CITY OF CUPERTINO
CLIMATE ACTION PLAN

APPENDIX B – GHG Inventory and Reductions Methodology

This appendix describes the emissions sectors, data sources, and methodology used to prepare the CAP's 2010 baseline emissions inventories and the 2020, 2035, and 2050 emissions forecasts. The community-wide and municipal operations inventory and forecast methodologies are presented separately in the sections below. The remainder of the appendix describes the assumptions and methodology used to estimate emissions reductions associated with implementation of the local CAP measures described in Chapters 3 and 4.

It should be noted that the 2010 inventories were prepared separately from the remainder of the CAP (i.e., emissions forecasts, CAP document, supporting appendices), and were not prepared by the same project team that developed the CAP. Per the Santa Clara County regional CAP project scope under which this CAP was prepared, the 2010 inventories were used as the baseline from which the 2020, 2035, and 2050 emissions forecasts were calculated. The 2010 baseline inventories were previously prepared under a separate project contract, and provided to the CAP project team for incorporation and use in preparing the emissions forecasts. However, during the course of preparing the emissions forecasts, several methodological errors were identified in the original 2010 baseline inventory work, and the CAP project team made revisions to the original work to prepare baseline inventories that reflected the best available data and methodologies at their time of completion. In addition, preparation of a baseline inventory methodology appendix was not included in the original scope of work for the baseline inventories, so this technical component was prepared as part of the CAP development process. This appendix describes, to the extent feasible, the methodologies used by the original baseline inventory project team based on the supporting data and inventory worksheets that were provided to the CAP project team. In the future, inventory updates should follow the methodologies presented below to provide consistency between inventory versions and allow direct comparisons from one year to another. It is likely that inventory methodologies will continue to evolve though, and the City may find it more beneficial to follow prevailing industry standards, even if those changes make direct comparisons to prior year inventories more difficult.

Community-wide Inventory and Methodology

This section describes revisions that the CAP project team made to the original baseline inventory. It then presents the emission sources, data sources, and methods used to develop the baseline GHG emissions inventories for the City according to each emissions sector.

BASELINE EMISSIONS INVENTORY REVISIONS

The CAP project team reviewed the original Cupertino community-wide inventory that was previously prepared by the baseline inventory project team. During this review, several methodological revisions were made to the original community-wide inventory to provide a more accurate and useful inventory for the purposes of climate action planning. These adjustments included methodological revisions to the transportation and solid waste sectors.

In the transportation sector, the original inventory used the California Department of Transportation (Caltrans) Highway Performance Monitoring System (HPMS) to identify vehicle miles traveled (VMT) to be allocated to the City. However, HPMS VMT data only accounts for VMT physically occurring on City roadways, which includes pass-through trips and does not consider the origin or destination of those VMT. Because the City's CAP cannot affect pass-through trips, and understanding the origin and destination of vehicle trips is important to allocating transportation emissions to the correct jurisdiction, the original transportation sector was revised using the origin-destination methodology. The Regional Targets Advisory Committee (RTAC) and Bay Area Air Quality Management District (BAAQMD) have recommended that emissions inventories use the origin-destination method to quantify transportation-related emissions. Therefore, the General Plan Amendment transportation consultant provided the CAP project team with VMT data using the RTAC-prescribed methods, which were used to revise transportation sector emissions in the original inventory. The RTAC methodology is described in the Transportation Sector section below.

The original inventory's solid waste sector included lifecycle emissions of annual solid waste disposed by City land uses. These lifecycle emissions would occur gradually over the lifetime of the solid waste's decomposition, but not necessarily during the year of the inventory. Because the remainder of the inventory is based on annual activities and emissions, this original solid waste methodology would not be consistent with the rest of the emissions inventory. The solid waste sector was revised to use the California Air Resources Board's first-order decay model to quantify annual GHG emissions associated with past and present solid waste disposed by the community.

EMISSIONS UNITS AND CLASSIFICATION

Emissions inventories are commonly expressed in metric tons (or tonnes) of carbon dioxide equivalent per year (MT CO_2e/yr) to provide a standard measurement that incorporates the varying global warming potentials (GWP) of different greenhouse gases. GWP describes how much heat a greenhouse gas can trap in the atmosphere relative to carbon dioxide, which has a GWP of 1. For example, methane has a GWP of 25, which means that 1 metric ton of methane will trap 25 times more heat than 1 metric ton of carbon dioxide, making it a more potent greenhouse gas. Some gases used in industrial applications can have a GWP thousands of times larger than that of CO_2. In order to maintain consistency within each inventory and between the baseline and projected emissions inventories, all GHG emissions have been quantified in units of MT CO_2e/yr.

Emissions can be described as direct or indirect, depending upon where the emissions generation occurs. Direct emissions are those where the consumption activity directly generates the emissions, such as natural gas combustion for heating or cooling. In this instance, natural gas can be consumed on-site and the resulting emissions are a direct result of that consumption. Indirect emissions are those where the consumption activity takes place within the jurisdiction, but the actual emissions generation occurs outside of that boundary. For example, a

Cupertino resident can consume electricity within their home, but that electricity may be generated in an area outside of the City's jurisdiction (e.g., power plants throughout the state).

ENERGY SECTOR

Emission Sources

Energy emissions are generated through the combustion of fossil fuels to generate electricity or directly provide power (e.g., natural gas combustion for water heating). The energy sector includes the use of electricity and natural gas in residential, commercial, and industrial land uses within the legal boundaries of the City. Although emissions associated with electricity production are likely to occur in a different jurisdiction, the emissions are allocated to the point of consumption and not the point of generation. In other words, consumers are considered accountable for the generation of those emissions. Therefore, electricity-related GHG emissions are considered *indirect* emissions because they are a result of activities occurring within the jurisdiction, even though emissions associated with electricity generation occur in different geographic areas, and natural gas-related GHG emissions are typically considered *direct* emissions because the consumption occurs on-site and within the jurisdiction.

Inventory Data Sources

PG&E provides electricity and natural gas to the community, and provided annual year 2010 electricity and natural gas consumption data for the City of Cupertino to develop the baseline inventory. PG&E provided all community-wide electricity and natural gas consumption data in the form of kilowatt-hours per year (kWh/yr) and therms per year (therms/yr), respectively. PG&E also provided an electricity emissions factor specific to their generation portfolio in the baseline year of 2010.

Inventory Methodology

Electricity-related GHG emissions were quantified using the PG&E-specific emission factor that accounts for PG&E's 2010 electricity production portfolio (e.g., the mix of coal, oil, wind, solar and other sources of electricity production). Natural gas GHG emissions were also quantified using a PG&E-specific natural gas emissions factor. The energy use activity data provided by PG&E was multiplied by the appropriate emissions factors to calculate total MT CO_2e/yr. The following emissions factors were used to calculate 2010 baseline emissions:

Table B-1 Baseline Energy Emissions Factors		
Energy Type	**Metric Tons CO_2e/kWh**	**Metric Tons CO_2e/therm**
Electricity	0.000204	-
Natural Gas	-	0.005321

TRANSPORTATION SECTOR

Emission Sources

Transportation emissions come from vehicle trips that begin and/or end within Cupertino's boundaries. Pass through trips (for example, non-local drivers on Highway 85 and Interstate 280) are not included within Cupertino's emissions inventory because the CAP measures would not affect those emissions. This sector includes GHG exhaust emissions from both private and City-owned vehicles.

Inventory Data Sources

Unlike most of the other emissions sectors where empirical activity data is available to more precisely calculate actual resource consumption (e.g., electricity used, wastewater generated, solid waste disposed), the transportation sector relies upon travel models to estimate vehicle use within a community. Travel models estimate the total vehicle miles traveled (VMT) within a community, which can then be combined with vehicle fuel emissions factors to estimate transportation-related emissions.

Daily VMT estimates were acquired from the City's General Plan Amendment transportation consultant to develop the transportation emissions for the CAP's 2010 baseline year. Estimates were provided for a General Plan baseline year of 2013 and the General Plan buildout year of 2040 under the highest growth land use alternative (to ensure the maximum amount of growth would be addressed by the CAP's measures). Daily VMT values were converted to annual VMT values using an annualization factor. The VMT estimates for 2013 and 2040 were then used to interpolate for years 2020 and 2035, and used to extrapolate the CAP's baseline year of 2010 and long-term target year of 2050. These calculations assumed a linear growth in vehicle miles traveled from 2010 through 2050 using the projected growth rate from 2013 to 2040. This ensured that transportation-related emissions are internally consistent (i.e., based on the same traffic model) between the General Plan Amendment and CAP, as opposed to using the Metropolitan Transportation Commission's VMT estimates, which were developed using different traffic models and demographic assumptions than those used in the City's General Plan Amendment.

Inventory Methodology

Emission factors for the transportation sector were obtained from the California Air Resources Board's (ARB) vehicle emissions model, EMFAC2011, which was the most recent version of EMFAC available at the time of the analysis. EMFAC2011 is a mobile source emission model for California that provides vehicle emission factors by both county and vehicle class. Santa Clara County-specific emission factors were used in this emissions inventory.

As described above, the adjusted transportation sector used origin-destination VMT data provided by the General Plan Amendment transportation consultant. This methodology is designed to omit pass-through highway trips from the emissions inventory and allocate a fair-

share of VMT and emissions to each vehicle trip's origin and destination. The VMT data provided for this method separates VMT by four different trip types: internal-internal, internal-external, external-internal, and external-external. The internal refers to an origin or destination that is within the City's jurisdiction, and the external refers to an origin or destination outside of the City's jurisdiction. All internal-internal VMT are included in the emissions inventory, while all external-external VMT, which are pass-through trips, are excluded from the inventory. For the internal-external and external-internal trips, half the trip distance is included in the City's inventory. The intent is to allocate half of the VMT for a trip to each jurisdiction that causes a trip (i.e., is a trip's origin or destination). As stated above, this method is consistent with guidance provided by RTAC and BAAQMD. It also provides a consistent methodology to allocate VMT to each jurisdiction responsible for a vehicle trip.

WASTEWATER SECTOR

Emission Sources

The wastewater sector includes emissions resulting from wastewater treatment processes and from energy used to power wastewater treatment plants. Treatment of wastewater influent could generate methane (CH_4) emissions, while discharged effluent could generate nitrous oxide (N_2O) emissions. Both of these emissions sources are considered direct process emissions, while electricity consumption to power the wastewater treatment plant would generate indirect GHG emissions (see previous discussion of indirect GHG emissions).

Inventory Data Sources

The City's wastewater is treated by the San Jose and Santa Clara County Wastewater Treatment Plant (WWTP), which also treats wastewater from the City of Saratoga and unincorporated Santa Clara County. A GHG emissions inventory for the San Jose and Santa Clara County Wastewater Treatment Plant was developed as part of the San Jose/Santa Clara Water Pollution Control Plant Master Plan. The emission inventory included GHG emission sources from the WWTP such as energy consumption (i.e., electricity and natural gas), stationary sources, nitrification and denitrification processes, effluent discharge, biosolids treatment, and production and transport of chemicals used for wastewater treatment. Cupertino's wastewater-related GHG emissions would be a portion of the total GHG emissions calculated for the WWTP's GHG inventory.

Inventory Methodology

Using a top-down approach, Cupertino's portion of the total WWTP's GHG emissions were allocated using the ratio of the City's population to the total population served by the WWTP. Cupertino's population and thus GHG emissions represent approximately 30% of the total WWTP's emissions.

WATER SECTOR

Emission Sources

The potable water sector includes energy emissions associated with water treatment, distribution, and conveyance. Water-related GHG emissions are considered indirect emissions similar to electricity-related emissions because the actual emissions generation occurs at a different geographical location than that of the consumption activity (i.e., treatment, distribution, and conveyance occur in a different location than final water consumption).

Inventory Data Sources

The amount of total annual potable water provided to the City was obtained from the San Jose Water Company 2010 Urban Water Management Plan (UWMP) and the CalWater Los Altos-Suburban District 2010 UWMP. Potable water consumed by the City was provided in units of million gallons per year.

Inventory Methodology

The original baseline emissions inventory information provided to the CAP project team included the community's total water consumption in 2010 (as millions of gallons) and the resulting emissions associated with that water consumption (as MT CO_2e/yr). However, the supporting emissions factors were not provided, suggesting that the calculations were prepared using a separate emissions-calculating software package. To establish consistency in future water sector emissions calculations, the City should incorporate the following methodology.

The CEC's *Refining Estimates of Water-Related Energy Use in California* report provides water-energy intensities for California, and was used to calculate the electricity required to provide potable water for the community. GHG emissions associated with potable water supply were then calculated using California's statewide electricity intensity factors from the California Climate Action Registry's General Reporting Protocol Version 3.1 (CCAR 2009). Statewide electricity intensity factors were used rather than local PG&E factors because electricity used to provide Cupertino's potable water could be provided by a mix of various utilities, particularly for water supply that is sourced outside of the City.

SOLID WASTE SECTOR

Emission Sources

The solid waste sector includes emissions associated with solid waste disposal. During the solid waste decomposition process, only organic materials release GHGs. Carbon dioxide emissions are generated under aerobic conditions (i.e., in the presence of oxygen), while CH_4 emissions are generated under anaerobic conditions (i.e., in the absence of oxygen), as in many landfill environments. Solid waste-related CO_2 emissions are considered biogenic emissions that are part of the natural carbon cycle. However, CH_4 emissions have a higher GWP and are

generated as a result of controllable landfill waste management techniques, and are therefore counted as GHG emissions within an emissions inventory. In addition, waste collection and hauling activities (i.e., heavy-duty haul trucks) also generate GHG exhaust emissions. However, hauling-related emissions are assumed to be included within the City's General Plan Amendment transportation consultant's traffic model, and therefore, represented within the Transportation Sector.

Inventory Data Sources

Solid waste generated within the City is primarily sent to the Newby Island Landfill. Annual tons of solid waste generated by land uses (e.g., residential, commercial) and waste characterization data (e.g., percentage of paper, plastic, green waste) were collected from CalRecycle. Historic population data was collected from the US Census.

Inventory Methodology

The California Air Resources Board's first-order-decay methodology was used to estimate landfill methane emissions in order to incorporate the time factor of the solid waste degradation process, which can take decades to occur. These calculations assumed that Cupertino's solid waste is disposed of in landfill facilities with methane capture systems in place that operate with 75% efficiency rates (per the US EPA's guidance on estimating landfill emissions). Decennial historic population estimates were used to interpolate solid waste disposal (on a per capita basis) from the 2010 baseline year to 1960, with the assumption that nearly 100% of the methane generated from landfill waste is released within 50 years; therefore, solid waste disposed more than 50 years ago would not still generate methane emissions. Annual solid waste emissions represent a snap shot of a community's solid waste, which is decomposing at various rates due to the different times of disposal into the landfill. This approach attempts to quantify the annual emissions that occurred in 2010 as a result of solid waste that was disposed of beginning in 1960 (i.e., what percentage of methane from waste disposed of in 1960 to 2010 is released in 2010?).

OFF-ROAD VEHICLES SECTOR

Emission Sources

Off-road equipment emissions are generated by fuel combustion for local construction equipment, lawn and garden equipment (e.g., lawn mowers, leaf blowers), industrial equipment, and light commercial equipment.

Inventory Data Sources

Data for construction, lawn and garden, industrial, and light commercial equipment were obtained from ARB's OFFROAD2007 model, which provides county-level emissions for off-road

equipment. Similar to the transportation sector, these emissions are modeled with OFFROAD2007 and not based on empirical activity data.

Inventory Methodology

As described above, OFFROAD2007 provides county-level GHG emissions for each off-road equipment category. Cupertino's share of the County's total households and population were calculated using 2009 ABAG estimates for 2010. These factors were then multiplied by the total county-wide emissions per off-road source to determine Cupertino's share of the emissions. Lawn and Garden Equipment emissions were calculated using Cupertino's share of total county households, while the remaining off-road emissions sources were allocated using Cupertino's share of the total county population.

Community-wide Emissions Forecast Assumptions and Methodology

BUSINESS-AS-USUAL

The baseline inventory was used to project the future community-wide GHG emissions under a business-as-usual (BAU) scenario. Cupertino's GHG emissions were forecast for the years 2020, 2035, and 2050 assuming that historic trends describing energy and water consumption, vehicle miles travelled, and solid waste generation will remain the same in the future, on a per unit basis (i.e., per resident, per employee, per service population). Therefore, emissions forecasts demonstrate what emissions levels are likely to be under a scenario in which no additional statewide or local actions are taken to curtail emissions growth.

Although most other cities participating in this collaborative CAP development process (i.e., Gilroy, Morgan Hill, San Jose, Saratoga, Santa Clara County) used *Plan Bay Area* growth projections to provide regional consistency, Cupertino's General Plan was in the process of being updated at the time of CAP development. Therefore, to ensure that the CAP covered the same growth projections being planned for in the General Plan Amendment, the CAP used population and employment projections that align with the General Plan's Preferred Land Use Alternative (which was also the highest-growth alternative analyzed). These same growth assumptions were used by the City's General Plan Amendment transportation consultant to develop the VMT estimates used to prepare the baseline emissions inventory (as described above). Table B-2 below presents the population and employment baseline and projection estimates used to develop the CAP's emissions forecasts. The service population line is the sum of population and employment. The forecasts applied different growth rates (i.e., population, employment, service population) to different emissions sectors, depending upon how these factors would influence future emissions.

Population growth rates were used to forecast residential electricity and natural gas use. Employment growth rates were used to forecast commercial/industrial electricity and natural gas

use, and off-road emissions sources. Service population growth rates were used to forecast water consumption, wastewater generation, and solid waste generation. As described in the transportation sector above, transportation emissions were based on estimated VMT growth as related to the City's General Plan Amendment highest growth scenario.

Table B-2 Population and Employment Factors				
	2010[1]	**2020**	**2035**	**2050[2]**
Population	58,739	62,926	69,207	75,488
Employment	26,220	32,227	41,238	50,249
Service Population	84,959	95,153	110,445	125,736

[1] 2010 population and employment values from Cupertino GPA EIR Volume 1, Pg 4.11-7, Table 4.11-1 Population, Household, and Employment Projections

[3] 2040 population and employment values from Cupertino GPA EIR Volume 1, Pg 3-12 were used to estimate 2050 values

Note: Linear interpolation used to calculate 2020 and 2035 values (i.e., straight line growth from 2010 to 2040)

FORECAST METHODOLOGY

The projected population and employment growth described above was used to project all non-transportation emission sectors (i.e., energy, solid waste, water, wastewater, off-road equipment). The following formula provides an example of how GHG emissions were projected using average annual growth rates:

$$\text{Emissions}_{PHY} = \text{Emissions}_{BASE} + (\text{Emissions}_{BASE} \times AAGR \times \text{Years})$$

Where:

Emissions$_{PHY}$ = GHG emissions during the planning horizon year

Emissions$_{BASE}$ = GHG emissions during the baseline year

AAGR = average annual growth rate (either population, employment, or service population,

as previously described)

Years = years of growth between the baseline and planning horizon year

For example, the planning horizon year 2020 emissions were projected from the baseline year 2010, which involves 10 years of growth (i.e., *Years* factor above). The planning horizon year 2035 involves 30 years of growth.

Transportation Sector

The preceding methodology was used to forecast emissions in all sectors except for transportation emissions. For the transportation sector, the City's General Plan Amendment transportation consultant provided buildout year 2040 VMT activity levels using the same activity-based travel model used to develop baseline year 2013 VMT. The 2040 VMT values are based on population and employment estimates that correlate to build out of the land uses identified in the General Plan Amendment. Daily VMT values were converted to annual VMT values using an annualization factor determined for each planning horizon year by the General Plan Amendment transportation consultant. The 2020 and 2035 horizon years VMT estimates were interpolated using the traffic consultant's 2013 and 2040 values, and 2050 horizon year was extrapolated from these values.

Municipal Operations Inventory and Methodology

The California Air Resources Board, ICLEI – Local Governments for Sustainability (ICLEI), and the Climate Registry (TCR) have co-developed standardized methods for quantifying and reporting GHG emissions from local government sources. These methods are contained within the Local Government Operations Protocol (LGOP).

As with the community-wide baseline inventory described in the preceding section, the Cupertino municipal operations 2010 baseline inventory was developed by a different team than that which prepared the CAP document and emissions forecasts (see the introduction to this Appendix for further description).

EMISSIONS QUANTIFICATION METHODOLOGY

Emissions Inventory Boundaries

Establishing the boundaries of an emissions analysis is an important first step in the greenhouse gas (GHG) inventory process. A city exerts varying levels of control or influence over the activities occurring within its borders. A municipal GHG inventory should be defined broadly enough to include all emissions sources that fall within the local government's direct and indirect control. In general, the inventory should encompass sources that are within the purview of the City's discretionary actions and regulatory authority, and can additionally include sources of indirect emissions that can be influenced by City policies or programs, such as solid waste reduction.

Cupertino's Organizational Boundary

Setting an organizational boundary for a GHG inventory involves identifying the facilities and operations that are to be included. National and international GHG accounting standards define the organizational boundary as the boundary that determines the operations owned or controlled by the reporting entity. The City of Cupertino's municipal operations inventory

encompasses the GHG emissions resulting from actions governed directly by the local government, such as municipal buildings, fleet, and streetlights. It should be noted that emissions from City employee commute trips were excluded from the inventory due to the lack of ownership of or control over the employee vehicles and employees commuting choices. This exclusion is compatible with the guidance provided within the LGOP, in which this emissions source can be voluntarily reported but is not required.

Scope of Emissions Sources in Cupertino

The GHG Protocol defines the operational boundary as the sum of all sources of direct and indirect emissions that are included in the inventory. The GHG Protocol divides the operational boundary into three different Scopes, defined as follows:

- **Scope 1** emissions are those that come from sources that are owned or controlled by the reporting entity, in this case, the City of Cupertino. From the municipal perspective, Scope 1 emissions are direct GHG emissions from sources owned or controlled by the City within Cupertino's boundaries. Such sources include stationary emitters like furnaces and boilers, and mobile emitters like vehicles and construction equipment.

- **Scope 2** emissions are indirect GHG emissions related to the consumption of purchased energy (i.e., electricity) that is produced by third-party entities, such as power utilities. From the municipal perspective, the emissions associated with all electricity purchased by the City are considered Scope 2.

- **Scope 3** emissions are other indirect GHG emissions not covered by Scope 2 that are associated with municipal activities. In a municipal inventory this generally includes emissions occurring upstream or downstream of a municipal activity, such as the methane emissions resulting from degradation of the City's solid waste deposited at a landfill outside of city limits, or the electricity used to pump water to the City from upstream reservoirs. Quantification and reporting of Scope 3 emissions is generally considered optional, but including them in a municipal inventory is appropriate where there is local control over an activity that has an indirect emissions reduction impact, such as diverting waste from landfills.

The 2010 municipal operations inventory includes emissions from the following sectors:

- **Facilities:** This sector comprises direct stationary emissions from natural gas combustion (Scope 1) and indirect emissions from purchased electricity for City buildings and facilities, and City streetlights and traffic signals (Scope 2);

- **Vehicle Fleet:** This sector includes direct emissions from fuel combustion in fleet vehicles (Scope 1);

- **Solid Waste:** This sector consists of the total solid waste sent to or contained within government-operated landfills (Scope 3), and solid waste sent to a landfill that is generated by government-owned and/or operated facilities (Scope 3); and

- **Water:** This sector includes indirect emissions from electricity used to convey and treat water consumed by municipal operations (Scope 2).

MUNICIPAL OPERATIONS INVENTORY METHODOLOGY BY SECTOR

Facilities

The Facilities sector comprises the Building Energy and Public Lighting subsectors. Building Energy emissions were calculated using metered electricity and natural gas activity data from the buildings and facilities operated by the City of Cupertino and 2010 emission factors. The activity data and emission factors were provided by PG&E. The Public Lighting subsector includes electricity consumption from City-operated streetlights, traffic lights, and other outdoor lighting operated by the City. Emissions were calculated using activity data from the streetlight, traffic light, and other outdoor lighting meters and 2010 emission factors. The activity data and emission factors were provided by PG&E, which were entered into ICLEI's CACP software.

Vehicle Fleet

This sector includes emissions from on-road and off-road fuel consumption from vehicles operated by the City of Cupertino, including the City vehicle fleet. Fleet data and fuel usage data was provided by the City. Relevant emission factors contained in ICLEI's CACP software were applied to both gasoline and diesel fuel quantities to obtain emissions estimates.

Solid Waste

The Solid Waste sector comprises the Municipal Operations and Landfill subsectors. The Municipal Operations subsector includes landfill methane emissions produced by solid waste generated by City government facilities. Municipal solid waste and recycling volume data was provided for each City facility. Emission factors for various waste categorization types contained in ICLEI's CACP software were used to quantify GHG emissions associated with municipal solid waste.

Water

This sector comprises electricity consumed by the City's water delivery subsector. The activity data were provided by each City facility. Emission factors contained in ICLEI's CACP software were used to estimate GHG emissions associated with municipal water consumption.

Municipal Operations Emissions Forecast Assumptions and Methodology

FORECAST METHODOLOGY

While standardized methods for quantifying *baseline* local government operations emissions are provided within the LGOP, the LGOP does not provide guidance on developing *future-year* emissions forecasts. For this reason, the CAP project team utilized a growth estimation methodology based on methods used frequently within city fiscal impact analyses. Rather than assuming that each emissions sector will increase at a one-to-one ratio with new population and employment growth, the analysis assumes that a portion of each sector's activity is independent and not influenced by growth. To reflect this assumption, the analysis estimates the degree of independence or dependence (expressed as a variable percentage) for each sector. The higher the percentage the more closely correlated the growth in emissions is to the growth in population and employment (referred to as service population). The factors used within the CAP are presented below in Table B-3.

Table B-3 Sector Activity Growth Variable Factors	
Sector/Subsector Variable	**Variable Factor**
Facilities	
Building Energy	40%
Public Lighting	40%
Vehicle Fleet	60%
Solid Waste	40%
Water Services	100%

Municipally-generated waste, building energy, and public lighting factors are 40% based on the understanding that future city growth will not create much additional need for City administrative operations, and since the growth is of an infill nature it is unlikely that public lighting needs will greatly increase (i.e., extensive new roads constructed that require net new street light installations). The vehicle fleet factor is 60% based on the assumption that the infill growth will generate only a small increase in the need for additional City vehicle use (e.g., code enforcement, parks department). The solid waste sector applies a 40% factor based on the assumption that growth in the community's service population would not directly result in proportional increases in municipal solid waste generation. Rather it assumes marginal growth in new City employees who would generate additional waste. The water sector conservatively used a 100% factor based on the assumption that treating and pumping demand will likely grow in close parallel to service population growth. However, given the relatively small contribution of water emissions to the City's baseline inventory, even a 40% factor as applied to other sectors would result in nearly identical emissions as when using a 100% factor.

Additionally, the analysis applied service population factors to identify the amount of emissions likely generated by an additional resident and employee. A residential factor of 100% and an employment factor of 50% were utilized. The lower employment factor serves to reduce the overall service population growth factor, and reflects the reality that the average resident demands considerably more services than the average non-resident employee. Table B-4 demonstrates how these factors dampen the service population growth rate to create the weighted service population values that from the basis for the forecast's growth rate estimates.

The application of the sector variable factors and the residential and employment factors provide a more nuanced method for estimating municipal operations growth. Using this method, emissions forecasts were developed for 2020, 2035, and 2050.

Table B-4 Residential and Employment Factors Influence on Service Population Growth Rates								
	2010		2020		2035		2050	
	Value	Service Factor	Value	Service Factor	Value	Service Factor	Value	Service Factor
Population	58,739	1.0	62,926	1.0	69,207	1.0	75,488	1.0
Employment	26,220	0.5	32,227	0.5	41,238	0.5	50,249	0.5
Service Population	84,959		95,153		110,445		125,737	
Weighted Service Population	71,849		79,040		89,826		100,612	
Weighted Service Population Annual Growth Rate	-	-	2010-2020	1.00%	2020-2035	0.91%	2035-2050	0.80%

Note: See Table B-2 for sources of population and employment values

Similar to the community-wide emissions forecast methodology described in the previous section, the municipal operations emissions were forecasted using the following formula:

$$\text{Emissions}_{PHY} = \text{Emissions}_{BASE} + (\text{Emissions}_{BASE} \times \text{SP}_{WEIGHTED} \times VF \times \text{Years})$$

Where:

$Emissions_{PHY}$ = GHG emissions during the planning horizon year

$Emissions_{BASE}$ = GHG emissions during the baseline year

$SP_{WEIGHTED}$ = weighted service population annual growth rate from Table B-4

VF = variable factor from Table B-3

$Years$ = years of growth between the baseline and planning horizon year

Emissions Reduction Estimates Methodology

This section of the appendix summarizes the methodology for quantifying the greenhouse gas (GHG) reductions estimates resulting from implementation of the local CAP measures. Calculations and/or background information are shown for horizon year 2020 (unless otherwise stated). Supporting tables may show reduction totals that vary slightly from those presented in the CAP due to rounding.

BASELINE AND MITIGATED SCENARIOS

Many of the emissions reduction calculations described throughout this section are based on a baseline scenario (e.g., how much energy would be consumed if the measure *is not* implemented) and a mitigated scenario (e.g., how much energy would be consumed if the measure *is* implemented). The difference between the baseline and mitigated scenarios represents the measure's reduction potential (i.e., baseline scenario - mitigated scenario = reduction potential).

The baseline energy use scenarios were calculated by multiplying the total housing units or square footage (shown in Tables B-7 and B-8 below) by climate zone-specific energy consumption factors (shown in Tables B-9 and B-10 below). Mitigated energy savings estimates were based on outputs from Lawrence Berkeley Laboratory's Home Energy Saver™ building energy modeling software, unless otherwise stated. As with the baseline calculations, total energy savings were calculated by multiplying the total units or square footage by participation rates assumed for each measure (shown as Progress Indicators in the CAP) by mitigated energy consumption factors.

Mitigated energy savings were then subtracted from baseline energy use levels to derive the total energy savings associated with the measure. These energy savings (expressed as kWh and therms) were multiplied by energy emissions factors expressed as MT CO_2e/kWh and MT CO_2e/therm. The electricity emissions factor used in these calculations was PG&E's 2020 estimated emissions factor (unless otherwise stated), which takes into account compliance with the Renewable Portfolio Standard and PG&E's own de-carbonizing activities (e.g., shifting energy purchases from coal-fired power plants to cleaner, natural gas plants). The natural gas emissions factor comes from the US Energy Information Administration. These mitigated scenario energy emissions factors are shown in Table B-5. Emissions reduction estimates were calculated by multiplying the total energy savings by their associated emissions factors, and then adding the electricity and natural gas emissions reductions together for total emissions reductions expressed as MT CO_2e/yr.

Table B-5 Mitigated Scenario Energy Emissions Factors		
Energy Type	**Metric Tons CO_2e/kWh**	**Metric Tons CO_2e/therm**
Electricity[1]	0.000132	-
Natural Gas	-	0.005303

[1] http://www.pge.com/includes/docs/pdfs/shared/environment/calculator/pge_ghg_emission_factor_info_sheet.pdf; see Table B-6 below for emissions factor inputs

Table B-6 Electricity Emissions Factor Inputs			
	Value	**Unit**	**GWP[3]**
CO_2	0.131[1]	MT CO_2/MWh	1
N_2O	0.000003[2]	MT N_2O/MWh	298
CH_4	0.000013[2]	MT CH_4/MWh	25
Total	0.132	MT CO_2e/MWh	1

[1] Source (CO_2 EF):
http://www.pge.com/includes/docs/pdfs/shared/environment/calculator/pge_ghg_emission_factor_info_sheet.pdf

[2] Source (N_2O and CH_4 EF): http://www.epa.gov/cleanenergy/documents/egridzips/eGRID_9th_edition_V1-0_year_2010_Summary_Tables.pdf

[3] Source (GWP - 100-yr): http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

BASELINE BUILDING INVENTORIES

For purposes of establishing the baseline energy use scenarios (from which the future mitigated scenario was developed), the City's electricity and natural gas consumption were modeled per land use type. This allowed application of local CAP measures to specific portions of the community (e.g., single-family homes, warehouses). The selected land use types correspond to those used in the California Energy Commission's Residential Appliance Saturation Survey and Commercial End Use Surveys, which describe energy consumption levels by building type across the state's various climate zones. Use of this type of granular data helped to make the emissions reduction estimates as closely applicable to Cupertino's local climate, as opposed to using more generalized assumptions, such as average California household electricity use or national-level data.

Residential land use types included single family-detached and –attached, 2-4 unit multi-family properties, 5+ unit multi-family properties, and mobile homes. Data from the Department of Finance's Table E-5 was used to estimate the future proportion of total residential units within these land use types based on the city's 2010 ratios as shown in Table B-7. These ratios were

then held constant through 2020 and 2035 reduction estimates, by multiplying the estimated total housing units in those years by these housing type ratios. This approach is consistent with the business-as-usual methodology used when developing the emissions inventory forecasts.

Table B-7 Cupertino 2010 Housing Units by Building Type						
	Total	Detached	Attached	2 – 4 Unit	5+ Unit	Mobile Home
Units	21,027	12,060	2,557	1,988	4,422	0
% of Total	100%	57.4%	12.2%	9.5%	21.0%	0.0%

Source: California Department of Finance, Table 2: E-5 City/County Population and Housing Estimates, 4/1/2010

Finding accurate data on the square footage of existing non-residential buildings in a community is typically more challenging than finding existing housing unit data, since there is no state database or annual report on this metric (at the city-specific level). Therefore, non-residential square footage estimates were collected from the City's General Plan Amendment Environmental Impact Report (EIR) and used as a proxy for the CAP's 2010 baseline year. The General Plan's buildout year estimates for 2040 were also used. Estimates for 2020 and 2035 were calculated using an average annual growth factor between the 2010 and 2040 values. Table B-8 shows the non-residential square footage estimates used to calculate the emissions reduction baseline and mitigated scenarios.

Table B-8 Cupertino Non-Residential Area				
Land Use Type	Built/Approved (square feet)	New from GPA (square feet)	Total in 2040 (square feet)	Average Annual Growth/yr
Office	8,929,774	4,040,231	12,970,005	1.7%
Commercial	3,729,569	1,343,679	5,073,248	1.3%

Source: City of Cupertino General Plan Amendment, Housing Element Update, and Associated Rezoning EIR, Volume I, Pg 3-13, Table 3-2 Summary – All Project Components Development Allocations

Data from the real estate analysis company Co-Star was also collected as part of the regional climate action planning project in which Cupertino was a participant. This data identified a 2010 baseline in non-residential area of approximately 14.4 million square feet, or 14% greater than the estimate provided in the City's General Plan EIR. In order to make the most conservative CAP reduction estimates, the values found in the EIR were used. This means that measures estimating commercial energy savings were applied to a smaller population group (i.e., square footage of commercial space) than might actually exist, resulting in lower, or more conservative, reduction estimates. CAPs are inherently based on numerous assumptions,

and it is industry practice to make more conservative assumptions when possible to avoid over-estimating the reduction potential of measure implementation.

BASELINE ENERGY USE BY BUILDING TYPE

As mentioned above, the baseline energy consumption scenarios were modeled using data from the CEC's reports. Baseline residential energy consumption levels (i.e., kWh/unit, therms/unit) were modeled by land use type using the CEC's Residential Appliance Saturation Study (RASS) data for Forecast Climate Zone 5 (see Table B-9). The housing types nomenclature used in the RASS does not exactly align with the terminology used in the DOF's housing estimate data shown in Table B-1, so "Single Family" in Table B-3 includes "Detached" units from Table B-1, while "Townhome" includes "Attached" units.

Table B-9 Baseline Residential Energy Consumption by Housing Type in Forecast Climate Zone 5		
Housing Type	**kWh/unit/year**	**therms/unit/year**
Single-Family	6,138	691
Townhome	3,815	402
2-4 Unit Apartment	3,418	376
5+ Unit Apartment	3,466	245

Source: 2009 California Residential Appliance Saturation Study, Prepared for California Energy Commission, Prepared by KEMA, Inc., October 2010

Baseline commercial energy consumption levels (i.e., kWh/sqft, kBTU/sqft) were identified by land use type using the CEC's Commercial End Use Survey (see Table B-10).

Table B-10 Baseline Commercial Energy Consumption by Land Use Type		
Housing Type	**kWh/square foot/year**	**kBTU/square foot/year**
Large Office	15.25	23.28
Retail	12.65	5.51

Source: California Commercial End-Use Survey, Prepared for California Energy Commission, Prepared by Itron, Inc., March 2006

DEMOGRAPHIC PROJECTIONS

Population, employment, and housing unit estimates were also prepared to support calculations for certain reduction measures. Table B-11 presents these values and their sources.

Table B-11
Cupertino Population, Employment, and Housing Unit Projections

	2010	2020	2035	2040
Population	58,739[1]	62,926	69,207	71,300[2]
Employment	26,220[1]	32,227	41,238	44,242[2]
Housing Units	21,027[1]	22,625	25,021	25,820[2]

[1] 2010 population and employment values from Cupertino GPA EIR Volume 1, Pg 4.11-7, Table 4.11-1 Population, Household, and Employment Projections

[2] 2010 housing unit value from California Department of Finance, Table 2: E-5 City/County Population and Housing Estimates, 4/1/2010

[3] 2040 population, employment, and housing unit values from Cupertino GPA EIR Volume 1, Pg 3-12

Note: Linear interpolation used to calculate 2020 and 2035 values (i.e., straight line growth from 2010 to 2040)

Community-wide Measures

C-E-1 ENERGY USE DATA ANALYSIS

This measure estimates the emissions reductions resulting from implementation of an advanced building energy management program to identify building optimization opportunities in system maintenance and operational controls. The calculations were based on electricity and natural gas use forecasts by land use type. Each land use type's total energy use was then multiplied by the end-use appliance and equipment ratios per the CEC's Commercial End Use Survey and Residential Appliance Saturation Study. This established the baseline scenario for energy use by land use type and end use.

The mitigated scenario was developed by applying varying energy savings to end use equipment in the baseline scenario. The assumed energy savings potential was based on a presentation from First Fuel, a building-energy analytics company that specializes in identifying low- or no-cost building energy optimization improvements.

The following end uses were assumed to realize 20% electricity savings in non-residential land uses through implementation of this measure:

- Cooling
- Exterior Lighting
- Heating
- Interior Lighting
- Office Equipment
- Ventilation

The following end uses were assumed to realize 20% electricity savings in single-family residential land uses through implementation of this measure:

- Convention Heaters
- Auxiliary Heaters
- Central Air Conditioning
- Room Air Conditioners
- Outdoor Lighting

C-E-2 RETROFIT FINANCING

This measure estimates the reduction in energy-related emissions (i.e., electricity and natural gas) resulting from retrofitting existing residential units and commercial properties. The measure includes retrofitting both residential and commercial properties based on pre-defined packages of energy efficiency retrofits. The basic retrofit package includes installation of high-efficiency light bulbs, ductwork sealing, and installation of programmable thermostats. The comprehensive retrofit package additionally includes gas water heater upgrades, gas furnace upgrades, attic insulation, and building envelope sealing/weatherization. Reduction estimate calculations for this measure included energy savings associated with past installation of utility-sponsored retrofit programs and estimates for similar types of retrofits.

PG&E provided energy savings related to residential and commercial efficiency programs that were installed in Cupertino homes and businesses between 2010 (the CAP's baseline year) and the second quarter of 2014 (the most current data available at the time of plan preparation). This data identified the following utility program-related energy savings within the Cupertino community, which were multiplied by the mitigated scenario emissions factors shown in Table B-5 to calculate associated emissions reductions:

	Residential	Commercial	Total	Reductions (MT CO_2e/yr)
kWh/yr	3,799,126	19,401,506	23,200,632	3,062
therms/yr	12,596	621,618	634,214	3,363
Total	-	-	-	**6,425**

Source: PG&E, 2014

In addition to these past reductions that have already been realized since the CAP's 2010 baseline year, this measure estimates additional future building retrofits that could be implemented by 2020. As described in Measure C-E-2 and C-E-3, there are several retrofit-oriented programs available to Cupertino residents, which could drive this future participation. It is likely that utility-sponsored programs will continue into the near future, through Energy

Upgrade California or similar programs. The City plans to continue its Green@Home and GreenBiz programs, which offer additional incentives to make energy- and water-saving retrofits. The City is also a participating member of the CaliforniaFIRST PACE program, which provides funding for commercial, industrial, and multi-family retrofit and renewable energy projects, with plans to roll out financing opportunities to single-family residents in the near future. Finally, Measure C-E-3 directs the City to partner with the local Realtor community to develop and implement an aggressive home and commercial building retrofit outreach campaign to advertise available financing/funding opportunities and provide local examples of retrofit energy and water savings for various property types. Based on comments from Realtor representatives who participated in a CAP focus group meeting, residential turnover is approximately 3% per year in Cupertino. The homeowner outreach program was devised as a point-of-sale strategy, so approximately 15% of Cupertino housing units could be introduced to the program by 2020. The CAP estimates that participation in all of these various retrofit-related programs could result in an additional 8% of housing units pursuing some type of energy-retrofit installation, with 5% of residential units pursuing a comprehensive package, as described above, and 3% pursuing a basic retrofit package. It also assumes that 7% of non-residential properties pursue comprehensive retrofit packages.

This additional level of participation in retrofit programs is estimated to provide reductions of an additional 1,727 MT CO_2e/yr, as shown in the table below, for total measure reductions of approximately 8,150 MT CO_2e/yr.

	Total	Reductions (MT CO_2e/yr)
kWh/yr	4,183,460	552
therms/yr	221,618	1,175
Total	-	**1,727**

Source: AECOM SSIMe^{TM} Building Energy Analysis, 2014

C-E-5 COMMUNITYWIDE SOLAR PHOTOVOLTAIC DEVELOPMENT

This measure estimates the reduction in electricity-related emissions resulting from installation of grid connected photovoltaic (PV) systems in residential and commercial uses. The measure uses National Renewable Energy Laboratory (NREL) solar insolation data specific to the City's geographic location and climate to estimate future PV-related reductions, or conversion of kilowatt hours to MT CO_2e/yr in instances when a solar analysis has calculated potential electricity generation rates.

This measure considers reductions resulting from solar PV systems installed community-wide from 2010-2014, the planned solar generation potential related to the Apple 2 Campus project,

the anticipated municipal solar installations (described in Measure M-F-2), and potential additional community-wide installations to occur by 2020.

Similar to the retrofit-related energy savings described in Measure C-E-2 above, PG&E also provided data on the amount of solar PV generation capacity installed community-wide from 2010-2014. Based on this data, approximately 5.5 MW of solar capacity were installed during that timeframe.

Based on the Draft EIR prepared for the Apple 2 Campus project, the new facility will incorporate approximately 650,000 square feet of solar panels capable of generating 15,000,000 kilowatt hours per year (kWh/yr).

The City has prepared solar reports to study the potential of municipal solar PV systems on City buildings/property, and has selected five viable sites for future installations. These systems combined would generate approximately 820,000 kWh/yr.

In addition, currently available tax credits, utility rebates, and financing programs make solar PV installations increasingly economically viable, which will likely lead to additional residential and non-residential installations in the future. PG&E is also beginning to implement its community shared solar program to further encourage development of local solar PV systems and participation in their development through purchase programs that sell the generated electricity locally. Therefore, the CAP conservatively assumed installation of another 1.5 MW of solar PV capacity by 2020 (i.e., in addition to the capacity installed since 2010, the planned Apple 2 Campus system, and the City's five planned municipal systems). This conservative estimate takes into account the gradual phase-out of California utility-funded solar incentive programs.

Where only generation capacity (e.g., kW, MW) was known or estimated, total installed capacities were multiplied by NREL solar insolation data to calculate total kWh of electricity generation potential. This total was then multiplied by the mitigated scenario emissions factor shown in Table B-5 to calculate the GHG emissions that would be offset by installation of the assumed PV systems. Where total generation potential was known, that amount of electricity was simply multiplied by the mitigated scenario emissions factor to calculate associated reductions.

The table on the following page demonstrates the inputs and calculations.

	Generation Capacity (MW)	Generation Potential (kWh/yr)	Reductions (MT CO₂e/yr)
Past Installations – 2010-2014	5.5[1]	9,470,000[2]	1,250
Future Installations – 2015-200	1.5	2,580,000[2]	341
Apple 2 Campus	-	15,000,000[3]	1,980
Municipal Solar Projects	-	820,000[4]	108
Total			**3,679**

[1] PG&E, 2014

[2] Calculated using NREL factors shown in table below

[3] Apple 2 Campus Project EIR, Pg 506 Renewable Energy Generation

[4] Solar Feasibility Study for the City of Cupertino, Prepared by Optony, Inc, December 2012

The table below demonstrates the assumptions used to convert solar PV system installed capacity to electricity generation potential, based on solar insolation data specific to Cupertino provided by NREL. While the table shows efficiency and area assumptions, these specific assumptions are not important to the calculation since they are directly related. That is, if the installed system's efficiency is greater than 15%, then the required system area can be reduced to generate the same amount of electricity. Conversely, if the system is less efficient, then a greater installation area would be required to generate the same amount of desired electricity.

Generation Potential (MW)	Watts/square foot	Efficiency	Area (square feet)	kWh/sqft/day[1]	Electricity Generated (kWh/yr)
1.5	15	15%	100,000	0.47	2,583,912
5.5	15	15%	366,667	0.47	14,527,329

[1] Solar Insolation data: National Renewable Energy Laboratory Renewable Resource Data Center, 2011

C-E-6 COMMUNITY-WIDE SOLAR HOT WATER DEVELOPMENT

This measure quantifies natural gas-related emissions reductions resulting from the installation of solar hot water heaters in residential units. Baseline water heating-related natural gas consumption levels per residential unit type were identified using CEC's Residential Appliance Saturation Survey data for Forecast Climate Zone 5. In addition, CEC data identifies the energy savings potential of solar hot water heaters for specific climates in California. The measure assumes that 47-63% of water-heating natural gas can be reduced through the use of solar hot water heaters, depending on the performance of the system and the building type in which it is installed.

Current utility-rebate programs have had little impact at broadly attracting solar hot water system users (e.g., California Solar Initiative – Thermal Program). This is possibly due to a combination of system expense and relatively cheap natural gas prices applicable to traditional hot water heater systems. However, the state's utilities have begun implementing more aggressive solar hot water pilot programs to identify the incentive levels at which participation begins to improve, and these programs may be expanded beyond pilot studies in the future. Therefore, the CAP assumed zero solar hot water installations would occur community-wide prior to 2020, but that participation would begin to occur by the 2035 target year. The CAP assumes that 5% of residential units and 5% of non-residential square footage will install (or have access to) a solar hot water heater by 2035.

The table below demonstrates the assumptions used to convert estimated solar hot water system installations to total therms or kBTU savings. Therms saved are then multiplied by the mitigated scenario emissions factor shown in Table B-6 (kBTU were first converted to therms and then multiplied by the emissions factor).

Residential Land Uses						
Property Type	Units (2035)	Hot water heater energy per unit (therms/yr)[1]	Solar Fraction[2]	Energy Savings per unit (therms/yr)	Participation Rate (% of units)	Total Savings (therms/yr)
Single-Family	15,110	169	70%	118.04	5%	89,180
Townhome	2,653	146	70%	102.44	5%	13,591
2-4 Unit Apartment	2,093	116	64%	74.22	5%	7,766
5+ Unit Apartment	5,154	72	64%	45.93	5%	11,837
Commercial Land Uses						
Property Type	Square Footage (2035)	Hot water heater energy per SF (kBTU/yr)[1]	Solar Water Heater Effectiveness[2]	Energy Savings per SF (kBTU/yr)	Participation Rate (% of square footage)	Total Savings (kBTU/yr)
Large Office	12,670,729	1.781	30%	0.53	5%	338,461
Retail	4,973,716	1.040	30%	0.31	5%	77,602

[1] Baseline Hot Water Natural Gas Consumption: Residential Appliance Saturation Survey, CEC, 2010; California Commercial End-Use Survey, CEC, 2006

[2] Solar Fraction: Solar Water Heating CEC 2013 Title 24 Pre-rulemaking Workshop, California Energy Commission, June 9, 2011; Solar Insolation: National Renewable Energy Laboratory Renewable Resource Data Center, 2011

C-E-7 COMMUNITY CHOICE ENERGY OPTION

The CAP explored several long-term reduction opportunities that were analyzed for the potential impact on the 2035 target, but were assumed to be infeasible for full implementation by the 2020 target year. One option explores community-wide participation in a community choice energy (CCE) district.

The measure assumes that by 2035, 75% of the community would voluntarily participate in a CCE district in which they purchase 100% emissions-free electricity. The Marin Clean Energy District currently provides electricity to 75% of its service population, so this participation rate was used as a best estimate for what might be possible in Cupertino at full program implementation.

Total electricity consumption projected for the 2035 horizon year was multiplied by the participation factor of 75% and then multiplied by PG&E's estimated 2020 electricity emissions factor (see Table B-6) to calculate the total GHG emissions that would be avoided by CCA participation. Calculation inputs are shown in the table below.

End User	kWh/yr	Participation Rate	Emissions Reductions (MT CO_2e/yr)
Residential	147,189,027	75%	14,571
Commercial / Industrial	431,644,101	75%	42,732

C-T-3 TRANSPORTATION DEMAND MANAGEMENT

This measure estimates the impact of transportation demand management programs designed to reduce single occupancy vehicles trips through commuter benefit programs as directed through SB 1339 and planned for at the new Apple 2 Campus project (per the project's EIR analysis). The estimated vehicle trip reductions were developed based on research available regarding the efficacy of various transportation demand management program options. The calculations assume implementation of rideshare/vanpool programs, telecommuting/alternative work schedules, and subsidized transit fares.

This measure assumes the following level of performance from each transportation demand management components. It is estimated that the enhanced rideshare program would yield a 3% reduction in auto commute trips. The telecommuting program would reduce auto commute trips by 2%. Subsidized transit passes at $40 per month program would reduce auto commute trips by 5%. Cumulatively the TDM program would achieve a 10% reduction in auto commute trips. These reductions were estimated by reviewing relevant TDM literature and case studies from existing TDM programs.

Rideshare promotion – A study conducted by Reid Ewing concluded that ridesharing programs can reduce daily vehicle commute trips to specific worksites by 5-15%, and up to 20% or more if implemented with parking pricing. This measure assumes 3% of commute trips shifted from single-occupancy vehicle (SOV) to other modes.

Telecommuting/alternative work schedule – A Center for Urban Transportation Research survey found vehicle trips reduced by up to 8% if 50% of employees are participating in alternative work programs, making it among the most effective commute trip reduction strategies considered in that study. A National Association of Regional Councils analysis estimates that compressed work weeks can reduce up to 0.6% of VMT and up to 0.5% of vehicle trips in a region. This measure assumes telecommuting/compressed work will result in an additional 2% of commute trips shifted from SOV to other modes (when combined with the other identified TDM programs).

Subsidized transit fares – Various studies of the impact of subsidized transit passes indicate reductions in drive-alone mode share of 4% to 42%, with an average reduction of 19%. This measure estimates an additional reduction in vehicle trips from transit pass subsidies of 5% (when combined with the other identified TDM programs).

The measure calculated a baseline scenario in which travel patterns remained constant from 2010 to 2020, and a mitigated scenario in which employees voluntarily participated in the TDM program offerings available at their jobs. The VMT difference in these two scenarios was used to calculate the estimated GHG emissions reduction attributed to implementation of this measure.

The baseline scenario assumes that 80% of vehicle trips in Cupertino are made in single-occupancy vehicles (per 2010 Census data). It also assumes that the average commute length is 15 miles (one way). It also assumes 255 commute days per year (five days per week, minus 5 holidays). Finally, it assumes that 3,200 employees community-wide will participate in ridesharing, telecommuting/alternative work schedule, or subsidized transit fares by 2020, representing approximately 10% of the 2020 estimated workforce. Apple already offers a comprehensive TDM program to its current employees in Cupertino. Per the Apple 2 Campus Project Draft EIR, these TDM programs would be offered to the 9,356 net new employees at the project site, along with expanded TDM offerings. The TDM program expansion would include increased Apple Transit service to additional geographic areas and with increased frequency, as well as mass transit shuttle links to expand current shuttle service to future high-capacity corridors, such as VTA BRT lines, electrified Caltrain lines, and Santa Clara BART extensions (Apple 2 Campus Project Draft EIR, pg 515). The CAP conservatively estimates that 10% of its employed population will have access to TDM programs, though it is likely that a higher proportion will ultimately have access to such programs following completion of the Apple 2 Campus project.

All of these factors were multiplied to establish a baseline annual VMT associated with SOV commuting. The VMT reduction rates described above were applied to this SOV VMT value to

determine the annual VMT reduction associated with implementation of this measure. The reduction was expressed as a percentage of total community-wide VMT, and then applied to fuel consumption estimates from the 2020 emissions projections. The result was total gasoline and diesel fuel consumption that would be reduced as a result of this measure, which were then multiplied by emissions factors provided by the California Air Resources Board EMFAC model to estimate total GHG emissions reductions. The following table shows the values and inputs used to calculate emissions associated with implementation of this measure.

Percent Reduction in VMT from Implementation of TDM Measures				
	VMT Split by Vehicle Fuel Type		Reduction in Total VMT by Vehicle Fuel Type	
	Gasoline	Diesel	Gasoline	Diesel
Reduction in Total VMT	90.5%	9.5%	0.54%	0.06%

2020 Mitigated Scenario – Vehicle Miles Traveled and Emissions							
	Community Travel (miles)	Weighted Average Fuel Efficiency (mi/gal)	Fuel Consumption (gallons)	Emissions Factors			Total Emissions (MT CO_2e/yr)
				CO_2 (g/gal)	N_2O (g/mi)	CH_4 (g/mi)	
Gasoline VMT (miles)	289,983,711	21.8	13,302,005	8,565	0.0700	0.0620	120,352
Diesel VMT (miles)	30,440,279	9.3	3,273,148	10,007	0.0500	0.0420	33,234
Total	320,423,990		16,575,153				153,586

Calculation of VMT, Fuel Consumption, and GHG Emission Reduction from TDM Measures			
	Community Travel (miles)	Fuel Consumption (gallons)	Total Emissions (MT CO_2e/yr)
Gasoline VMT (miles)	1,734,575	79,568	720
Diesel VMT (miles)	182,082	19,579	199
Total	1,916,657	99,146	919

Reference sources for VMT reduction assumptions related to implementation of TDM programs included:

- Bryon York and David Fabricatore, 2001, Puget Sound Vanpool Market Assessment, www.wsdot.wa.gov

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- Reid Ewing, 1993, TDM, Growth Management, and the Other Four Out of Five Trips.

- Alyssa Freas and Stuart Anderson, 1994, Effects of Variable Work Hour Programs on Ridesharing and Organizational Effectiveness, Transportation Research Record 1321

- Center for Urban Transportation Research, 1998, A Market-Based Approach to Cost-Effective Trip Reduction Program Design, http://ntl.bts.gov/lib/3000/3600/3633/cashdoc.pdf

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- Comsis Corporation , 1993, Implementing Effective Travel Demand Management Measures: Inventory of Measures and Synthesis of Experience, USDOT and Institute of Transportation Engineers (www.ite.org), www.bts.gov/ntl/DOCS/474.html

- Victoria Transport Policy Institute , 2009, Trip Reduction Tables, http://www.vtpi.org/tdm/tdm41.htm

- Victoria Transport Policy Institute , 2008, Transportation Elasticities, http://www.vtpi.org/elasticities.pdf

C-T-7 COMMUNITY-WIDE ALTERNATIVE FUEL VEHICLES

This measure estimates the reduction in vehicle emissions resulting from a community-wide shift towards alternative-fueled vehicles. Based on automobile industry projections and other market absorption studies, assumptions for the potential vehicle fleet transition towards alternative-fuels by 2020 were developed. These assumptions estimate a shift from gasoline and diesel passenger and light duty vehicles to plug-in hybrid electric vehicles (PHEV) and compressed natural gas (CNG) vehicles.

The calculations used the community's 2020 vehicle miles travelled (VMT) estimates to develop a baseline scenario for community-wide transportation emissions (based on the same assumptions used to develop the transportation sector emissions inventory). This scenario includes assumptions for VMT by fuel type (e.g., gasoline, diesel, CNG) and by vehicle class (i.e., passenger cars, light duty trucks, medium duty trucks, heavy duty trucks, buses, motorcycles). Emission factors for the transportation sector were obtained from the California Air Resources Board's (ARB) EMFAC model, which is a mobile source emission model for California that provides vehicle emission factors by both county and vehicle class. Santa Clara County-specific emission factors were used in this calculation. The mitigated scenario includes assumptions for how VMT by fuel type and by vehicle class would begin to shift from one type to another. For example, it assumes that 5% of gasoline passenger cars switch to plug-in hybrid electric vehicles by 2020. Emissions factors for alternative-fueled vehicles were collected from academic studies, industry sources, the US Energy Information Administration, and other agencies. The mitigated scenario vehicle emissions were subtracted from the baseline scenario to estimate the GHG emissions reduction potential of the community-wide shift toward alternative-fueled vehicles described in the measure. The following table identifies the fuel switch-by-vehicle type assumptions used to calculate reductions from this measure.

Fuel Switch Assumptions	
Baseline Fuel and Switch	**Percent VMT Switch**
From Gasoline To:	
Gasoline Passenger Cars	***5%***
Diesel	0%
CNG	0%
BEV	0%
PHEV	5%
Gasoline Light Duty Trucks	***5%***
Diesel	0%
CNG	0%
BEV	0%
PHEV	5%
Gasoline Medium Duty Trucks	***0%***
Diesel	0%
CNG	0%

BEV	0%	
PHEV	0%	
Gasoline Heavy Duty Trucks	***3%***	
Diesel	0%	
CNG	3%	
BEV	0%	
PHEV	0%	
From Diesel To:		
Diesel Passenger Cars	***5%***	
Gasoline	0%	
CNG	0%	
BEV	0%	
PHEV	5%	
Diesel Light Duty Trucks	***0%***	
Gasoline	0%	
CNG	0%	
BEV	0%	
PHEV	0%	
Diesel Medium Duty Trucks	***0%***	
Gasoline	0%	
CNG	0%	
BEV	0%	
PHEV	0%	
Diesel Heavy Duty Trucks	***3%***	
Gasoline	0%	
CNG	3%	
BEV	0%	
PHEV	0%	
Diesel Buses	***60%***	
Gasoline	0%	
CNG	40%	
BEV	0%	
PHEV	20%	

C-W-1 SB-X7-7

Senate Bill X7-7 established a goal to reduce per capita water consumption by 20% by December 31, 2020. In order to calculate the water savings and emission reductions associated with implementation of SB X7-7, the baseline year's total water consumption was divided by the City's baseline population to determine the baseline per capita water consumption rate in units of million gallons per capita per year (MG/capita/yr).

Assuming business-as-usual (BAU) growth, the projected 2020 population was multiplied by the baseline per capita water consumption rate (MG/capita/yr) to estimate the total BAU water consumption in year 2020. Then, assuming implementation of SB X7-7, the baseline per capita water consumption rate was multiplied by (1 – 0.2) to calculate the SB X7-7 target per capita water consumption rate in year 2020. The target per capita water consumption rate was then multiplied by the projected 2020 population to estimate the total water consumption for the City assuming implementation of SB X7-7. Total water savings were calculated by subtracting the SB X7-7 total water consumption from the BAU total water consumption.

The total water savings associated with SB X7-7 were then multiplied by a water intensity factor in units of kilowatt-hours per million gallons to estimate the associated electricity saved from the water savings. Water use was assumed to be 85% indoor water use and 15% outdoor. Indoor water use was calculated using the total water intensity factor, to include wastewater treatment energy use as well. Outdoor water use only used energy intensity factors for supply/conveyance, treatment, and distribution. Water intensity factors were provided by the California Energy Commission's report *Refining Estimates of Water-Related Energy Use in California*, prepared by Navigant Consulting in 2006. Finally, the electricity saved was multiplied by the mitigated 2020 PG&E electricity emissions factor shown in Table B-6 to estimate the GHG savings associated with implementation of SB X7-7 in the community. The table below identifies the inputs used to calculate emissions reductions associated with this measure.

	Value	Units
Baseline Year		
Operational Year	2010	year
Total Water Consumption	3,248	million gallons (MG)
Population (residents)	58,739	capita
Baseline Water Efficiency	0.055	MG/capita/yr
Planning Horizon Year		
Operational Year	2020	year
Planning Horizon Population (residents)	62,926	capita
Total BAU Water Consumption	3,480	million gallons (MG)
SB X7-7 Water Efficiency Level	0.044	MG/capita/yr
Total Water Consumption (under SB X7-7)	2,784	million gallons (MG)
Water Savings	696	MG/yr

Outdoor Savings	*104*	*MG/yr*
Indoor Savings	*592*	*MG/yr*

Water Use Energy Intensity Factors[1]		
Water Process	**Northern CA (kWh/MG)**	**Southern CA (kWh/MG)**
Water Supply/Conveyance	150	8,900
Water Treatment	100	100
Water Distribution	1,200	1,200
Wastewater Treatment	2,500	2,500
Total	3,950	12,700

[1] Source: http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF

C-SW-2 FOOD SCRAP AND COMPOSTABLE PAPER DIVERSION

An inventory of the community's organic waste was created using Cal Recycle waste volume and characterization data. Using the first-order decay methodology from the 2006 IPCC guidelines, fugitive methane emissions from the organic landfill waste were calculated for base-case and mitigated scenarios. This measure assumes that 40% of residential households will divert 80% of food scrap and compostable paper waste from landfills by 2020, and that 10% of commercial businesses with divert 20% through participation in the City's existing food scrap and compostables collection service. The measure further assumes that 85% of residential and commercial landscape waste is diverted from the solid waste stream, either through on-site composting/mulching or disposal in green waste bins. This measure would apply to GHG emissions associated with new waste generated and would not apply to waste in place disposed prior to CAP implementation. Further, these calculations are based on the assumption that the landfill(s) accepting the City's waste have a methane capture system in place with a 75% efficiency rate.

The City's waste inventory was developed using community-wide waste disposal data collected from CalRecycle for the years 1995-2011. These historical disposal rates (i.e., waste tons disposed per population) were projected to 2020 and 2035 using estimated population growth rates, and backcast to 1950 using historic census data. The 2008 State Waste Characterization Study was used to estimate the volume of community-wide waste by various waste categories (e.g., lumber, food scraps, grass). It was assumed that the City's waste composition is comparable to that of the statewide average (as represented in the State Waste Characterization Study). This created the community-wide baseline solid waste emissions profile, against which solid waste diversion measures were calculated.

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The community-wide total 2020 estimated tonnage was then multiplied by the proportional share of each appropriate waste category in the State's waste characterization study, and multiplied by the measure's participation rates to determine the total solid waste to be diverted from implementation of this measure. The IPCC's first-order decay methodology was then applied to calculate the total GHG emissions associated with that volume of waste to determine the measure's GHG reduction.

C-SW-3 CONSTRUCTION AND DEMOLITION WASTE DIVERSION PROGRAM

This measure assumes community-wide compliance with the City's Green Building Ordinance requirement for 60% of construction and demolition (C&D) waste to be diverted from landfills. An inventory of the community's organic waste was created using Cal Recycle waste volume and characterization data. Using the first-order decay methodology from the 2006 IPCC guidelines, fugitive methane emissions from the organic landfill waste were calculated for base-case and mitigated scenarios. This measure assumes that all new construction and applicable retrofit projects will divert 60% of their generated C&D waste from landfills by 2020. This measure would apply to GHG emissions associated with new waste generated and would not apply to waste in place disposed prior to CAP implementation.

The community's waste inventory was developed using community-wide waste disposal data collected from CalRecycle for the years 1995-2011. These historical disposal rates (i.e., waste tons disposed per population) were projected to 2020 and 2035 using estimated population growth rates. The 2008 State Waste Characterization Study was used to estimate the volume of community-wide waste by various waste categories (e.g., lumber, food scraps, grass). It was assumed that the community's waste composition is comparable to that of the statewide average (as represented in the State Waste Characterization Study). The community-wide total 2020 estimated tonnage was then multiplied by the proportional share of each appropriate waste category in the state's waste characterization study, and multiplied by the measure's participation rates to determine the total solid waste to be diverted from implementation of this measure. The IPCC's first-order decay methodology was then applied to calculate the total GHG emissions associated with that volume of waste to determine the measure's GHG reduction.

C-G-1 URBAN FOREST PROGRAM

This measure estimates reductions associated with the carbon sequestration potential of new trees planted as part of City landscaping requirements and development agreements. The calculations are based on extrapolating the carbon potential of a typical tree planting palette. The measure assumes that the nearly 2,400 net new trees described in the Apple 2 Campus project EIR will be planted by 2020, in addition to 100 net new trees planted community-wide. Trees planted to achieve implementation of this Urban Forest Program measure might be found in decorative landscaping, new City street planting strips, or parks and recreation areas.

A sample plant palette was created, including Camphor, Modesto Ash, Sweetgum, Roble Negro, Turkish Pine, Bolander Beach Pine, London Planetree, and Common Crape Myrtle. There are myriad tree palette options, and the tree types included in this measure's calculations may not correlate exactly with those selected for planting in the community. Carbon sequestration rates specific to the species and age of the sample plant palette were collected from the Center for Urban Forest Research (CUFR) Tree Carbon Calculator and used to calculate the annual sequestration potential of the trees from 2015 – 2020. For purposes of the calculation it was assumed that an equal number of trees will be planted each year, though the exact number of trees planted per year may vary.

M-F-1 SUSTAINABLE ENERGY PORTFOLIO

This measure estimates the emissions reductions associated with the City purchasing its electricity from lower-emissions sources than currently provided through PG&E's portfolio. The measure assumes future development of a Community Choice Energy program, in which the City could participate, or municipal participation in PG&E's proposed Green Option program. The measure further assumes that the City would participate in the Green Option program level that provides 75% clean electricity. Alternatively, calculations for participation in the CCE assumed that electricity purchases would be 100% clean.

Both scenario calculations used the City's estimated total kWh/yr based on the 2020 emissions forecast and subtracted the estimated electricity generation of solar PV systems described in M-F-2 to calculate the total remaining electricity the City would need to purchase. The Green Option scenario assumed that 75% of the remaining electricity need would be emissions-free, and used the baseline electricity emissions factor to calculate emissions avoided from implementation of this measure. The CCE scenario assumed that 100% of the remaining electricity need would be emissions-free.

In the CAP, this measure is not included in the 2020 target achievement estimates. It is included in the 2050 target achievement scenario, and in that instance, reductions from the state's Renewable Portfolio Standard (RPS) are omitted to avoid double counting emissions from these overlapping strategies. The table below shows the inputs used to calculate the 2020 reduction estimates for these two scenarios, which are described in the CAP for illustrative purposes only (as presented in the Measure M-F-1 text).

Inputs	Values
2020 Electricity - kWh/yr	5,086,069
2020 Solar PV Production - kWh/yr	818,390
Electricity Available for Measure - kWh/yr	4,267,679

Green Option Scenario	
% Clean Electricity Purchased of City Total	75%
Electricity Affected by Measure - kWh/yr	3,200,759
2020 BAU Emissions Factor – MT CO_2e/kWh	0.000204
Measure Reductions – MT CO_2e/yr	**651**
CCE Scenario	
% Clean Electricity Purchased of City Total	100%
Electricity Affected by Measure - kWh/yr	4,267,679
2020 BAU Emissions Factor – MT CO_2e/kWh	0.000204
Measure Reductions – MT CO_2e/yr	**870**

M-F-2 RENEWABLE OR LOW-CARBON ELECTRICITY GENERATION

This measure assumes the installation of five solar PV systems by 2020 that the City has previously studied. The calculations use the findings from a City-commissioned solar feasibility analysis report. The report estimated the electricity generation potential of the five systems based on solar access, system size, and other applicable factors. The report concluded that approximately 820,000 kWhr/yr of emissions-free electricity could be generated following installation of the five systems. Reductions were calculated by multiplying the electricity generation potential by the mitigated 2020 electricity emissions factor show in Table B-6. Emissions reductions from this measure are presented in combination with reductions associated with the state's RPS, which is why the mitigated electricity emissions factor was used, instead of the baseline emissions factor. This allows reductions from both actions to be calculated and presented separately.

Inputs	Values
2020 Solar Electricity Generation - kWh/yr	818,390
2020 Mitigated Emissions Factor – MT CO_2e/kWh	0.000132
Measure Reductions – MT CO_2e/yr	**108**

M-F-3 ADVANCED ENERGY MANAGEMENT

This measure estimates the emissions reductions resulting from implementation of an advanced building energy management program to identify building optimization opportunities in system maintenance and operational controls. The calculations were based on electricity and natural gas use per facility as identified in the supporting documents to the original baseline inventory. Each facility's total energy use was then multiplied by the end-use appliance and equipment ratios per the CEC's Commercial End Use Survey. The Survey provides information based on different land use types, so proxy land uses were selected to align with the different municipal facilities being analyzed, as follows: City Hall was analyzed as a Large Office, the Monta Vista Recreational Center and Quinlan Community Center were analyzed as Schools, the Corporation Yard was analyzed as an Unrefrigerated Warehouse, and the Engineering Department was analyzed as a Small Office. This established the baseline scenario for energy use by facility and end use. The following table shows the percentage of energy use attributed to each end use within each land use category.

Energy End Use	Large Office	School	Small Office	Unrefrigerated Warehouse
Electricity				
Air Compressors	0.36%	0.00%	0.28%	1.45%
Cooking	0.36%	2.44%	0.26%	0.49%
Cooling	19.54%	10.37%	17.71%	3.03%
Exterior Lighting	2.43%	7.89%	4.41%	12.49%
Heating	2.59%	2.50%	1.80%	1.25%
Interior Lighting	18.76%	40.39%	24.61%	51.68%
Miscellaneous	3.85%	4.25%	4.77%	6.68%
Motors	1.87%	0.92%	0.22%	4.26%
Office Equipment	27.16%	5.77%	31.47%	5.07%
Process	0.00%	0.00%	0.06%	0.00%
Refrigeration	2.15%	6.00%	2.17%	7.28%
Ventilation	20.22%	19.07%	10.86%	5.14%
Water Heating	0.70%	0.42%	1.38%	1.18%
Natural Gas				
Air Compressors	0.00%	0.00%	0.00%	0.00%
Cooking	0.33%	4.05%	0.22%	0.00%
Cooling	0.00%	0.00%	0.00%	0.00%
Exterior Lighting	0.00%	0.00%	0.00%	0.00%
Heating	85.11%	79.63%	95.06%	91.54%
Interior Lighting	0.00%	0.00%	0.00%	0.00%
Miscellaneous	0.00%	0.05%	0.00%	1.61%
Motors	0.00%	0.00%	0.00%	0.00%
Office Equipment	0.00%	0.00%	0.00%	0.00%
Process	0.00%	0.00%	0.00%	0.00%
Refrigeration	0.00%	0.00%	0.00%	0.00%
Ventilation	0.00%	0.00%	0.00%	0.00%
Water Heating	14.56%	16.27%	4.72%	6.84%

The mitigated scenario was developed by applying energy savings to the baseline scenario. Energy savings potential was based on information from First Fuel, a building-energy analytics company that specializes in identifying low- or no-cost building energy optimization improvements. The following end use savings were used to calculate total reductions from implementation of this measure.

Air Compressors – 10% savings (kWh)

Cooling – 20% savings (kWh)

Exterior Lighting – 25% savings (kWh)

Heating – 20% savings (therms)

Interior Lighting – 25% savings (kWh)

Equipment Motors – 20% savings (kWh)

Office Equipment – 20% savings (kWh)

Process Electricity – 10% savings (kWh)

Refrigeration – 10% savings (kWh)

Ventilation – 20% savings (kWh)

Water Heating – 10% savings (kWh)

M-F-4 EXISTING BUILDING ENERGY RETROFIT

This measure estimates the emissions reductions resulting from implementation of building lighting retrofits and plug load efficiency programs identified in the City's detailed energy audit. This audit provided estimates for electricity use reductions totaling approximately 313,000 kWh/yr following implementation of these opportunities. These savings were multiplied by the mitigated electricity emissions factor presented in Table B-6.

Inputs	Values
Building Lighting Retrofits	
Electricity Savings per year- kWh/yr	254,272
2020 Mitigated Emissions Factor – MT CO_2e/kWh	0.000132
Measure Reductions – MT CO_2e/yr	**34**

Plug Load Efficiency	
Electricity Savings per year- kWh/yr	59,130
2020 Mitigated Emissions Factor – MT CO_2e/kWh	0.000132
Measure Reductions – MT CO_2e/yr	**8**

M-F-6 PUBLIC REALM LIGHTING EFFICIENCY

This measure estimates the reduction in electricity-related emissions resulting from installation of high-efficiency street light bulbs. As part of an energy performance contract, the City upgraded 99% of the City-owned streetlights, resulting in savings of approximately 872,000 kWh/yr. In addition to street lights, the City-commissioned detailed energy audit identified opportunities to retrofit lighting at City parks, particularly in parking lots and along pathways. The energy audit estimated an electricity savings potential of approximately 75,000 kWh/yr following implementation of these upgrades. The table below shows the inputs used to calculate emissions reductions associated with this measure. As with most of the other energy measures, these calculations use the mitigated 2020 electricity emissions factor shown in Table B-6.

Inputs	Values
Street Light Retrofits	
Electricity Savings per year- kWh/yr	871,860
2020 Mitigated Emissions Factor – MT CO_2e/kWh	0.000132
Measure Reductions – MT CO_2e/yr	**115**
Parking Lot/Park Facility Light Retrofits	
Electricity Savings per year- kWh/yr	74,898
2020 Mitigated Emissions Factor – MT CO_2e/kWh	0.000132
Measure Reductions – MT CO_2e/yr	**10**

M-F-7 LANDSCAPE WATER CONSERVATION

This measure estimates the reductions associated with water conservation resulting from the City's implementation of climate-sensitive irrigation controllers in 2011 through its energy performance contract. Based on the City's detailed energy audit, this program saves approximately 19 million gallons of water each year. The detailed energy audit also cites a 2008 baseline water use of 137 million gallons per year, so the irrigation efficiency savings provided a savings of approximately 14% over baseline levels. Due to the complexities inherent in modeling emissions associated with potable water use and water conservation, this CAP used a top-down reduction estimate to determine 2020 emissions reductions from this measure. The CAP forecasts estimate water-related emissions in 2020 of 7 MT CO_2e/yr. Since this measure has resulted in water savings of 14% over baseline levels, the CAP calculated 14% of the 2020 emissions value to determine the emissions reductions associated with this measure. The table below shows the inputs used to calculate reductions from this measure.

Inputs	Values
Water Savings from Irrigation Retrofit Program – million gallons/year	19
2008 Baseline Municipal Water Use – million gallons/year	138
Water Savings Achievement	14%
2020 Water Sector Emissions - MT CO_2e/yr	7
Measure Reductions – MT CO_2e/yr	**1**

M-VF-1 LOW EMISSION AND ALTERNATIVE FUEL VEHICLES

This measure estimates reductions associated with transitioning the municipal fleet towards alternative fuel vehicles. The measure is based on the City's desire to comply with the Bay Area Climate Compact's goal to achieve vehicle fleets in which zero- or low-emissions vehicles make up 25% of the total fleet by 2018. Since the CAP's near-term target year is 2020, this measure extended the goal to transition 28% of the municipal fleet by 2020. Approximately 90 vehicles comprise the City's baseline vehicle fleet, including 5 hybrid electric vehicles. To achieve the 28% target, the City would need 25 vehicles in its fleet to be zero- or low-emissions vehicles, which means 21 additional vehicles would need to be transitioned by 2020.

The City's fleet inventory tracks vehicles by age, make and model, fuel type and annual consumption, and annual mileage. This information was used to identify which vehicles could potentially be replaced by 2020 with a hybrid or low-emissions option. As with the energy measure calculations, a baseline and mitigated scenario were developed, with the difference

between the two representing the emissions reductions that would result following implementation of this measure. The baseline scenario assumed that annual fuel use and mileage per vehicle would remain constant through 2020. The mitigated scenario assumed certain vehicles would be replaced with hybrid or other low-emissions options, and those new vehicles would have the same annual mileage as their baseline scenario counterparts. This mileage was then converted into annual fuel use assuming greater mileage efficiency in the mitigated scenario vehicles. The measure assumed conversions of passenger vehicles, light-duty trucks, and heavy-duty trucks to low-emissions options. The mitigated scenario assumes passenger vehicles are replaced with a Ford Escape hybrid or comparable vehicle, light-duty trucks are replaced with a Ford plug-in hybrid electric CMAX or comparable vehicles, and that heavy-duty vehicles are replaced with a GMC Sierra 3500 or comparable efficiency vehicle.

The following table identifies the 21 additional fleet vehicles estimated for conversion in this measure. The vehicles are presented as pairs with the baseline vehicle on top in gray and the corresponding mitigated vehicle option below. The table identifies the fuel use per year for each vehicle and scenario, along with miles per gallon (MGP) and mileage per year.

Vehicles	Gallons/Year	MPG	Mileage/Year
1989 Chevy C20 Pickup Truck	384	11	4,219
Ford Escape Hybrid	66	32	4,219
1990 Chevy 2500 Pickup Truck	774	11	8,513
Ford Escape Hybrid	133	32	8,513
1997 Ford RGRXLS	637	15	9,552
Ford Escape Hybrid	149	32	9,552
1998 GMC 3500 Pickup Truck	483	5	2,415
GMC Sierra 3500	134	18	2,415
1998 GMC 3500 Pickup Truck	760	5	3,800
GMC Sierra 3500	211	18	3,800
2000 Ford Ranger Mini Truck	251	21	5,270
Ford Escape Hybrid	82	32	5,270
1995 Ford Ranger Mini Truck	303	20	6,054
Ford Escape Hybrid	95	32	6,054
1997 Ford Aerostar Minivan	72	17	1,232
Ford Escape Hybrid	19	32	1,232

1999 Ford Taurus	141	21	2,959
PHEV CMAX	34	43	2,959
1996 Ford Aerostar Mini Cargo	162	18	2,923
Ford Escape Hybrid	46	32	2,923
1996 GMC 3500 Pickup Truck	556	12	6,675
Ford Escape Hybrid	104	32	6,675
1998 Ford E250 Cargo Van	488	15	7,326
Ford Escape Hybrid	114	32	7,326
1995 Ford Ranger	224	21	4,706
Ford Escape Hybrid	74	32	4,706
2003 Ford Crown Victoria	373	18	6,707
PHEV CMAX	78	43	6,707
1999 Ford Crown Victoria	263	18	4,726
PHEV CMAX	55	43	4,726
2005 Ford Crown Victoria	392	19	7,457
PHEV CMAX	87	43	7,457
2008 Ford Crown Victoria	230	19	4,361
PHEV CMAX	51	43	4,361
1995 Ford Aerostar Mini Van	282	18	5,073
PHEV CMAX	59	43	5,073
1998 Ford Ranger Mini Truck	441	21	9,259
Ford Escape Hybrid	145	32	9,259
1998 Ford Ranger Mini Truck	262	21	5,512
Ford Escape Hybrid	86	32	5,512
1998 Dodge Dakota Mini Truck	521	16	8,336
PHEV CMAX	97	43	8,336

Summation			
	Gallons/Year		Mileage/Year
Baseline Scenario Total	7,999		117,074
Mitigated Scenario Total	1,919		117,074
Difference	6,080		-

The fuel savings were converted to emissions reductions using the vehicle fuel emissions factors in the following table.

	CO_2 (g/gal)	N_2O (g/mi)	CH_4 (g/mi)
Gasoline emissions	8,565	0.07	0.06
Diesel emissions	10,007	0.05	0.04

Source: CCAR's General Reporting Protocol version 3.1

In addition to these fuel emissions factors, the hybrid vehicle replacements were conservatively assumed to achieve 50% of their mileage needs from their electric battery systems, with the remaining 50% to be powered by gasoline internal combustion engines. Emissions related to re-charging the hybrid vehicles were included in the calculations and assumed to use the mitigated scenario electricity emissions factor shown in Table B-6.

M-VF-3 BEHAVIOR / FUEL CONSERVATION

This measure estimates the reductions associated with implementation of a vehicle fleet telematics program that would support fuel-efficient driving practices, regular vehicle maintenance, and reduced vehicle miles traveled through GPS-based vehicle route optimization. The calculations assume implementation of M-VF-1 described above in calculating the total amount of remaining gasoline fuel use that could be affected by this measure. If Measure M-VF-1 were not implemented, then reductions associated with this measure would be greater due to the larger amount of gasoline fuel use.

As in Measure M-VF-1 described above, this measure calculated a baseline scenario for 2020 vehicle fuel use, incorporating the vehicle replacements presented above. This resulted in a total baseline use of approximately 20,700 gallons of gasoline. The calculations for this measure assume a 10% reduction in fleet gasoline-vehicle fuel use following measure implementation. This would result in a fuel use reduction of approximately 2,070 gallons of gasoline in 2020. The table below shows the fuel emissions factors (based on those shown in Measure M-VF-1 above) applied to the estimated fuel reduction to calculate the total emissions reductions resulting from this measure.

	CO_2 (g/gal)	N_2O (g/mi)	CH_4 (g/mi)
Gasoline	17,734,079	2,813	2,492
Metric Tons[1]	17.73	0.0028	0.0025
GWP[2]	1	298	25
MT CO_2e	18	0.8	0.1

[1] See previous table for fuel emissions factors

[2] Source (GWP - 100-yr): http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

SOLID WASTE MEASURES

Based on the original baseline municipal operations inventory, the City disposed of 376 tons of municipal solid waste in 2010. Per the methodology used to prepare the municipal baseline inventory, the total tonnage of disposed waste was split into waste types, with the waste characterization data provided by the CIWMB 1999 Waste Characterization Study. Waste categories from the report were then bundled to fit the waste categories of the CACP software used to develop the solid waste baseline emissions inventory. The following waste characterization rates were used in this calculation.

Paper Products	Food Waste	Plant Debris	Wood/Textile	All Other Waste
39.4%	9.8%	17.0%	6.7%	27.1%

Source: CIWMB 1999 Waste Characterization Study -- Public Administration Group:
http://www.ciwmb.ca.gov/WasteChar/BizGrpCp.asp

The total disposed solid waste was then organized into these waste categories. It was assumed that the All Other Waste category included non-organic waste materials that would not decompose within the landfill to produce methane emissions. The other four categories were then totaled and used to calculate new ratios of the emissions contribution from each category. These new ratios were multiplied by the 2020 solid waste emissions forecast value (i.e., 99 MT CO_2e/yr) to estimate the future emissions contribution by waste type so that reduction measures could be applied to individual waste types, as shown in the table below.

	Paper Products	Food Waste	Plant Debris	Wood/Textile	All Other Waste	Total
Tons	148	37	64	25	102	376
Tons – Organic Waste	148	37	64	25	-	274
Organics Ratio	54%	13%	23%	9%	-	100%
Share of 2020 Emissions (MT CO_2e/yr)	54	13	23	9	-	99

It should be noted that this calculation assumes that the methane-generating potential of these four waste categories are the same. Specific emissions factors by material type from the EPA's WARM model were considered for use in this calculation. However, as specified on the WARM website, those factors are for use in lifecycle emissions analysis, and are not appropriate for emissions inventory analysis. While these four waste types may produce methane at varying rates, no one emissions factor can be applied to easily calculate the reductions from the CAP's measures with a high-level of accuracy. Therefore, these calculations were prepared to ensure that total emissions reductions from the solid waste measures were not greater than the total emissions forecast for the sector, in order keep reduction estimates within the realm of feasibility.

The measure could have alternatively been quantified to assume that 80% of organic waste materials are diverted from landfills by 2020 (as described in Measure M-SW-1 Action 1), to achieve the same total amount of reductions as shown in these individual measures, without the specificity of where the reductions would come from. While solid waste emissions reductions are highly complicated to estimate (as opposed to energy reductions, which rely upon on simple emissions factors), reductions from this sector also represent a relatively small proportion of total municipal reductions estimated from this CAP (i.e., 12% in 2020). Even if no solid waste management strategies were pursued, the City could still achieve its 2020 reduction target through energy- and transportation-sector measures. Additionally, solid waste emissions are counted as a Scope 3 emissions source in the LGOP emissions inventory guidance, acknowledging that the City has limited ability to influence reductions from this source since the City lacks financial or operational control over the landfills in which municipal solid waste is disposed. Scope 3 emissions can be voluntarily reported, but are understood to be based upon less accurate or specific data as Scope 1 and Scope 2 emissions sources, which also contributes to the lower level of accuracy in their associated emissions reduction calculations.

The following three solid waste measures are each based on the same methodology and input table presented above.

M-SW-1 Waste Reduction

This measure estimates the reductions associated with removing paper and paper-products from the municipal waste stream through a paperless office policy and other waste reducing and diverting programs. The calculations assume that implementation of this measure could result in an 80% reduction in paper waste from the solid waste stream. Per the solid waste emissions table presented in the introduction to the municipal solid waste measures, it was assumed that 80% of the emissions attributed to the Paper Products category could be offset by 2020, as shown below. As described in the CAP's municipal solid waste discussion section, future municipal waste characterization surveys will be the best method to monitor successful implementation of this measure.

	Paper Products	Food Waste	Plant Debris	Wood/Textile	All Other Waste	Total
Share of 2020 Emissions (MT CO$_2$e/yr)	54	13	23	9	-	99
Diversion Rate	80%	-	-	-	-	-
Reductions (MT CO$_2$e/yr)	43	-	-	-	-	**43**

M-SW-2 Food Scrap and Compostable Paper Diversion

This measure estimates reductions associated with continued implementation of the City's organics collection program, including expansion to municipal facilities that currently lack food scrap collection bins. It also assumes continued implementation of green waste management practices in City parks, medians, and other landscapes, such that the majority of green waste is composted on-site, mulched by lawnmowers, or otherwise diverted from the solid waste stream. Per the solid waste emissions table presented in the introduction to the municipal solid waste measures, it was assumed that 90% of the emissions attributed to the Food Waste and Plant Debris categories could be offset by 2020, as shown below. As described in the CAP's municipal solid waste discussion section, future municipal waste characterization surveys will be the best method to monitor successful implementation of this measure.

	Paper Products	Food Waste	Plant Debris	Wood/Textile	All Other Waste	Total
Share of 2020 Emissions (MT CO$_2$e/yr)	54	13	23	9	-	99
Diversion Rate	-	90%	90%	-	-	-
Reductions (MT CO$_2$e/yr)	-	12	21	-	-	**33**

M-SW-3 Construction and Demolition Waste Diversion

This measure estimates reductions associated with implementation of the City's Green Building Ordinance, which requires diversion of 60% of construction and demolition waste from applicable new construction and renovation projects, including municipal projects. Per the solid waste emissions table presented in the introduction to the municipal solid waste measures, it was assumed that 60% of the emissions attributed to the Wood/Textile category could be offset by 2020, as shown below. As described in the CAP's municipal solid waste discussion section, future municipal waste characterization surveys will be the best method to monitor successful implementation of this measure.

	Paper Products	Food Waste	Plant Debris	Wood/Textile	All Other Waste	Total
Share of 2020 Emissions (MT CO$_2$e/yr)	54	13	23	9	-	99
Diversion Rate	-	-	-	60%	-	-
Reductions (MT CO$_2$e/yr)	-	-	-	5	-	**5**