



Memorandum

Date:	April 10th, 2012
To:	Adam Stern, Calla Ostrander, Sachiko Tanikawa San Francisco Department of the Environment
From:	Rich Walter, Rahul Young, Khalid Husain ICF International
Subject:	Technical Review of the 2010 Community-wide GHG Inventory for City and County of San Francisco

This memo provides a summary of key findings from ICF International’s review of the community-wide greenhouse gas (GHG) inventory for the City and County of San Francisco for calendar year 2010 (hereafter referred to as the “2010 community-wide GHG inventory”) prepared by the San Francisco Department of the Environment (SFE).

This memo is organized into the following sections:

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1. Background

ICF International (hereafter referred to as “ICF”), a publicly-traded technical, management and strategy consulting firm with expertise in climate change, energy, transportation, waste, and other issues,¹ was hired by the San Francisco Department of the Environment (SFE) in December 2011 to undertake an independent, third-party review of the 2010 community-wide GHG inventory. ICF has prepared numerous GHG inventories for companies, cities, counties, states, and countries including preparation of the U.S. national GHG inventory since the late 1980s. This current effort represents the second time that ICF has provided technical review of San Francisco’s community inventory, having conducted such an

¹ Please refer to ICF’s website (www.icfi.com) for further info. ICF’s NASDAQ symbol is “ICFI”

exercise in 2008 for the community-wide GHG emissions for San Francisco for 1990, 2000 and 2005 years. Since then, SFE has produced a 2010 Community-wide GHG Inventory and has also taken the opportunity to review and improve methodologies and data used in earlier inventories (affecting 1990, 2000 and 2005 inventories across some sectors).

2. Methodology

ICF's technical review of SFE's 2010 community-wide GHG inventory consisted primarily of a desk review of (a) the GHG Inventory; (b) inventory guidance documents and; (c) approximately 40 supporting documents (back-up records, raw data, PDF files of relevant reports, and email correspondence). Other than visits to the SFE, our review did not include site visits to specific community-wide emissions producing entities. The focus of our review has been primarily on the activity data, emissions factors, overall approaches and methods as well as documentation for the 2010 community-wide GHG inventory.

ICF's review consisted of the following key components:

- **Kick-off meeting:** A kick-off meeting between ICF and SFE was held in person in December 2011. Subsequent discussions took place via telephone and in person.
- **Review of GHG Inventory and supporting calculations:** ICF's review consisted of checking the methods and accuracy of quantification approaches, with a focus on transparency and completeness of calculations, as well as clear and verifiable references and assumptions for key parameters, with a focus on activity data, emissions factors and calculation approaches applied for the 2010 inventory. Numerical checks of the inventory numbers, both in terms of activity data as well as tons CO₂ equivalent (tons CO₂e) by sector and in aggregate, were performed by ICF. In addition, a review of any methodological changes in the 2010 inventory (in relation to earlier years) and a consistent application of those changes to earlier years' inventories were also reviewed.
- **Check of requested activity data and emissions factors calculations against inventory:** ICF requested original activity data from relevant agencies to double-check the accuracy of such numbers used by SFE in its community-wide GHG inventory. Given that electricity and natural gas usage (primarily for buildings, as well as for some transportation) as well on-road transportation in aggregate accounted for approximately 94% of total community-wide GHG emissions in 2010 (please see Figure 1), ICF focused on these sectors by obtaining and reviewing electricity and natural gas consumption totals for the City and County of San Francisco from Pacific Gas & Electric (PG&E), electricity breakouts from the San Francisco Public Utilities Commission (SFPUC), and on-road vehicle miles travelled (VMT) data from the San Francisco County Transportation Agency (SFCTA). In addition, ICF reviewed individual emissions factors for electricity (pounds of CO₂ per megawatt-hour, or lb CO₂ /MWh) for 2010 from PG&E (third-party verified) and SFPUC, as well as an emissions factor for on-road vehicles (grams of CO₂e per mile travelled) from the Bay Area Air Quality Management District

(BAAQMD). A check for consistency of data and methods for the 1990 inventory was also performed by ICF.

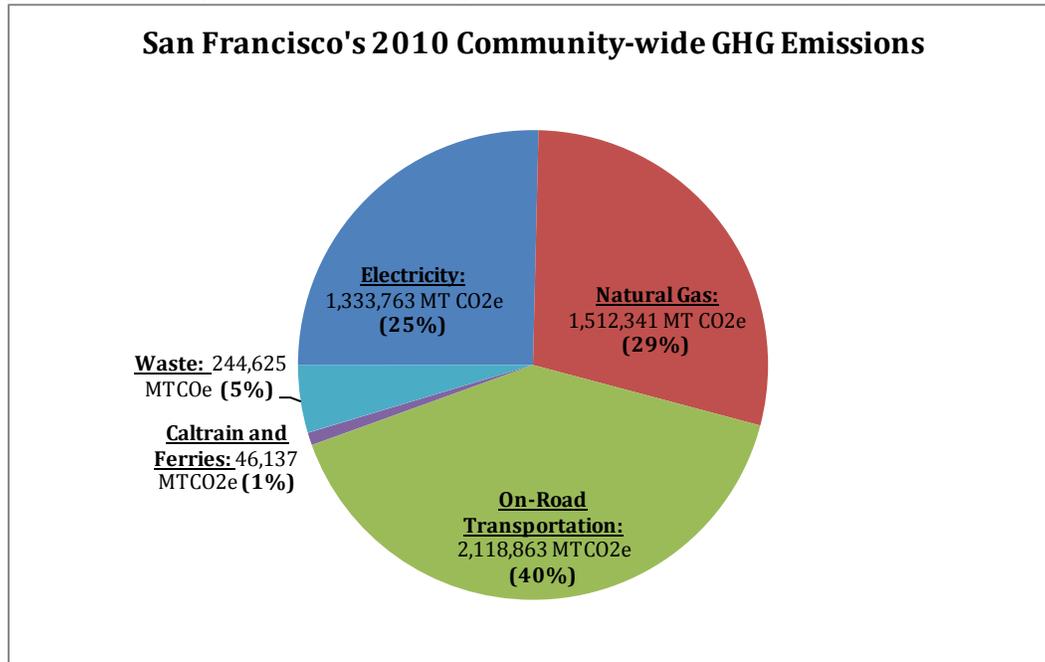
- **Discussions with relevant agencies:** As part of the process to obtain and review relevant inventory data and ask questions of clarification, ICF held discussions with PG&E, SFPUC, SFCTA, and BAAQMD during the technical review process.
- **Consultation with ICLEI and review of relevant GHG inventory guidance:** Currently, no single, comprehensive and widely-accepted protocol exists for community-wide GHG inventories. ICLEI – Local Governments for Sustainability (ICLEI) is devising a community-wide GHG protocol and aims to release it in the latter half of 2012 (per discussion with ICLEI in February 2012). ICF consulted with ICLEI on several community-wide GHG inventory issues, with a focus on electricity and waste, during the course of the review. Given the absence of a consensus community-wide GHG protocol, ICF reviewed the following guidance documents, which were considered relevant and useful to the review:
 - *GHG Protocol: Corporate Accounting and Reporting Standard* (Revised Edition, 2004), prepared by the World Resources Institute/World Business Council for Sustainable Development;
 - *Local Government Operations Protocol (LGOP)* (version 1.1, 2010), jointly prepared by the California Air Resources Board (CARB), the Climate Action Reserve (CAR), the California Climate Action Registry (CCAR), and ICLEI;
 - *International Local Government GHG Emissions Analysis Protocol* (version 1.0, 2009) prepared by ICLEI;
 - *California Community-Wide Greenhouse Gas Baseline Inventory Protocol White Paper* (draft, 2011), prepared by the Association of Environmental Professionals;²
 - *Guidelines for National Greenhouse Gas Inventories* (2006), prepared by the Intergovernmental Panel on Climate Change (IPCC).
- **Interim findings by ICF:** Following the above steps, ICF produced interim findings and submitted them to SFE in February 2012. Periodic updates were also communicated to SFE from December 2011 up to completion of the review.
- **Revisions by SFE and Final Review by ICF:** Based on ICF's findings, SFE revised the 2010 community-wide GHG inventory (as well as that of 1990). ICF reviewed the revised 2010 and 1990 inventories by conducting a final check on methods, calculations and overall conclusions.

² For full disclosure, ICF notes that Rich Walter, one of the reviewers of San Francisco's 2010 community-wide GHG inventory, is a member of the Climate Change Sub-Committee of the California chapter of AEP, which is the author of the AEP 2011 white paper. However, the white paper guidance on electricity-related emissions was not written by Mr. Walter nor by ICF.

3. Key Findings

San Francisco's 2010 community-wide GHG emissions inventory is comprised of five key components. The amount of GHG emissions and the percentage they comprised of the total 2010 inventory are shown in Figure 1.

Figure 1: Breakout of Sources and Emissions for San Francisco's 2010 Community-wide GHG Emissions



- **Electricity:** Consumption in both buildings (broken out by residential, commercial and municipal categories) as well as for transportation uses (BART and MUNI). In 2010, this was comprised of electricity from PG&E (general grid electricity), SFPUC, Direct Access providers and Potrero power plant; in 1990, the electricity was obtained from PG&E (general grid electricity), SFPUC, the Hunter's Point power plant and the Potrero power plant.
- **Natural Gas:** Consumption for residential, commercial and industrial use. PG&E supplied natural gas and emissions factor (lbs CO₂/therm).
- **On-Road Transportation:** On-road vehicles (e.g., on highways, city streets and other paved roads) comprising vehicle usage within San Francisco's boundaries as well as on-road travel into and out of the city, without any pass-through travel, were estimated using the SFCHAMP model run by SFCTA. SFCTA performed a back-casted calculation and applied the same methods to estimate 1990 emissions. Emissions factors (grams CO₂e/mile) were derived from BAAQMD.
- **Waste:** This category consisted of GHG emissions arising from waste sent to landfills (after accounting for diversion of waste that was recycled and composted) following a "methane

commitment” approach.³ SFE relied on ICLEI guidance and used ICLEI tools (CACP and CAPP) for GHG emissions estimates.

- Caltrain and Ferries: This category comprised a portion of Caltrain as well as ferry usage (commuter and leisure ferries) attributable to San Francisco. Both modes used diesel.

Here are the key findings from ICF’s review of San Francisco’s 2010 community-wide GHG emissions inventory:

1. **Clear accounting of boundaries, emissions sectors and key sources of emissions:** The documentation and quantification of activity levels from all major sources of emissions that fall within a community’s boundaries is generally more complicated than a smaller range or subset, such as for an industrial or a purely municipal inventory. San Francisco’s 2010 community-wide GHG inventory represents an appropriate attempt at capturing major emission sources and calculating resultant activity levels. It appears that all of the major stationary and mobile categories have been accounted for and appropriately quantified, which at a community-wide level can be a challenging task.
2. **Original source documents for key sectors match activity levels:** ICF requested original source documents documenting 2010 activity levels for electricity and natural gas consumption (with a focus on PG&E and SFPUC), on-road transportation (SFCTA on-road vehicles VMT data based on the SFCHAMP model), and waste (through consultations with ICLEI and various tools, namely CACP and CAPP). The activity data were available and matched SFE’s 2010 community-wide inventory data.
3. **Consistency in methods between 2010 and 1990:** Although ICF’s focus has been on reviewing the 2010 community-wide inventory, ICF understands that the city’s Climate Action Plan (CAP) has reduction goals in relation to a 1990 baseline. Hence ICF also undertook a review of consistency between the 2010 data collection and calculation methods in relation to those used to estimate 1990 GHG emissions. Our review leads us to conclude that as community-wide inventory methods have improved since 1990, SFE has been consistent in applying the same methods for each sector between 2010 and the baseline year of 1990. Key examples include:
 - a. Electricity: Community-wide electricity emissions factors have been revised in an accurate and consistent manner.
 - b. Natural gas: Consumption calculation methods, particularly for the municipal sector, originally differed slightly in 2010 in relation to the earlier 1990 method, leading to immaterial differences. ICF recognizes that issues arose due to data limitations in 1990. SFE has however correctly applied the same consumption methods for the 1990 inventory as it did for the 2010 one and this issue has now been resolved.

³ The “methane commitment” approach is an IPCC method in which landfill methane emissions are quantified based on the current year’s waste generation. Since waste in a landfill takes many years to decay and thus takes many years to emit all of its associated methane, this approach in essence is quantifying the future emissions of today’s waste. Alternatively, this approach is assuming that waste generation doesn’t change from current levels and thus uses the emissions of today’s waste as a proxy for all waste in the landfill.

- c. On-Road Transportation: SFCHAMP, SFCTA's transportation model for San Francisco, did not exist in 1990. It is now considered a reliable and rigorous transportation planning model. On-road VMT were derived from this model and applied to 2010 as well as to 1990 inventory years.
 - d. Waste: Although not initially covered in the 1990 inventories, or subsequently until 2010, SFE did calculate waste-related emissions in 2010 using a methane commitment approach and has applied the same approach to 1990.
 - e. Steam: Although included in the original 1990 inventory, SFE recently decided not to include steam separately in its 2010 inventory (with the main assumption that natural gas combustion, the source of steam, is already included, and hence excluding steam is appropriate to avoid double-counting). This exclusion has been applied to both the 2010 inventory and the 1990 inventory.
4. **Community-wide electricity emissions factors have been reviewed in depth and validated:**

In 1990, San Francisco's electricity was derived from imported power (from both PG&E and from the SFPUC) as well as electricity derived from two power plants located within the city (Hunter's Point and Potrero power plants. In 2010, San Francisco's electricity was derived from imported power (from PG&E and from SFPUC), direct access and locally generated power from the Potrero power plant (the plant shut down in late 2010).

Some critics have expressed concern about the inclusion of locally generated emissions from the two local power plants in the community-wide GHG inventory for 1990 and subsequent years and the comparison of current emissions to prior years when these plants were fully operational.

ICF's review of inventory guidance explored different methods for computing electricity-related emissions:

- A) use of an emissions factor (EF) based on PG&E grid power, SFPUC power generation and Direct Access, as well as local generation from the two power plants (this is SFE's approach);
- B) use of a blended EF based on PG&E grid power, SFPUC power generation, and Direct Access power generation only; and
- C) identification of the two power plant emissions as direct emissions or point sources (Scope 1) separate from electricity consumption as indirect emissions (Scope 2).

The first approach has been SFE's approach. The second approach follows an approach suggested in AEP's *California Community-Wide Greenhouse Gas Baseline Inventory Protocol White Paper* (2011). The third approach was explored in conversation between ICF and ICLEI as an alternative approach to separate the EFs from Hunter's Point and Potrero Power plants from the weighted community-wide EF by categorizing these two sources as point sources with direct emissions. The three approaches are summarized in Figure 2.

Figure 2: Three Approaches to Electricity Sector Community-wide Emissions Factor Derivation

<p style="text-align: center;"><u>Approach A</u> Blended EF: Purchased & Local</p>	<p style="text-align: center;"><u>Approach B</u> Exclude direct local utility emissions</p>	<p style="text-align: center;"><u>Approach C</u> Point sources + blended</p>
<ul style="list-style-type: none"> • Takes into account both locally and generated power in a blended manner. • Presumes that the Hunters Point and Potrero power plants serve the city based on proximity and reduce transmission and distribution losses to further locales. • Comparison of 2010 to 1990 inventories is a function of change in electricity consumption and relative greater reliance on PG&E overall grid with local plant closure. Also affected by changes in SFPUC emissions factors and Direct Access. 	<ul style="list-style-type: none"> • Does not include local direct utility electricity-generation emissions. • Does not take into account locally generated power being consumed in San Francisco • Likely understates local use of locally generated power. • Comparison of 2010 to 1990 inventories is a function of change in electricity consumption and changes in PG&E overall grid and SFPUC emissions factors, as well as additional Direct Access electricity. 	<ul style="list-style-type: none"> • Discloses direct emissions from two local power plants separately from indirect emissions from electricity consumption. • If totals of Scope 1 and Scope 2 are added, this results in double-counting of electricity emissions. • Comparison of 2010 to 1990 inventories is a function of reduction in direct emissions with plant closures as well as changes in electricity consumption, PG&E and SFPUC emission factors, and Direct Access.

SFE’s Approach A is an appropriate method for community-wide GHG inventory development. The use of a customized emissions factor is recognized as appropriate (in some cases) for community-level inventories in ICLEI’s *International Local Government GHG Emissions Analysis Protocol* (2009). The key assumption underlying this approach is that the local power plants primarily serve the city they are located in. This is reasonable given the plants’ historical use, increasing electricity flow into the city over the years to meet expanding demand, and the general objective of avoiding the inefficiencies of transmission and distribution losses, among other factors. However, in any electricity grid, electricity generated at one point can be physically delivered to locations some distance from the generation point, and thus it is possible that electricity from the local power plants may also have served other jurisdictions. It was beyond ICF’s scope of work to assess local dispatch for 2010 and earlier years.

Approach B could be used to develop a community-wide GHG inventory, but it does not reflect the likely case that San Francisco has received substantial portions of electricity generated from the local power plants during the inventory years, which would result in a different emissions factor from average grid emissions factors. This approach is suggested in AEP’s draft *California Community-Wide Greenhouse Gas Baseline Inventory Protocol White Paper* (2011). However, the paper has not been as widely reviewed as other published protocols.

Approach C, the separate source approach, is not recommended. Though this approach would segregate local power plant emissions from electricity consumption emissions, reporting of both Scope 1 and Scope 2 electricity-related emissions in the emissions total would lead to double-counting. If Scope 1 electricity emissions were not included in the total, then this approach becomes functionally the same as Approach B.

5. **Other key emissions factors (EFs) have been reviewed and validated in consultation with relevant agencies and organizations:**
 - a. Revised PG&E and SFPUC 2010 electricity EFs: The 2010 PG&E electricity EF completed third-party verification in January 2012. In addition, the SFPUC made slight revisions to its 2010 EF. SFE has reflected both of these revised numbers in its 2010 community-wide inventory.
 - b. Natural gas EF: The natural gas EF that SFE applied matched the value recommended by PG&E. This factor was consistently applied in the community-wide GHG inventories.
 - c. Revised on-road vehicles 2010 EF: ICF reviewed the 2010 on-road vehicles EF originally provided by BAAQMD via SFE. Other than a slight change in the global warming potential (GWP) of N₂O (from 296 to 310) to be consistent with IPCC's Second Assessment Report's GWPs, the revised EF has been validated by BAAQMD and reflected by SFE in its inventory.

6. **Electricity consumption totals were slightly mismatched but have been corrected and consistently applied throughout the inventory:** Slight mismatches in electricity totals were noticed by ICF in SFE's inventory, namely in the consumption total in relation to the derivation of the community-wide EF factor (in essence applying total consumption over individually weighted EFs). In addition, ICF recommended that SFE include total electricity consumption, instead of removing the electricity consumption related to PG&E's ClimateSmart program. ICF recommends instead that the offsets from the ClimateSmart program be treated as a separate line item to the inventory overall. These issues have now been rectified and consumption totals consistently reflected in the inventory.

7. **Natural gas consumption methods were slightly mismatched between 1990 and 2010 inventories but have been corrected and consistently applied:** Slight immaterial inconsistencies were found for natural gas consumption values, particularly for municipal natural gas. In addition, ICF recommended that SFE include total natural gas consumption, instead of removing the natural gas consumption related to PG&E's ClimateSmart program. ICF recommends instead that the offsets from the ClimateSmart program be treated as a separate line item to the inventory overall. These issues have since been rectified and correctly reflected in the inventory.

8. **Waste-related calculations are acceptable but could be improved:** SFE's waste-related GHG emissions were calculated using a methane commitment approach, which is not as accurate for identifying current year emissions as a "waste-in-place" method. However, the SFE approach, one of two recommended IPCC methods, is an acceptable method and provides an approximation of organic emissions occurring in landfills, while taking into account waste

diversion (primarily recycling and composting) measures. A more detailed and rigorous approach to estimating current year emissions would be to employ a “waste-in-place” method. This method estimates current year landfill emissions by collecting and using historical waste disposal data to determine the nature of waste in landfills today and then using a first-order exponential decay method to determine landfill emissions today and adjusting for current year methane capture rates.

9. **GHG emissions calculations for off-road (BART and Caltrain) in the absence of up-to-date and detailed data availability have been reasonably calculated:** While updated values in as granular a manner as possible is always desirable, data availability challenges are common in many community-wide inventories. For BART, SFE applied relevant consumption values from 2007 and appropriately scaled them to 2010. For Caltrain, ridership numbers were taken from 2008 and scaled to 2010 based on Caltrain estimates (in the absence of total direct gallons of diesel usage).

4. Suggestions for Future Improvement

The following are suggested areas for future improvement for SFE’s consideration in relation to the development of San Francisco community-wide GHG inventories:

1. **Community-wide electricity emissions factor:** As described in section 3, SFE could devise and apply an electricity emissions factor at a community-wide level in several ways. Each method has implications for how electricity-related emissions are calculated; the effects that those have on the overall inventory are substantial with a range of possible resultant inventory reductions from 1990 to 2010. ICF suggests that SFE could apply Approaches A and B) and show the resultant impact on emissions (including reductions in relation to 1990). For Approach A, it would be useful to identify a more precise estimate of the electricity dispatched from the two local power plants to serve loads in the city in past years. This was beyond the scope of ICF’s review. Such an analysis could help develop a more accurate picture of the electricity grid. It would require the cooperation of PG&E and the California Independent Service Operator (CAISO). It is unknown to what degree such an analysis may require confidential data unavailable due to disclosure rules. This analysis is not considered essential by ICF for completion of an appropriate community-wide inventory that is representative, is not commonly done for local community-wide inventories, and could represent substantial additional effort on the part of SFE.
2. **Disaggregation of BAAQMD EFs between Different Types of Vehicles:** SFE has employed BAAQMD’s blended emissions factor, weighted across gas and diesel as well as across all vehicle classes. As EFs will vary between different types of vehicles (i.e., passenger vehicles and trucks) and fuels used, disaggregation to the extent possible between these two broad categories as well as within them (i.e., different classes of light duty and heavy duty vehicles) could improve transparency, accuracy and tracking of CO₂e calculations for on-road transportation especially for different vehicle classes.

3. **Application of Waste-in-Place Method for Waste-related Emissions:** SFE has employed a methane commitment approach that only takes into account future expected emissions from organically degradable materials going to landfills, all attributable to waste disposal in a given year. While this approach is certainly allowable (e.g., by IPCC and other entities), a more accurate approach would be to apply a “waste-in-place” method described earlier. In addition, updated waste characterization studies would ensure that SFE applies the most current representation of waste that is sent to landfills. Finally, ICF notes that wastewater-related emissions are not included in the community-wide inventory. While this category is likely to result in a minor level of emissions (in relation to total inventory numbers), consideration of this category would allow SFE to obtain a broader and more accurate picture of waste-related emissions.
4. **Applying direct diesel usage for Caltrain:** SFE has applied a ridership-based approach for estimating GHG emissions from Caltrain. While this is certainly one approach that could lead to an approximate level of emissions, a more accurate approach would be to obtain and apply diesel consumption numbers directly and attribute that usage to San Francisco accordingly. ICF understands that diesel consumption numbers were not available for 2010 (hence the ridership approach), but this could be another area of targeted effort on the part of SFE.
5. **Inclusion of Non-CO₂ Gases:** SFE’s inventory guidance document mentions the difficulty in accurately quantifying non-CO₂ emissions for most non-waste and transportation sectors, as well as the insignificant role that these gases are expected to contribute to overall GHG emissions in comparison to CO₂). Although CH₄ and N₂O are included in sectors such as on-road transportation and waste, most of the remaining inventory does not include non-CO₂ gases. These judgments appear reasonable for now, but the inclusion of non-CO₂ gases for electricity, natural gas and fuel consumption, as well as hydrofluorocarbons (HFCs), e.g., from building chillers and refrigerators and vehicle air conditioners, could further improve the scope of the inventory.
6. **Clearer links to data sources:** For the purposes of ensuring full transparency and credibility, tracking emissions in the future, as well as making it easier for third-party verifiers to corroborate calculations, it is useful to have clearly laid-out components and sub-components of the inventory which are linked to each other. The organization of the 2010 inventory certainly represents a major improvement over the 2005 inventory and earlier year inventory files that ICF reviewed in 2008. However, we suggest continued efforts by SFE to have a *single* Excel file that clearly contains all information for key inventory segments in a completely referenced and linked manner.

5. Conclusion and Summary Statement

Based on its review of SFE's 2010 community-wide GHG emissions inventory, ICF International has verified the information submitted by SFE as being consistent with existing emissions methodologies. The emission estimates were calculated in a consistent and transparent manner and were found to be a fair and appropriate representation of SFE's community-wide GHG emissions and were free from material misstatement. ICF identified several minor, immaterial discrepancies in the greenhouse gas inventory which were corrected by SFE during the course of the verification. ICF has verified a total of **5,255,730 metric tons of CO₂ equivalent (CO₂e) emissions for the 2010 community-wide GHG inventory**. This number represents an approximate reduction of approximately 14.5% in relation to the revised 1990 community-wide GHG emissions of 6,149,440 metric tons of CO₂e emissions. ICF has made several suggestions that could further enhance the scope, rigor and transparency for future inventory efforts.