment	-	-	39	11	-	8
Indirect	Energy	Electricity consumption	120,258	58,922	150,447	91,652	-	66,274
		Wastewater treatment	2,115	-	-	-	-	-
	Transportation	Aircraft	-	-	5,131	-	-	-
	Waste	Municipal solid waste	18,251	10,838	42,506	15,397	-	23,520
		Wastewater treatment	12					
Total			**317,184**	**192,952**	**433,111**	**218,800**	**11,206**	**190,480**

Note: Blank cells in this table indicate that the given source category is not applicable to a specific jurisdiction. Population data for each jurisdiction can be found in Table A-1 of Appendix A.

Table 3-3. Baseline CO_2e emissions for 2010 by source sector and geographic jurisdiction.

Type	Source Sector	Source Category	Geographic Jurisdiction					
			Placer	El Dorado (unincorporated)	South Lake Tahoe	Washoe	Carson	Douglas
Direct	Transportation	On-road mobile sources	68,567	64,742	56,307	45,113	9,675	59,942
		Recreational boats	5,712	1,663	3,442	2,285	-	2,892
		Other off-road equipment	9,571	10,365	24,649	8,375	-	5,792
	Fuel combustion	Wood combustion	41,657	15,391	36,602	3,618	-	7,029
		Natural gas combustion	46,200	22,207	112,849	49,858	-	11,961
		Other combustion	1,046	911	2,361	423	-	1,421
	Fires	Wildfires and prescribed burns	58,372	21,278	-	-	-	12,002
	Land use	Livestock	9,809	2,925	-	-	-	-
	Waste	Wastewater treatment	-	-	44	11	-	7
Indirect	Energy	Electricity consumption	157,801	68,854	169,344	98,456	-	68,089
		Wastewater treatment	2,300	-	-	-	-	-
	Transportation	Aircraft	-	-	4,739	-	-	-
	Waste	Municipal solid waste	4,446	3,374	12,136	3,890	-	2,858
		Wastewater treatment	12					
Total			**405,493**	**211,710**	**422,473**	**212,028**	**9,675**	**171,994**

Note: Blank cells in this table indicate that the given source category is not applicable to a specific jurisdiction. Population data for each jurisdiction can be found in Table A-1 of Appendix A.

3.3 Future-Year Emissions

Future-year GHG emissions inventories were developed by projecting the 2005 baseline inventory using growth rates from each of the five TMPO growth alternatives for 2020 and 2035 (see **Figures 3-4 and 3-5**). For 2020, the GHG emissions inventory total CO_2e ranges from -2% to 3% higher than 2005 baseline totals; alternative 1 (BAU) projects the smallest increase in emissions and alternative 5 projects the largest increase in emissions. For 2035, the GHG emissions inventory total CO_2e ranges from 2% to 9% higher than 2005 baseline totals; as with the year 2020, alternative 1 (BAU) projects the smallest increase in emissions, with alternative 5 projecting the largest increase in emissions. The BAU scenario projects lower emissions because it extends the current plan, which relies on existing land use zoning and would authorize no additional development rights or allocations beyond those authorized in the 1987 RTP.

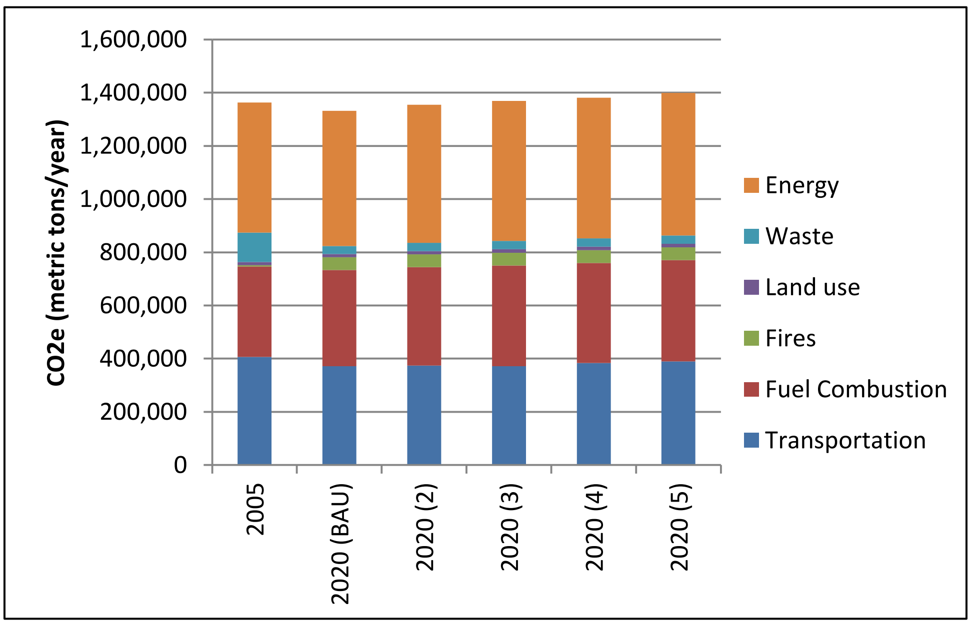

Figure 3-4. GHG CO_2e emissions by source sector for 2020 for each scenario.

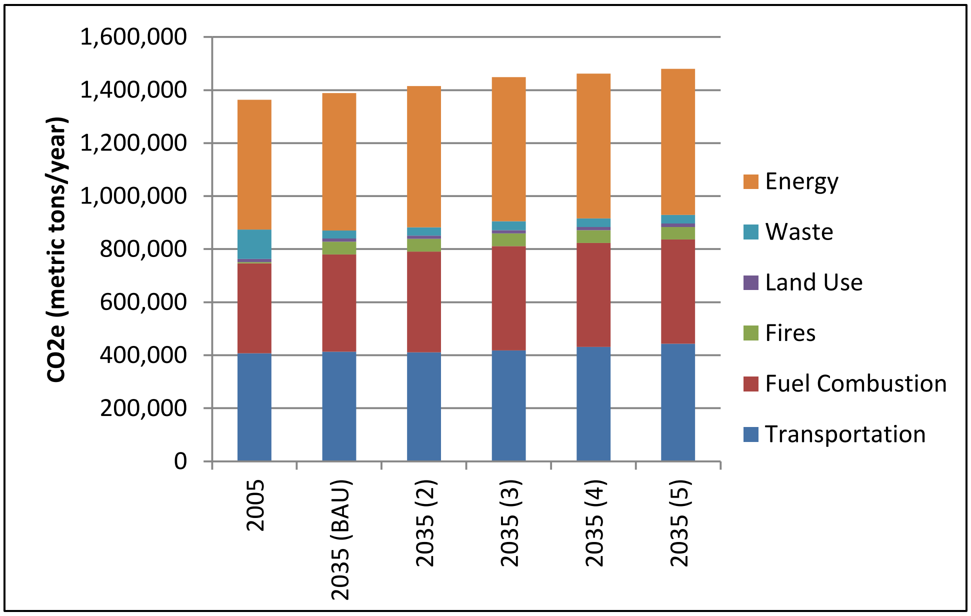

Figure 3-5. GHG CO_2e emissions by source sector for 2035 for each scenario.

Tables 3-4 and 3-5 summarize the Basin-wide 2020 and 2035 GHG emissions inventories for each source category by each of the five TMPO growth alternatives. Emissions from on-road mobile sources are lower than 2005 for all five of the growth scenarios (this is due to VMT totals that are lower in 2020 than in 2005). This decrease in emissions is consistent with TMPO's draft RTP and EIS (Tahoe Metropolitan Planning Organization, 2012a, b), which note the reduction of VMT from the TransCAD model outputs. For other source categories, average growth in CO_2e emissions from 2005 is 7% for 2020 and 10% for 2035.

Table 3-4. Future-year GHG emissions for 2020 by source category for each TMPO alternative.

Type	Sector	Category	2005	2020				
				Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Direct	Transportation	On-road mobile sources	325,282	281,319	283,351	280,867	291,405	296,932
		Recreational boats	22,403	29,834	29,834	29,834	29,834	29,834
		Other off-road equipment	53,860	54,458	55,798	55,583	56,934	57,591
	Fuel combustion	Wood combustion	97,700	105,431	107,397	110,752	109,420	110,522
		Natural gas combustion	236,232	250,520	255,749	261,663	260,838	263,776
		Other combustion	5,858	6,322	6,445	6,656	6,573	6,639
	Fires	Wildfires and prescribed burns	4,284	47,968	47,968	47,968	47,968	47,968
	Land use	Livestock	12,734	12,734	12,734	12,734	12,734	12,734
	Waste	Wastewater treatment	57	62	63	65	64	65
Indirect	Energy	Electricity consumption	487,553	505,661	516,913	523,698	527,289	533,887
		Wastewater treatment	2,115	2,282	2,327	2,403	2,373	2,397
		Aircraft	5,131	5,304	5,304	5,304	5,304	5,304
	Waste	Municipal solid waste	110,512	29,814	30,397	31,392	30,997	31,309
		Wastewater treatment	12	14	14	14	14	15
Total			**1,363,734**	**1,331,722**	**1,354,294**	**1,368,933**	**1,381,747**	**1,398,972**

Table 3-5. Future-year GHG emissions for 2035 by source category for each TMPO alternative.

Type	Sector	Category	2005	2035				
				Alt 1	Alt 2	Alt 3	Alt 4	Alt 5
Direct	Transportation	On-road mobile sources	325,282	315,870	312,293	318,863	331,985	342,004
		Recreational boats	22,403	35,767	35,767	35,767	35,767	35,767
		Other off-road equipment	53,860	55,785	56,849	57,038	57,902	58,823
	Fuel combustion	Wood combustion	97,700	106,492	110,370	115,026	113,946	114,272
		Natural gas combustion	236,232	254,181	262,605	271,406	270,456	272,165
		Other combustion	5,858	5,423	6,629	6,922	6,854	6,874
	Fires	Wildfires and prescribed burns	4,284	47,968	47,968	47,968	47,968	47,968
	Land use	Livestock	12,734	12,734	12,734	12,734	12,734	12,734
	Waste	Wastewater treatment	57	62	65	68	67	67
Indirect	Energy	Electricity consumption	487,553	515,457	529,849	541,715	543,470	548,809
		Wastewater treatment	2,115	2,305	2,393	2,499	2,474	2,482
		Aircraft	5,131	6,239	6,239	6,239	6,239	6,239
	Waste	Municipal solid waste	110,512	30,114	31,264	32,644	32,324	32,421
		Wastewater treatment	12	14	15	15	15	15
Total			**1,363,734**	**1,388,412**	**1,415,041**	**1,448,902**	**1,462,200**	**1,480,641**

4. Conclusions and Recommendations

To address a fundamental knowledge gap regarding direct and indirect GHG emissions in the Lake Tahoe region, we used regional GHG inventories for baseline years of 2005 and 2010 and future years of 2020 and 2035. Local activity data was collected to be used to estimate baseline emissions for various source sectors and forecasts data that could be used to project baseline estimates to the future years of interest. Key findings from the work are summarized below:

- Basin-wide CO_2e emissions total 1,363,734 metric tons in 2005, and these emissions increased by 5% to 1,433,374 metric tons in 2010.
- The energy sector (i.e., electricity usage) is the single largest source of GHG emissions in the Basin-wide inventories, accounting for 36% of total CO_2e emissions in 2005 and 39% in 2010.
- On-road motor vehicles are the second-largest source of CO_2e emissions in the Basin, accounting for 30% of total CO_2e emissions in 2005 and 27% in 2010.
- The top three sectors (energy, transportation, and fuel combustion) account for over 90% of CO_2e emissions in both 2005 and 2010.
- The California side of the Basin is responsible for 69% and 73% of the baseline emissions for 2005 and 2010, respectively. The City of South Lake Tahoe accounts for 32% of total emissions in 2005 and 30% of total emissions in 2010.
- GHG emission changes from 2005 to 2020 range from -2% to 3%, and changes from 2005 to 2035 range from 2% to 9%.
- Alternatives 1 and 2 have the lowest forecasted GHG emission levels for 2020 and 2035. Alternative 1, the BAU scenario, extends the current plan, relies on existing land use zoning, and would authorize no additional development rights or allocations beyond those authorized in the 1987 RTP.
- From 2005 to 2020, on-road mobile source emissions decreased by 9% to 14% across the various forecast scenarios. From 2005 to 2035, emissions decreased by 2% to 4% for scenarios 1 through 3, while emissions for scenarios 4 and 5 increased by 2% and 5% respectively.

These findings identify the major sources of GHG emissions within the Basin and provide a starting point for setting reduction targets and identifying potential mitigation strategies that can be implemented to meet those reduction targets in the future. Going forward, we offer the following recommendations for improving these inventories:

- As part of Mobility 2035, the Lake Tahoe Regional Transportation Plan Update, an integrated model that converts travel demand model output to EMFAC2011, is being developed. This model will produce CO_2 estimates for on-road mobile sources (Norberg, 2012). Results from this model should be compared to inventory results presented here to ensure the consistency of emission estimates for on-road mobile sources.

- For the baseline inventories, high-quality activity data for some categories were more readily available for the California side of the Basin than the Nevada side. For example, electricity consumption from Nevada Energy was only available at the regional (multi-county) level. As a result, improved Nevada data should be incorporated into inventory estimates should such data become available in the future.
- Fire activity in the Basin is highly variable from year-to-year. As a result, consideration should be given to developing a "typical year" baseline inventory that could be used for comparisons to emissions resulting from planned burning projected to occur in future years.
- Limited information is available on future-year prescribed burning plans and goals; therefore, baseline fire emissions were held constant for future years (based on the average emissions from 2005 and 2010). Better future-year estimates of fire emissions should be developed as information becomes available.

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Appendix A

Detailed Activity Data and Emissions Factors by Source Sector

This appendix provides detailed information on the activity data and emission factors that were used to calculate GHG emissions for each source category in the Tahoe Basin, as well as information on the data that were used to allocate Basin-wide emissions to individual jurisdictions (i.e., counties and the City of South Lake Tahoe).

A.1 Activity Data for Spatial Allocation

Table A-1 summarizes population, households, and employment for the Lake Tahoe Basin by geographic jurisdiction. These data were provided by TRPA for the base years of 2005 and 2010.

Table A-1. Population, households, and employment by region (provided by TRPA).

Region	Population		Households		Employment	
	2005	2010	2005	2010	2005	2010
Carson	0	0	0	0	0	0
Douglas	5,556	5,370	2,390	2,334	12,206	6,516
Washoe	7,684	7,765	3,201	3,262	5,031	3,795
El Dorado (unincorporated)	7,848	9,610	2,902	3,581	484	550
South Lake Tahoe	20,893	22,854	8,351	9,277	7,536	8,191
Placer	9,108	8,874	3,763	3,693	3,626	3,553
California	37,849	41,338	15,016	16,551	11,646	12,294
Nevada	13,240	13,135	5,591	5,596	17,237	10,311
Total	**51,089**	**54,473**	**20,607**	**22,147**	**28,883**	**22,605**

A.2 On-Road Mobile Sources

For on-road mobile sources, emissions were calculated using VMT data from TRPA's TransCAD travel demand model, fleet mix and fuel economy data from ARB's EMFAC2007 model, and emissions factors from the California Climate Action Registry's general reporting protocol (California Climate Action Registry, 2008) (see **Table A-2**). VMT data from TransCAD are not vehicle specific; therefore, output from the EMFAC2007 model was used to determine what fraction of the VMT is attributable to gasoline and diesel vehicles and also to determine the average fuel economy (miles per gallon) of gasoline and diesel vehicles.

Table A-2. Summary by year and fuel type of the fleet characteristics and corresponding emission factors for the Lake Tahoe Basin.

Year	Fuel Type	Fleet Characteristics		Emission Factors		
		VMT Fraction	MPG	CO_2 (metric tons / gallon)	CH_4 (metric tons / mile)	N_2O (metric tons / mile)
2005	Gasoline	0.95	16.7	0.00881	4.55×10^{-8}	5.56×10^{-8}
	Diesel	0.05	7.5	0.01015	3.57×10^{-9}	3.56×10^{-9}
2010	Gasoline	0.93	16.0	0.00881	4.55×10^{-8}	5.56×10^{-8}
	Diesel	0.07	9.8	0.01015	3.57×10^{-9}	3.56×10^{-9}
2020	Gasoline	0.93	16.6	0.00881	4.55×10^{-8}	5.56×10^{-8}
	Diesel	0.07	8.9	0.01015	3.57×10^{-9}	3.56×10^{-9}
2035	Gasoline	0.92	16.7	0.00881	4.55×10^{-8}	5.56×10^{-8}
	Diesel	0.08	8.7	0.01015	3.57×10^{-9}	3.56×10^{-9}

Basin-wide on-road vehicle activity data (miles/day) was provided by TRPA for the base years of 2005 and 2010 (see **Table A-3**). Following SB 375 guidance on assigning VMT to various regions across California, GHG emissions from mobile sources should be estimated based on VMT from all internal-internal trips (trips that start and end in the Basin) and half of the internal-external trips (trips that start in the Basin and end outside or vice versa). VMT from all external-external trips (those that start and end outside the Basin) should be excluded (Regional Targets Advisory Committee, 2009). This formula was used to derive the GHG VMT value shown in Table A-3; **Figure A-1** shows the breakdown of VMT by trip type that was used for all calculations (Tahoe Metropolitan Planning Organization, 2012b).

Table A-3. VMT (miles/day) by region and year (provided by TRPA).

Region	2005	2010
Carson	71,265	67,192
Douglas	425,785	416,276
Washoe	295,067	313,294
El Dorado (Unincorporated)	485,974	405,581
South Lake Tahoe	398,209	352,739
Placer	403,549	429,540
Tahoe Total	2,079,849	1,984,623
GHG VMT Total	1,539,088	1,459,299

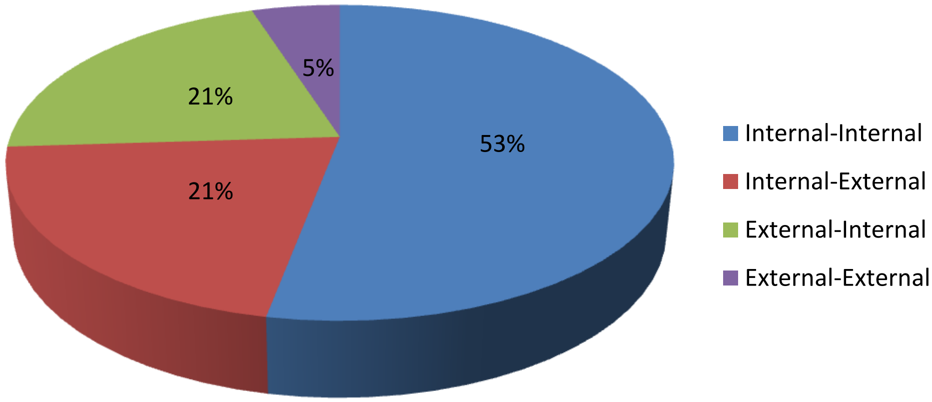

Figure A-1. Breakdown of VMT by trip type.

A.3 Recreational Boats

For recreational boats operating in Lake Tahoe, emissions were estimated using fuel consumption activity from TRPA and emission factors from the California Climate Action Registry's general reporting protocol (California Climate Action Registry, 2008) (see **Table A-4**).

Table A-4. Emission factors for ships and boats by fuel type (metric tons/gallon).

Fuel Type	CO_2	CH_4	N_2O
Gasoline	8.81×10^{-3}	6.40×10^{-7}	2.20×10^{-7}
Diesel	1.02×10^{-2}	7.40×10^{-7}	2.60×10^{-7}

Table A-5 shows the fuel estimates from a TRPA EIS for the Lake Tahoe Shorezone (Tahoe Regional Planning Agency, 2006). The EIS provided fuel use for 2004 and the future year of 2027 and hours used for 2004 and 2010. For 2010, fuel use was estimated by multiplying the hours used by the gallons/hour based on the 2004 data. Fuel use for 2005 was interpolated between 2004 and 2010.

Table A-5. Total fuel consumption in the Basin by fuel types provided by TRPA (gallons).

Fuel Type	2004	2005	2010
Gasoline	2,639,068	2,509,272	1,781,440
Diesel	3,884	8,884	15,072

A.4 Aircraft

Aircraft emissions were estimated for the Lake Tahoe airport using fuel data collected for 2010 and emissions factors from the California Climate Action Registry's general reporting protocol (California Climate Action Registry, 2008) (see **Table A-6**).

Table A-6. Emission factors by fuel type (metric tons/gallon).

Fuel Type	CO_2	CH_4	N_2O
Jet Fuel	9.57×10^{-3}	2.70×10^{-4}	3.10×10^{-7}
Aviation Gasoline	8.32×10^{-3}	7.04×10^{-3}	1.10×10^{-7}

Fuel consumption for jet fuel and aviation gasoline was provided by the airport's fuel vendor for 2009 and 2010 (Golden, 2011). For 2005, the airport used a different fuel vendor and the fuel consumption data were unavailable. Therefore, 2005 fuel consumption was estimated by scaling the 2010 fuel consumption using airport traffic activity (number of flights) from the FAA.[14] According to the airport fuel vendor, 95% of the fuel sold at the airport is jet fuel. Using this breakdown, emissions were calculated for each fuel type by multiplying fuel consumption with the appropriate emissions factor and relative percentage of use. **Table A-7** summarizes the fuel consumption (gallons) for jet fuel and aviation gasoline for the Lake Tahoe airport.

Table A-7. Fuel sales data for the Lake Tahoe airport and number of flights.

Activity	2005	2010
Flights	24,662	22,777
Fuel sales (gallons)	229,279	211,754

A.5 Other Off-Road Equipment

For all other off-road equipment, ARB's OFFROAD2007 model was run for the base years of 2005 and 2010 (see **Table A-8**). Annualized emissions for off-road vehicles[15] were calculated by multiplying the daily emissions by 365. These emissions only represent the California portion of the Basin. Therefore, in keeping with previous emissions inventory development for the Basin conducted by the DRI (Gertler et al., 2008), emissions for the California side were scaled up to account for the Nevada side of the Basin using the ratio of Basin-wide population for California and Nevada to the population of the California side of the Bain only. A population scaling factor of 1.32 was calculated using population data from TRPA. Emissions were allocated to geographic jurisdiction using population estimates.

[14] Airport traffic activity data available from the FAA website (http://aspm.faa.gov/main/taf.asp).
[15] Emissions from pleasure craft were excluded since they are calculated separately.

Table A-8. Daily emission from OFFROAD2007 (metric tons/day).

Class	CO_2		CH_4		N_2O	
	2005	2010	2005	2010	2005	2010
Construction and Mining Equipment	73.18	79.33	0.01	0.01	0.00	0.00
Entertainment Equipment	0.09	0.09	0.00	0.00	0.00	0.00
Industrial Equipment	9.34	10.51	0.01	0.00	0.00	0.00
Lawn and Garden Equipment	3.41	3.74	0.01	0.01	0.00	0.00
Light Commercial Equipment	5.09	5.72	0.00	0.00	0.00	0.00
Logging Equipment	17.98	17.98	0.01	0.00	0.00	0.00
Other Portable Equipment	0.13	0.13	0.00	0.00	0.00	0.00
Railyard Operations	0.00	0.00	0.00	0.00	0.00	0.00
Recreational Equipment	2.88	3.65	0.03	0.03	0.00	0.00
Transport Refrigeration Units	7.01	8.99	0.00	0.00	0.00	0.00
Total	**119.10**	**130.13**	**0.06**	**0.06**	**0.01**	**0.01**

A.6 Wood Combustion

Wood fuel combustion was calculated using wood burning activity estimates from a local wood burning survey (Kuhns et al., 2004), data on the annual number of households and visitors, and emissions factors from the California Climate Action Registry's general reporting protocol (California Climate Action Registry, 2008).

Wood combustion emission factors for wood combustion are in kilograms per Million British Thermal Unit (kg/MMBtu). Since fire activity data is the mass of wood burned, the emission factors were converted to metric tons per Mega-gram wood (metric tons/Mg wood) for each pollutant using the default wood moisture of 12% and wood heat content of 15.38 MMBtu per ton of wood burned from the reporting protocol (see **Table A-9**).

Table A-9. Default wood moisture, heat content, and CO_2 equivalent emission factors by pollutant.

Wood Moisture	Wood Heat Content (MMBtu/ton)	Emission Factor (kg CO_2e /MMBtu)			Emission Factor (metric tons CO_2e/Mg wood)		
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
12%	15.38	93.86	0.32	0.004	1.6	0.005	0.00006

A local study of PM source characterization in Lake Tahoe, estimates a wintertime wood burn rate of 450 Mg wood/day (120 days in winter) and a summertime wood burn rate of 29 Mg wood/day (90 days in the summer) (Kuhns et al., 2004); see **Table A-10**. It was assumed that for 2005, burn rates were similar to 2004 rates. For 2010, the amount of wood burned in 2005 was scaled using household and visitor growth rates from 2005 and 2010. Emissions from wood consumption were then allocated to geographic jurisdictions based on the number of households that use wood to primarily heat their homes, which was collected from the 2000 U.S. Census (U.S. Census Bureau, 2000); see **Table A-11**.

Table A-10. Wood consumption by fire type (Mg/year).

Type	2005	2010
Residential Fires	54,000	57,577
Campfires	2,610	2,397
Total	**56,610**	**59,974**

Table A-11. Households primarily heated with wood by region.

Region	Households
Carson	-
Douglas	68
Washoe	35
El Dorado	503
Placer	403
Total	**1,009**

A.7 Natural Gas Fuel Combustion

Natural gas fuel combustion emissions were calculated using fuel consumption activity from local utilities and emissions factors from the California Climate Action Registry's general reporting protocol (California Climate Action Registry, 2008); see **Table A-12**.

Table A-12. Emission factors for natural gas combustion (metric tons/MMBtu). (California Climate Action Registry, 2008) (California Climate Action Registry, 2008)

Fuel	CO_2	CH_4	N_2O
Natural Gas	53.06	0.005	0.0001

For most of the Basin, Southwest Gas is the primary provider of natural gas to residential and commercial customers. Southwest Gas (Rader, 2011) provided activity data for total consumption (therms)[16] for residential and commercial gas use for Placer, Washoe, and Douglas counties, and for the City of South Lake Tahoe (see **Table A-13**). Residential natural gas consumption rates, derived from the Southwest Gas data, were applied to the number of households in the unincorporated portion of El Dorado County to estimate residential fuel

[16] 10 therms = 1MMBtu

usage. Similarly, commercial fuel use for the unincorporated portion of El Dorado County was derived based on the ratio of residential to commercial usage from the data provide by Southwest Gas. This step was required because PG&E, the utility serving this portion of El Dorado County, did not provide activity data in time for use in this inventory.

Table A-13. Natural gas usage by region from Southwest Gas.

Region	Usage (therms)			
	2005		2010	
	Res.	Com.	Res.	Com.
Carson	-	-	-	-
Douglas	2,348,038	389,491	1,825,502	423,039
Washoe	7,443,001	2,000,356	7,041,221	2,331,298
El Dorado (unincorporated)	2,742,987	664,875	3,277,281	897,215
South Lake Tahoe[a]	13,795,666	6,603,333	14,253,781	6,960,074
Placer	6,790,702	1,629,419	7,074,904	1,609,971
Nevada Total	9,791,039	2,389,847	8,866,723	2,754,337
California Total	23,329,355	8,897,627	24,605,966	9,467,260
Tahoe Total	**33,120,394**	**11,287,474**	**33,472,689**	**12,221,597**

[a] Usage for the City of South Lake Tahoe is from 2006 as this is the closest complete year. Usage from 2006 to 2010 varies little and ranges from 1,079 to 1,126 therms per year.

A.8 Other Fuel Combustion

Emissions from home heating fuel combustion of propane (LPG) and distillate oil were calculated based on (1) the number of households using these fuels to heat their homes and (2) emissions factors (see **Table A-14**) from the California Climate Action Registry's general reporting protocol (California Climate Action Registry, 2008).

Table A-14. Emission factors for LPG (metric tons/Btu).

Fuel Type	CO_2	CH_4	N_2O
LPG	6.3×10^{-8}	1.1×10^{-11}	6.0×10^{-13}
Distillate Oil	7.3×10^{-8}	8.0×10^{-13}	3.0×10^{-13}

In the absence of detailed consumption data, the EPA recommends that consumption can be estimated using the number of HDDs[17] in the region for the year of interest, the number of households using the fuel to heat their homes, and an average household consumption rate

[17] HDDs provide a representation of how cold a region's average temperature was over some period of interest and are calculated as the difference between a day's average temperature and some base temperature (e.g., 65°F).

per HDD (U.S. Environmental Protection Agency, 2009). The number of households using LPG and distillate oil as their primary home heating source from the 2000 U.S. Census (U.S. Census Bureau, 2000) was scaled to 2005 and 2010 using the household growth rate from 2005 to 2010 (see **Table A-15**). Heat consumption for the Basin was then calculated by multiplying the number of households using LPG and distillate oil as their primary home heating source with the Basin annual average HDD value of 7,882[18] and the average household consumption rate of 11,647 BTU/HDD.

Table A-15. Households using LPG as their primary home heating source by region.

Region	Fuel Type					
	LPG			Distillate Oil		
	2000	2005	2010	2000	2005	2010
Carson City	-	-	-	-	-	-
Douglas	191	185	178	70	68	65
Washoe	39	39	40	32	32	33
El Dorado (including South Lake Tahoe)	414	468	528	26	29	33
Placer	166	162	158	23	22	22
Nevada Total	230	224	218	102	100	98
California Total	580	629	686	49	52	55
Tahoe Total	**810**	**853**	**904**	**151**	**152**	**153**

A.9 Wildfires and Prescribed Burns

Emissions from wildfires and prescribed burns are a function of the type and amount of vegetation consumed by each fire event. Previously, STI generated a national inventory of CO_2 emissions from fires using the BlueSky Smoke Modeling Framework, a system developed by STI and the USDA Forest Service (Raffuse et al., 2008). The BlueSky system reconciles satellite fire detections with ground-based reports to estimate the area burned by each fire event, then uses detailed land cover data, fuel consumption algorithms, and emission factors to calculate the type and amount of vegetation burned and the resulting emissions. The BlueSky system includes the SmartFire model (Raffuse et al., 2009), a geospatial processing tool that aggregates and reconciles information about when and where fires occur.

In addition, CalFire maintains a GIS database of fire history as part of its FRAP. The CalFire data is available for historical years back to 1990 and were used to verify BlueSky data and evaluate fire trends.

The BlueSky/SmartFire system was used to develop activity data for 2005 and 2010 for major wildfires and large prescribed burns. For smaller prescribed fires (e.g., pile burns) that

[18] Annual average HDD for the Basin was calculated using a climate summary from the South Lake Tahoe airport for the years 2000 to 2008 (http://www.wrcc.dri.edu/summary/tvl.ca.html).

are not captured by SmartFire, activity data were derived from the Lake Tahoe Fuel Reduction Plans (LTFRP) (USDA Forest Service, 2012) and other sources that describe forest management and fire activities in the Basin (USDA Forest Service, 2012) and (Osborn, 2012); see **Table A-16**.

Table A-16. Acres burned and number of piles by region from SmartFire and LTFRP.

Region	2005		2010	
	SmartFire (acres burned)	LTFRP (# of piles)	SmartFire (acres burned)	LTFRP (# of piles)
Carson	-	-	-	-
Douglas	-	162	1,000	400
Washoe	-	-	-	-
El Dorado (unincorporated)	-	365	400	900
South Lake Tahoe	-	-	-	-
Placer	-	162	949	400
Nevada Total	-	162	1,000	400
California Total	-	527	1,349	1,300
Total	**-**	**689**	**2,349**	**1,700**

BlueSky only estimates CO_2 emissions; therefore, using EPA guidance (U.S. Environmental Protection Agency, 2011), the CO_2 emissions were scaled by 0.0001641 to calculate N_2O and by 0.0029813 to calculate CH_4

A.10 Livestock

Emissions from livestock were based on ARB estimates of animal populations in the Basin and emission factors for each animal type from EPA GHG guidance documents (U.S. Environmental Protection Agency, 2009) (see **Table A-17**).

ARB produces refined livestock population estimates by county and air basin (Reid et al., 2008). They combine statewide summaries of livestock populations from the annual Agricultural Resource Directory for dairy and beef cows published by the California Department of Food and Agriculture and the Agricultural Census developed by the USDA, providing populations for other animal types (e.g. swine, sheep, horses, and goats). **Table A-18** summarizes the livestock population from the 2003 ARB livestock population report[19] for the Basin; these populations were held as being constant for 2005 and 2010.

[19] Data summarized from the ARB livestock population report (http://www.arb.ca.gov/ei/areasrc/lstkpopmeth.pdf).

Table A-17. Emission factors by livestock category (metric tons/head-year).

Category		CH_4	N_2O
Dairy Cattle	Young Heifers	6.70×10^{-2}	5.96×10^{-3}
	Calves	4.50×10^{-2}	5.96×10^{-3}
Range Cattle	Beef Cows	9.40×10^{-2}	2.54×10^{-3}
	Beef Bulls	5.30×10^{-2}	2.54×10^{-3}
	Beef Heifers	5.90×10^{-2}	2.54×10^{-3}
	Beef Calves	5.90×10^{-2}	2.54×10^{-3}
	Stockers	5.80×10^{-2}	2.54×10^{-3}
Poultry	Broilers	-	2.36×10^{-4}
	Layer & Pullets	-	2.36×10^{-4}
	Turkeys	-	8.74×10^{-4}
Other	Swine	1.50×10^{-3}	3.81×10^{-6}
	Sheep	8.00×10^{-3}	-
	Horses	1.80×10^{-2}	-
	Goats	5.00×10^{-3}	-

Table A-18. Livestock population in 2005 by region and category (number of head).

Category		El Dorado	Placer	Total
Dairy Cattle	Young Heifers	38	184	222
	Calves	75	367	442
Range Cattle	Beef Cows	549	1,000	1,549
	Beef Bulls	25	45	70
	Beef Heifers	99	179	278
	Beef Calves	230	418	648
	Stockers	83	406	489
Poultry	Broilers	55	91	146
	Layer & Pullets	150	289	439
	Turkeys	210	11,570	11,780
Other	Swine	23	26	49
	Sheep	261	329	590
	Horses	194	237	431
	Goats	46	53	99

A.11 Solid Waste

Emission estimates for solid waste were calculated using data on solid waste generation from local utilities, waste composition percentages developed by CalRecycle (Cascadia Consulting Group, 2009), and the solid waste module in the ICLEI's CACP software. Total municipal solid waste (MSW) quantities were collected for the Basin for 2005 and 2010 from South Tahoe Refuse, which provided data on MSW produced from the City of South Lake Tahoe, El Dorado County, and Douglas County. For the northern portion of the Basin, Tahoe Truckee Sierra Disposal manages the collection of solid waste; however, they were unable to provide data in time for use in this project. Therefore, waste generation was calculated for Washoe and Placer Counties using the average per-capita waste generation rates from the counties for which data were available. **Table A-19** shows total solid waste by jurisdiction and year.

Table A-19. Solid waste generated by region (tons/year).

Region	2005	2010
Carson	-	-
Douglas	35,213	17,116
Washoe	23,051	23,295
El Dorado (unincorporated)	16,226	20,207
South Lake Tahoe	63,636	72,676
Placer	27,324	26,622
Nevada Total	58,264	40,411
California Total	107,186	119,504
Total	**165,450**	**159,915**

Table A-20 shows the waste composition percentages derived from CalRecycle data that were used in the CACP software. For the year 2005, a methane capture efficiency of zero was used in the CACP software, as Lockwood had not installed a methane recovery system at that time. For the year 2010, a methane capture efficiency of 75% was used (Ling-Barnes, 2010).

Table A-20. Waste composition percentages from CalRecycle.

CACP Waste Type	Percentage
Paper Products	17.3%
Food Waste	15.5%
Plant Debris	10.8%
Wood or Textiles	17.3%
Other	39.1%

A.12 Wastewater Treatment

All four of the treatment plants that process the Basin's wastewater treat the water aerobically, producing no methane emissions and only small amounts of N_2O. N_2O emissions estimates from these wastewater treatment plants were calculated based on population using guidance from the IPCC greenhouse gas emissions inventories documentation (Intergovernmental Panel on Climate Change, 2006). N_2O emissions from wastewater treatment processes were calculated as shown in **Equation 2**.

$$N_2O = \text{Population x Protein fraction x Emissions factor} \quad \textbf{(2)}$$

An emissions factor of 3.5274 x 10^{-6} tons of N_2O per person per year was used along with a default protein fraction of 1.25, which represents the amount of food waste that may have been washed down the drain.

For direct GHG emissions estimated for the three facilities in the Basin, emissions were assigned to each facility based on the population of the area it serves (see Figure 2-6). For the Truckee facility, which lies outside the Tahoe Basin, a portion of N_2O emissions and GHG emissions resulting from electricity consumption at that facility were treated as indirect sources for the Basin-wide inventory. The portion of the Truckee facility's emissions included as an indirect source in the inventory was based on the percentage of the facility's annual waste that comes from the Basin (35%). This percentage and annual electricity consumption at the Truckee treatment plant were obtained from staff at that facility.

A.13 Energy

Natural gas fuel combustion emissions were calculated using fuel consumption activity from local utilities (Liberty Energy and Nevada Energy) and emission factors from local utilities and the California Climate Action Registry's general reporting protocol (California Climate Action Registry, 2008); see **Table A-21**.

Table A-21. Emission factors (metric tons/KWh) for energy consumption.

Year	CO_2	CH_4	N_2O
2005	7.52 x 10^{-4}	1.36 x 10^{-8}	3.67 x 10^{-8}
2010	8.18 x 10^{-4}	1.28 x 10^{-8}	2.83 x 10^{-9}

Historically, electricity for the California and Nevada sides of the Basin has been provided by Sierra Pacific Power Company and Nevada Energy, respectively. However, Sierra Pacific Power was recently sold to Liberty Energy Utilities Company, and the customers previously served by Sierra Pacific are now served by a subsidiary of Liberty Energy known as California Pacific Electric Company.

To estimate GHG emissions from electricity consumption on the California side of the Basin, we obtained usage data (KWh) for commercial, government, and residential activity from Liberty Energy. These data covered the unincorporated portion of El Dorado County, the City of South Lake Tahoe, and Placer County. For the Nevada side of the Basin, electricity consumption for residential and commercial activity was obtained from Nevada Energy. However, the data represented a service area that includes most of western Nevada (they were unable to provide data at a smaller spatial geographic level). Therefore, for Douglas and Washoe counties, energy consumption was estimated using county-level population and default electricity consumption rates (KWh/person) for 2005 and 2010 from the California Energy

Commission's (CEC) energy almanac[20] (see **Tables A-22 and A-23**).

In addition to residential and commercial energy use, energy consumption by wastewater treatment plants was considered. There are three plants in the Basin, but their energy use is captured in the data provided by Liberty Energy. However, portions of the north shore send their waste to a treatment plant in Truckee. Energy consumption for the Truckee plant was provided by the Tahoe-Truckee Sanitation Agency (Parker, 2011), and this plant was treated as an indirect source in the inventory. Since only 35% of the wastewater treated at the plant is from the Basin, the total energy consumption from the plant (7,800,000 KWh) was scaled down to represent the energy used to treat the Basin's wastewater.

Table A-22. Total energy consumption in the Basin for 2005 (KWh).

Region	Wastewater Treatment	Other		
		Residential	Commercial	Total
	2005			
Carson	-	-	-	-
Douglas	-	45,032,562	42,961,768	87,994,330
Washoe	-	62,277,127	59,413,352	121,690,478
El Dorado	-	50,508,001	27,725,315	78,233,316
South Lake Tahoe	-	77,296,460	122,458,783	199,755,243
Placer	2,808,000	80,272,646	79,398,687	159,671,333
Nevada Total	-	107,309,689	102,375,119	209,684,808
California Total	2,808,000	208,077,107	229,582,785	437,659,892
Total	**2,808,000**	**315,386,795**	**331,957,905**	**647,344,700**

Table A-23. Total energy consumption in the Basin for 2010 (KWh).

Region	Wastewater Treatment	Other		
		Residential	Commercial	Total
	2010			
Carson	-	-	-	-
Douglas	-	42,539,653	40,583,493	83,123,146
Washoe	-	61,512,180	58,683,580	120,195,760
El Dorado	-	54,753,474	29,303,393	84,056,867
South Lake Tahoe	-	80,729,417	126,006,353	206,735,770
Placer	2,808,000	86,459,092	106,185,396	192,644,488
Nevada Total	-	104,051,833	99,267,074	203,318,906
California Total	2,808,000	221,941,983	261,495,142	483,437,125
Total	**2,808,000**	**325,993,815**	**360,762,215**	**686,756,031**

[20] Data from the CEC's energy almanac are available from the following website: http://www.energyalmanac.ca.gov/electricity/us_per_capita_electricity-2010.html

A.14 Forestry Carbon Stocks

To determine the quantity of forest in the Tahoe region, we relied on the COLE2 database, which is maintained by the FIA program as a record of the health of forests in the United States. The number and size of the trees in various forests are recorded into the COLE2 database by manual surveys of the forests. Due to resource limitations, these plots are usually subdivided and only a portion of the plot is surveyed during a select year; then the data for that parcel are used to estimate the carbon stock for the rest of the plot. For the next year, another portion of the plot may be estimated and those results are used to make a new estimate of the carbon stock for the plot (which could vary significantly from the previous year due to fires or other activity in the plot).

Because of this process, the tree carbon data obtained from the COLE2 database were averaged over a 10-year period to create a single baseline scenario. The tree carbon data were converted to CO_2 stock in metric tons by multiplying total carbon by 3.76, which is the ratio of the molar weight of CO_2 to the molar weigh of carbon. **Table A-24** summarizes the 10-year average tree carbon (metric tons) for the Basin by geographical jurisdictions.

Table A-24. Total tree carbon (metric tons) by geographic jurisdiction.

Region	2005
Carson	32,777
Douglas	117,240
Washoe	2,422
El Dorado (Unincorporated)	392,749
South Lake Tahoe	0
Placer	138,246
Nevada Total	152,439
California Total	530,995
Total	**683,434**

Appendix B

Emissions Summary by Greenhouse Gas Pollutant

Each GHG differs in its ability to absorb heat in the atmosphere. Non-CO_2 emissions data are converted to CO_2e values based on each GHG's GWP.[21] N_2O has a GWP of 310 (it absorbs 310 times more heat per molecule than carbon dioxide) and CH_4 has a GWP of 21. Total CO_2e emissions are summed across all pollutants. **Tables B-1 and B-2** summarize GHG emissions by pollutant and the resulting total CO_2e for each source category. Values in tables B-1 and B-2 are rounded to the nearest whole number. Many values were less than 1 and were not included in the table. Total CO_2e calculations included decimals and unlisted values less than 1.

Table B-1. 2005 baseline emissions (metric tons/year) by pollutant and CO_2e for each source category.

Type	Source Sector	Source Category	2005			
			CO_2	N_2O	CH_4	CO_2e
Direct	Transportation	On-road mobile sources	315,740	29	24	**325,282**
		Recreational boats	22,197	1	2	**22,403**
		Other off-road equipment	52,056	4	28	**53,860**
	Fuel combustion	Wood combustion	90,081	4	303	**97,700**
		Natural gas combustion	235,628	0	22	**236,232**
		Other combustion	5,820	0	1	**5,858**
	Fires	Wildfires and prescribed burns	3,848	1	11	**4,284**
	Land use	Livestock	-	22	280	**12,734**
	Waste	Wastewater treatment	-	0	-	**57**
Indirect	Energy	Electricity consumption	486,631	2	9	**487,553**
		Wastewater treatment	2,111	0	0	**2,115**
	Transportation	Aircraft	2,180	0	140	**5,131**
	Waste	Municipal solid waste	-	-	5,262	**110,512**
		Wastewater treatment	-	0	-	**12**
Total Emissions			**1,216,292**	**63**	**6,082**	**1,363,734**

[21] GWP is an index developed by the(IPCC to quantify the relative radiative forcing effects of a given GHG using CO_2 as the reference gas (California Climate Action Registry, 2009).

Table B-2. 2010 baseline emissions (metric tons) by pollutant and CO_2e for each source category.

Type	Source Sector	Source Category	2010			
			CO_2	N_2O	CH_4	CO_2e
Direct	Transportation	On-road mobile sources	295,231	28	23	**304,348**
		Recreational boats	15,847	0	1	**15,994**
		Other off-road equipment	56,878	4	26	**58,751**
	Fuel combustion	Wood combustion	96,165	4	324	**104,297**
		Natural gas combustion	242,454	0	23	**243,075**
		Other combustion	6,120	0	1	**6,161**
	Fires	Wildfires and prescribed burns	82,312	14	245	**91,652**
	Land use	Livestock	-	22	280	**12,734**
	Waste	Wastewater treatment	-	0	-	**62**
Indirect	Energy	Electricity consumption	561,757	2	9	**562,543**
		Wastewater treatment	2,297	0	0	**2,300**
	Transportation	Aircraft	2,013	0	129	**4,739**
	Waste	Municipal solid waste	-	-	1,272	**26,704**
		Wastewater treatment	-	0	-	**12**
Total Emissions			**1,361,074**	**75**	**2,333**	**1,433,374**