City and County of San Francisco
2030 Sewer System Master Plan

TASK 800
TECHNICAL MEMORANDUM NO. 804
GREENHOUSE GAS EMISSIONS EVALUATION

FINAL DRAFT
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CITY AND COUNTY OF SAN FRANCISCO
2030 SEWER SYSTEM MASTER PLAN

TASK 800

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GREENHOUSE GAS EMISSIONS EVALUATION

1.0 PURPOSE

The purpose of this technical memorandum is to provide the approach to, and present the results of, the greenhouse gas (GHG) emissions estimates for the four configurations evaluated in October 2007 and for the baseline and preferred configuration evaluated in November 2008 for the San Francisco Sewer System Master Plan (SSMP). In addition, the boundary conditions and assumptions used to develop GHG emissions estimates for the baseline and the project configurations are presented in this memorandum. The findings presented in this Technical Memorandum (TM) are the results based on the components considered in the configurations at the time of evaluation and may not reflect the master plan program GHG emissions.

2.0 BACKGROUND

Keeping with the master plan goals to promote sustainability, GHG emissions for each project configuration were evaluated. In general, annual GHG emissions generated at treatment plants are a function of the flow treated, the influent water quality, and the treatment processes. For this evaluation, the estimated annual GHG emissions are a result of the operations phase of each project configuration. This analysis focuses on carbon dioxide, methane, and nitrous oxide emissions as these gases are relevant to and comprise the majority of GHG emissions generated from the collection and treatment of wastewater. The GHG emissions summarized in this TM are the annual GHG emissions generated at build-out (30-year time horizon[1]).

3.0 APPROACH

A multi-step approach was developed to evaluate the GHG emissions of the project configurations. An outline of the approach is summarized below.

3.1 Select Standard GHG Reporting Protocol

The state of California adopted the Global Warming Solutions Act (also known as Assembly Bill 32, AB 32) in September of 2006. This Act is the first regulatory program in the U.S. that will require public and private agencies statewide to reduce GHG emissions to 1990 levels by 2020 and 80 percent below 1990 levels by 2050. Currently, there is no mandate on publicly owned treatment works (POTWs); however, the California Air Resources Board (ARB) has stated that POTWs would be included in the near future and early voluntary reporting is recommended.

Pursuant to AB 32, the California Climate Action Registry General Reporting Protocol (CCAR GRP) is selected for this analysis, a set of measuring standards and protocols aligned with the international GHG Protocol Initiative and adapted to California. Assembly Bill 32 recommends using this protocol where appropriate and to the maximum extent feasible. Agencies that choose to participate in the CCAR process will not be required to significantly alter their reporting or verification program except as determined by ARB for compliance purposes.

3.2 Set Boundaries for the Analysis

The purpose of this analysis is to compare the Global Warming Potential (GWP) resulting from the energy consumption of the baseline and the preferred configuration wastewater treatment and pumping operations. The term "boundary" in this context means selecting the system components for which we will be estimating GHG emissions: specifically carbon dioxide, methane, and nitrous oxide.

This analysis focuses on carbon dioxide, methane, and nitrous oxide GHG emissions as these gases are relevant to and comprise the majority of GHG emissions generated from the collection and treatment of wastewater. The estimated annual GHG emissions are a result of the operations phase of the project configurations. In general, annual GHG emissions generated are a function of the flow treated, the influent water quality, and the treatment processes used.

System components included in this analysis are:

- Wastewater collection system and effluent pump stations,
- Wastewater liquids treatment processes,
- Wastewater biosolids treatment processes,
- Biosolids hauling to disposal sites (but not the GHG emissions from disposal), and
- Chemical production and transport to the treatment facilities.

The system components included within the boundary are assessed as to energy consumption and chemical usage for all unit processes. Also included is the fuel consumption for transportation of the chemicals to the treatment facility and biosolids to the application/disposal sites.

3.3 Identify Direct and Indirect Sources of GHG Emissions

Direct emissions are those resulting from sources owned or controlled by the agency, such as stationary combustion sources, mobile combustion sources, and treatment unit

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1 Average annual growth rate of 0.6%.

processes. Indirect emissions are those originating from the actions of the agency, but are produced by sources owned or controlled by another entity, such as the production of purchased and consumed electricity, natural gas, and chemicals.

3.4 Estimate Quantities of GHG Emissions

The quantities of GHGs emitted are calculated as follows:

- Electricity consumption (kilowatt-hours) x Emission factor #1
- Natural gas consumption (cubic feet or British thermal units) x Emission Factor #2
- Vehicle fuel consumption (gallons) x Emission Factor #3

3.5 Express GHG Emissions in Terms of "Annual "Carbon Dioxide Equivalents" (CO_2e)

The major anthropogenic GHG in the atmosphere contributing to global warming is carbon dioxide. Other GHGs differ in their ability to absorb heat in the atmosphere relative to carbon dioxide. For example, methane has 21 times the capacity to absorb heat relative to carbon dioxide, so it is considered to have a global warming potential (GWP) of 21. Therefore, a pound of emissions of carbon dioxide is not the same in terms of climatic impact as a pound of methane emitted, and GHG emissions are often reported in terms of "CO_2 equivalents," which is calculated by multiplying the amount of emissions of a particular GHG by its GWP.

Table 1 Greenhouse Gases and their Associated Global Warming Potentials (GWPs)
2030 Sewer System Master Plan
City and County of San Francisco

Greenhouse Gas	GWP* (unit mass CO_2e/unit mass of GHG emitted)
Carbon Dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous Oxide (N_2O)	310

* GWPs from the Intergovernmental Panel on Climate Change Second Assessment Report (1996) for a 100-year time horizon. These GWPs are still used today by international convention and the U.S. to maintain the value of the carbon dioxide "currency," and are used in this inventory to maintain consistency with international practice.

4.0 CONFIGURATION ANALYSIS

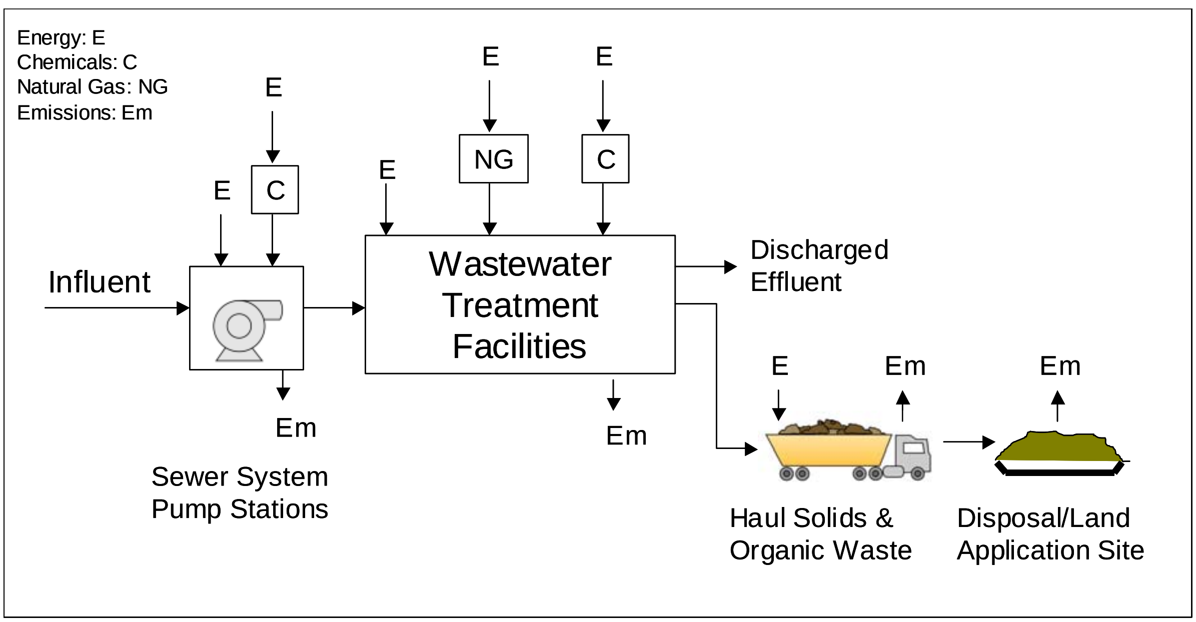
The GHG emissions for the four configurations were calculated as detailed above. The configuration boundary conditions and results are summarized below.

4.1 Configuration Boundary Conditions

The development of GHG emissions estimates requires a set “boundary” to define the life cycle stages, the unit processes, and the time frame that is included in the analysis. For this evaluation, only the operations phase of the treatment facilities and pump stations is considered. This includes unit processes at the treatment facilities and pump stations throughout the collection system, as well as the hauling of biosolids and the production and hauling of the chemicals consumed for treatment of the wastewater and biosolids.

Energy derived from on-site solar panels serves to avoid GHG emissions (that would have otherwise been generated from purchased electricity) and is considered as an offset in this analysis. In addition, we have compared current methods of handling organic waste (which consists of hauling the organic waste from the Transfer Station to a land application or disposal site) to the potential scenario of digesting the organic waste and then hauling the remaining waste to a land application or disposal site. Figure 1 illustrates the basic boundary set for this evaluation.

Figure 1 Unit Process Boundary for the San Francisco Sewer System Master Plan Configuration GHG Evaluation



The data sources used to estimate the GHG emissions are discussed in the sections below and the assumptions are listed in Appendix A.

4.1.1 Treatment Plant Operations

The total energy demand for treatment plant operations and pump stations throughout the sewer system are based on the operation and maintenance (O&M) estimates developed by SFPUC, Brown and Caldwell, and Carollo Engineers.

4.1.2 Chemical Production and Handling

The total chemical consumption estimated for the existing system was based on treatment plant operation data averaged over the years 2004 through 2006. Chemical dose assumptions are also based on treatment plant operation data for years 2004 through 2006, in addition to the 2003 Baseline Facilities Report. The California Climate Action Registry General Reporting Protocol (CCAR GRP) considers energy required for the production of chemicals consumed in treatment processes to be outside the boundary of this type of evaluation. However, in order to provide a more complete comparison of the impacts of the SSMP configurations, the embodied energy of chemical production was included in this analysis. The energy required per unit chemical consumed is based on conversion factors per "Energy in Wastewater Treatment" by William F. Owen and certified Environmental Product Declarations produced by Eka Chemicals.

In order to estimate the GHG emissions generated from the transport of the chemicals, SFPUC provided the supply location of the chemicals, as well as the type of hauling truck and fuel consumed. Table 2 lists the chemicals included in the analysis for each treatment plant and Master Plan configuration.

4.1.3 Biosolids Handling

Estimates of GHG emissions generated from the transport of biosolids are based on the type of truck used, the type of fuel consumed, and the distance to the land application or disposal (landfill) site provided by the SFPUC.

4.1.4 Renewable Energy

The SFPUC provided on-site solar power generation data for the existing system and configurations at build-out. The data were used to calculate indirect GHG emissions avoided had SFPUC purchased electricity equivalent to the power produced by the solar panels.

4.1.5 Organic Waste Digestion and Handling

Organic waste in San Francisco is typically wet or partially wet food waste material from restaurants, grocery stores, and other commercial establishments, along with yard wastes and other mixed organic materials. Greenhouse gas emissions generated from the transport, processing, and disposal/land application of organic waste were estimated using waste composition data and disposal/land application site information from SFPUC.

Table 2 Chemicals Used and Included in the Evaluation
2030 Sewer System Master Plan
City and County of San Francisco

	Existing & Baseline	1	2	3	4
South East Plant (SEP)	Hypochlorite - Disinfection Bisulfite - Dechlorination Hypochlorite - Odor Control Ferric Chloride - Dewatering Polymer - Thickening Polymer - Dewatering Liquid Oxygen - Aeration	WWF Hypochlorite - Disinfection WWF Bisulfite - Dechlorination Hypochlorite - Odor Control HPO - Secondary	WWF Hypochlorite - Disinfection WWF Bisulfite - Dechlorination Hypochlorite - Odor Control HPO - Secondary	WWF Hypochlorite - Disinfection WWF Bisulfite - Dechlorination Hypochlorite - Odor Control Bisulfite - Dechlorination	WWF Hypochlorite - Disinfection WWF Bisulfite - Dechlorination Hypochlorite - Odor Control
Bayside Biosolids Center (BBC) - (Alt 1, 2, & 4) **or** **Westside Biosolids (WBC) - (Alt 3)**	(Biosolids treatment split among existing treatment facilities)	Hypochlorite - Odor Control Ferric Chloride - Dewatering Polymer - Thickening Polymer - Dewatering	Hypochlorite - Odor Control Ferric Chloride - Dewatering Polymer - Thickening Polymer - Dewatering	Hypochlorite - Odor Control Ferric Chloride - Dewatering Polymer - Thickening Polymer - Dewatering	Hypochlorite - Odor Control Ferric Chloride - Dewatering Polymer - Thickening Polymer - Dewatering
Oceanside Plant (OSP)	Hypochlorite - Disinfection Hypochlorite - Odor Control Bisulfite - Dechlorination Ferric Chloride - Pretreatment Polymer - Thickening Polymer - Dewatering Liquid Oxygen - Aeration	Hypochlorite - Odor Control Ferric Chloride - Pretreatment Polymer - Thickening Polymer - Dewatering Liquid Oxygen - Aeration	Hypochlorite - Odor Control Ferric Chloride - Pretreatment Polymer - Thickening Polymer - Dewatering Liquid Oxygen - Aeration	WWF Hypochlorite - Disinfection Hypochlorite - Odor Control Ferric Chloride - Pretreatment Polymer - Thickening Polymer - Dewatering Liquid Oxygen - Aeration	Hypochlorite - Odor Control Ferric Chloride - Pretreatment Polymer - Thickening Polymer - Dewatering Liquid Oxygen - Aeration
North Point Facility (NPF)	Hypochlorite - Disinfection Bisulfite - Dechlorination Ferrous Chloride Hydrogen Peroxide - Odor Control	Hypochlorite - Disinfection Bisulfite - Dechlorination	Hypochlorite - WWF Disinfection & Odor Control Bisulfite - Dechlorination Ferric Chloride - Dewatering	Hypochlorite - Disinfection & Odor Control Bisulfite - Dechlorination	Hypochlorite - Disinfection & Odor Control Bisulfite - Dechlorination
Collection	Hypochlorite - Odor Control Hydrogen Peroxide - Odor Control Ferrous Chloride	Hypochlorite - Odor Control Hydrogen Peroxide - Odor Control Ferrous Chloride	Hypochlorite - Odor Control Hydrogen Peroxide - Odor Control Ferrous Chloride	Hypochlorite - Odor Control Hydrogen Peroxide - Odor Control Ferrous Chloride	Hypochlorite - Odor Control Hydrogen Peroxide - Odor Control Ferrous Chloride

Processing assumptions were based on those presented in the draft project memorandum, "Status on Organic Waste Processing" (Brown & Caldwell, March 30, 2007).

4.2 Configuration Greenhouse Gas Emission Estimates

The resulting GHG emissions based on the boundary conditions described above for each Master Plan configuration evaluated in October 2007 are summarized in Figures 2 and 3, and in Table 3.

5.0 BASELINE AND PREFERRED CONFIGURATION ANALYSIS

The GHG emissions for the baseline and preferred configurations were calculated as detailed above. The configuration boundary conditions and results are summarized below.

5.1 Baseline and Preferred Configuration Boundary Conditions

A different set of boundary conditions was developed for the baseline and preferred configuration evaluated in November 2008. Similar to the previous boundary conditions, only the operations phase of the treatment facilities and pump stations is considered for this analysis. The reason that only the operations phase is considered is that construction-related emissions are a relatively small component of the life cycle emissions for a long-lived utility such as the SFPUC wastewater treatment facilities. This includes unit processes at the treatment facilities and pump stations throughout the collection system, as well as the hauling of biosolids and the production and hauling of the chemicals consumed for treatment of the wastewater and biosolids. This analysis does not include emissions from organic waste digestion and handling.

Energy derived from both biogas and on-site solar panels serves to avoid GHG emissions (that would have otherwise been generated from purchased electricity) and is considered as an offset in this analysis. Figure 4 illustrates the system boundary set for this type of analysis.

For a detailed description of the data sources and the assumptions used to estimate the GHG emissions resulting from the operations of the baseline and preferred configuration refer to Appendix B.

The data sources and assumptions applied to estimate the GHG emissions are discussed in the sections below.

Figure 2 Configuration Carbon Dioxide Equivalent (CO_2e) Emissions for Each Master Plan Configuration Evaluated in October 2007

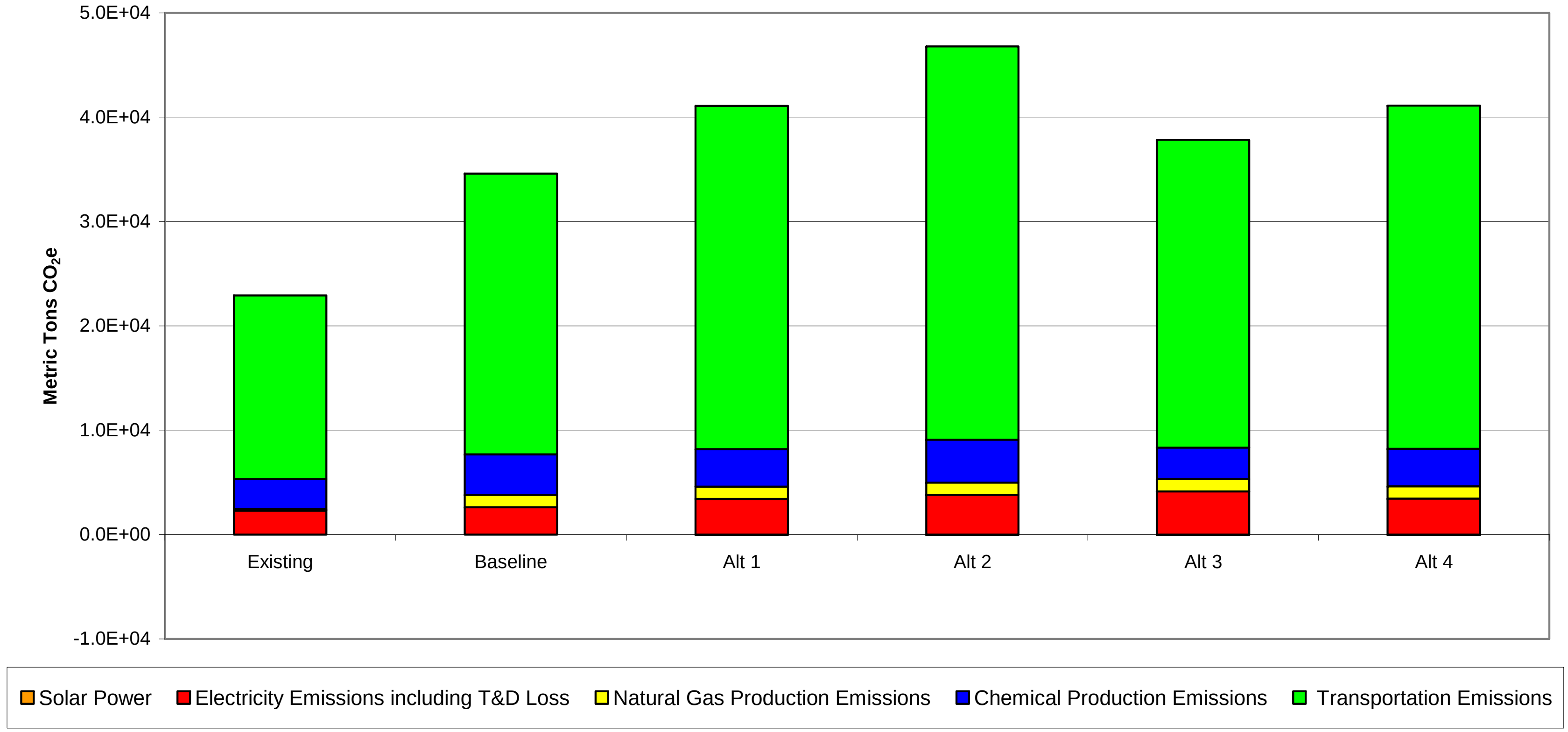


Table 3 Metric Tons CO_2 Equivalent Emissions for Each Master Plan Configuration Evaluated in October 2007
2030 Sewer System Master Plan
City and County of San Francisco

	INDIRECT				DIRECT	TOTAL CO_2e Emissions[2]
	Solar Power	Electricity Emissions including T&D Loss [(1)]	Natural Gas Production Emissions	Chemical Production Emissions	Transportation Emissions	
Existing	-11	2,290	162	2,878	17,585	**22,915**
Baseline	-11	2,630	1,181	3,884	26,899	**34,594**
Alt 1	-21	3,418	1,181	3,603	32,889	**41,091**
Alt 2	-21	3,814	1,181	4,105	37,696	**46,796**
Alt 3	-21	4,142	1,181	3,012	29,500	**37,836**
Alt 4	-21	3,435	1,181	3,603	32,889	**41,108**

Notes:

(1) Transmission and Distribution (T&D) loss is assumed to be 8% based on California Energy Commission's "Guidance to the California Climate Action Registry: General Reporting Protocol" (June 2002).

(2) The baseline and configuration emissions presented in this table are not comparable to the results of the preferred configuration and baseline evaluated in November 2008 because the boundary conditions differ. Refer to the boundary condition sections and the Appendices for the assumptions used in each evaluation.

Figure 3 Carbon Dioxide Equivalent (CO2e) Emissions Resulting from Handling of Organic Waste for Configurations Evaluated in October 2007

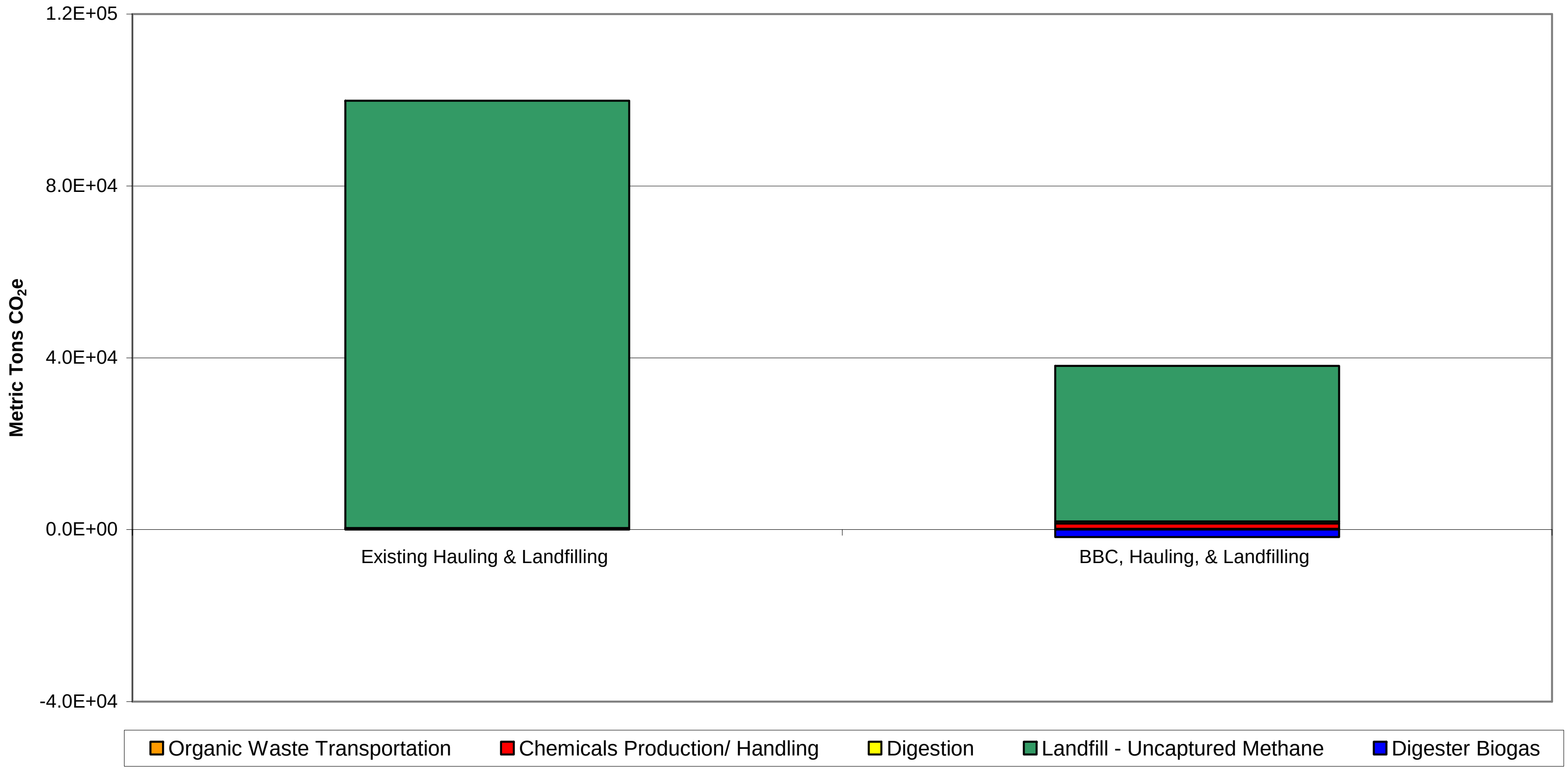
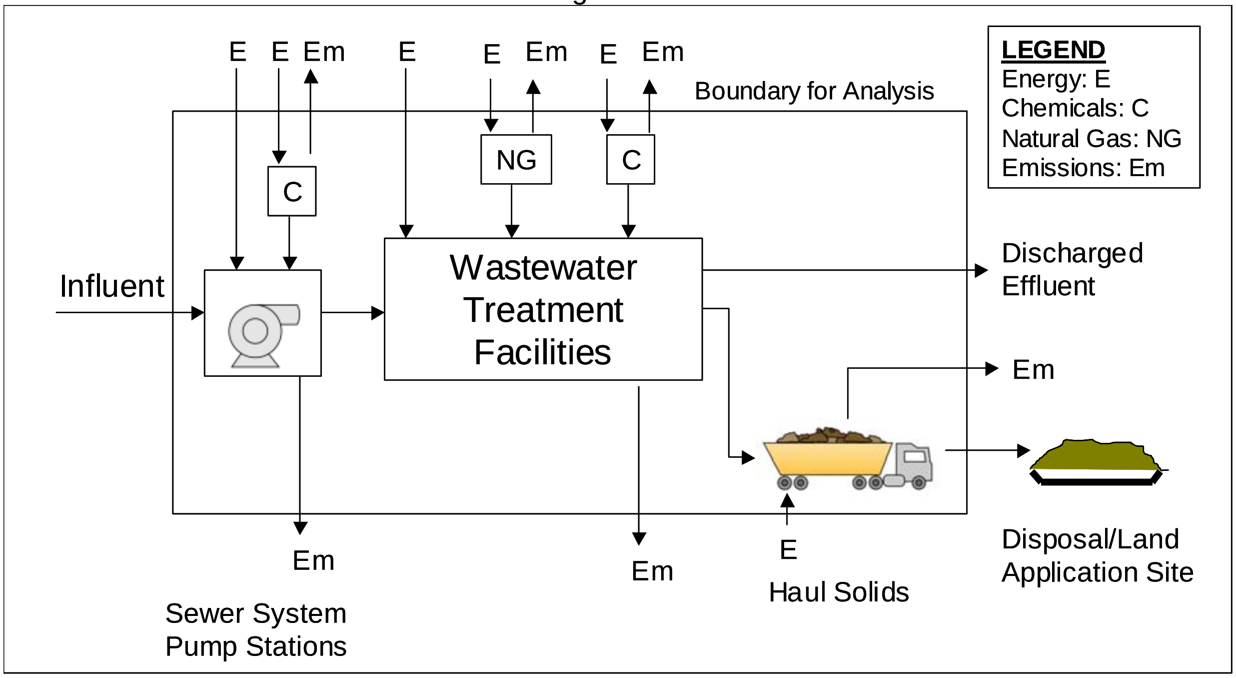


Figure 4 Unit Process Boundary for the San Francisco Sewer System Master Plan Baseline and Preferred Configuration GHG Evaluation



5.1.1 Collection System and Treatment Plant Operations

The total energy demand for treatment plant operations and pump stations throughout the sewer system are based on the operation and maintenance (O&M) estimates developed by SFPUC, Brown and Caldwell, and Carollo Engineers.

5.1.2 Chemical Production and Handling

The total chemical consumption estimates are based on treatment plant operation data for the year 2007. Chemical dose assumptions are based on treatment plant operation data for 2004 through 2007, in addition to the 2003 Baseline Facilities Report.

The California Climate Action Registry General Reporting Protocol considers energy required for the production of chemicals consumed in treatment processes to be outside the boundary of this type of estimate. However, in order to provide a more complete representation of the impacts of the baseline and the preferred configuration, the energy consumed for chemical production is included in this analysis. The energy required per unit chemical consumed is based on conversion factors per “Energy in Wastewater Treatment” by William F. Owen and certified Environmental Product Declarations produced by Eka Chemicals.

In order to estimate the GHG emissions generated from the handling (transport) of the chemicals, SFPUC provided the supply location of the chemicals, as well as the type of hauling truck and type of fuel consumed.

Table 4 lists the chemicals included in the analysis for each treatment plant for the baseline and preferred configuration.

Table 4 Chemicals Used and Included in the Evaluation
2030 Sewer System Master Plan
City and County of San Francisco

	Baseline	Preferred Configuration
Southeast Plant (SEP)	Sodium Hypochlorite - Disinfection Bisulfite - Dechlorination Hydrogen Peroxide - Odor Control Ferric Chloride - Dewatering Polymer - Thickening Polymer - Dewatering	WWF Hypochlorite - Disinfection WWF Bisulfite - Dechlorination Hydrogen Peroxide- Odor Control HPO - Secondary
Bayside Biosolids Center (BBC)	(Biosolids treatment split among existing treatment facilities)	Hypochlorite - Odor Control Ferric Chloride - Dewatering Polymer - Thickening Polymer - Dewatering
Oceanside Plant (OSP)	Hypochlorite - Disinfection Hypochlorite - Odor Control Ferric Chloride - Pretreatment Polymer - Thickening Polymer - Dewatering Liquid Oxygen - Aeration	Hypochlorite - Odor Control Ferric Chloride - Pretreatment Polymer - Thickening Polymer - Dewatering Liquid Oxygen - Aeration
North Point Facility (NPF)	Hypochlorite - Disinfection Bisulfite - Dechlorination Ferrous Chloride (North Shore PS)	Hypochlorite - Disinfection Bisulfite - Dechlorination Ferrous Chloride (North Shore PS)
Collection	Hypochlorite - Odor Control Hydrogen Peroxide - Odor Control Ferrous Chloride	Hypochlorite - Odor Control Hydrogen Peroxide - Odor Control Ferrous Chloride

5.2 Baseline and Preferred Configuration Greenhouse Gas Emission Estimates

The resulting estimates for GHG emissions of the preferred configuration and baseline evaluated in November 2008 are summarized in Table 5 and Figure 5.

Table 5 Comparison of Annual CO_2 Equivalent Emissions for the Baseline and Preferred Configuration [1]
2030Sewer System Master Plan
City and County of San Francisco

Configuration	INDIRECT CO_2e Emissions [2] (All values in metric tons of CO_2e emissions per year rounded to the nearest 100 metric tons)				TOTAL CO_2e Emissions [4] [5]
	Electricity Production [3]	Natural Gas Production	Chemical Production	Chemical & Biosolids Transportation	
Baseline	2,700	100	7,600	8,000	**18,400**
Preferred Configuration	3,300	1,200	5,500	7,500	**17,500**

Notes:

(1) Estimated CO_2e emissions resulting from operations of the configuration show during dry and wet weather (year-round) conditions. Does not include emissions related to capital construction.

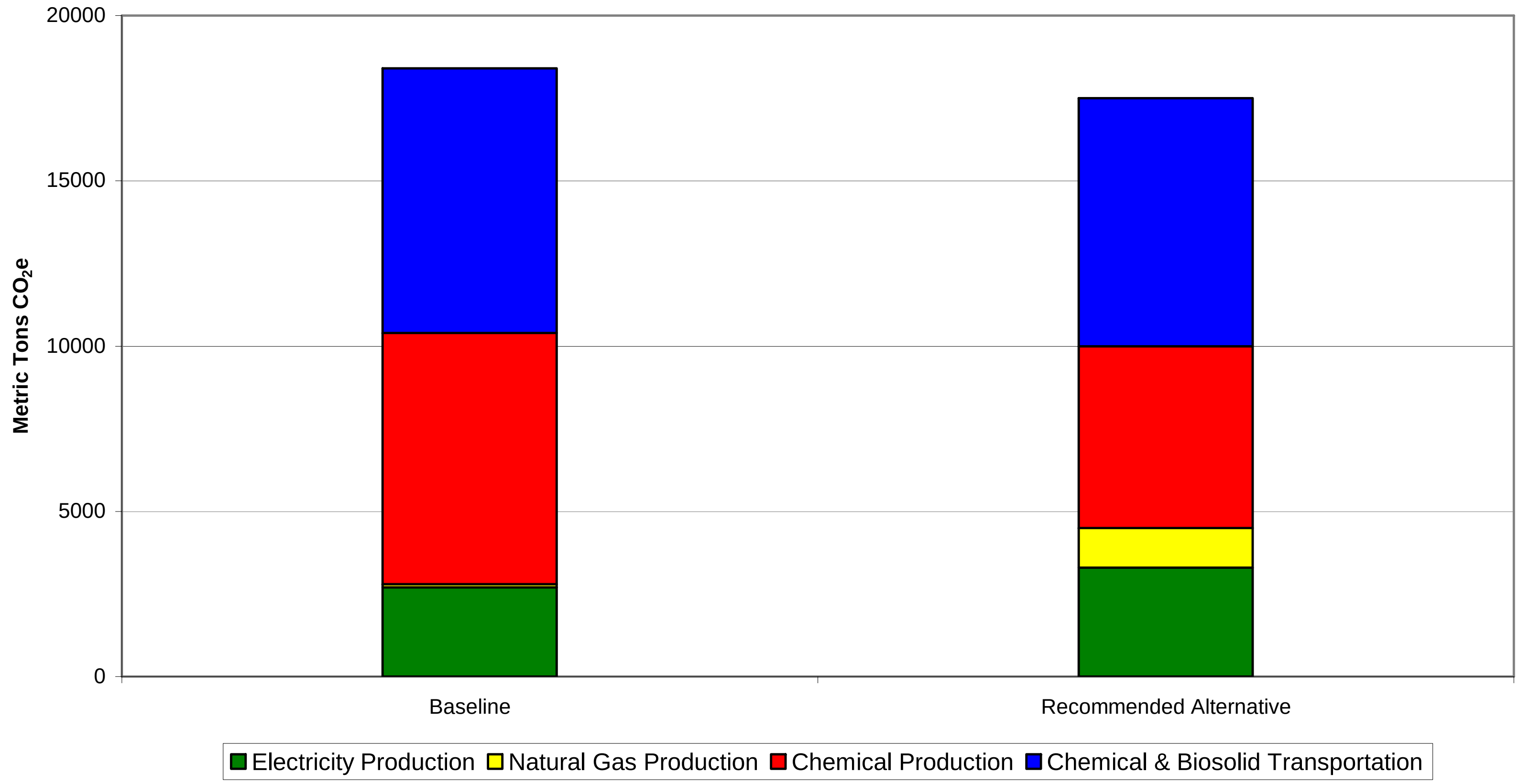
(2) Solar power and cogeneration from the use of biogas (which is renewable or "biogenic") results in avoiding CO_2e emissions from the use of purchased electricity from PG&E, which primarily uses anthropogenic sources of fuel (e.g. natural gas). Therefore, the summary of CO_2e emissions in Table 1 does not include emissions from solar or biogas derived electricity.

(3) The electricity production-related CO_2e emissions include transmission and distribution (T&D) loss, assumed to be 8% based on California Energy Commission's "Guidance to the California Climate Action Registry: General Reporting Protocol" (June 2002).

(4) The total or the sum of all production and transportation values.

(5) The baseline and preferred configuration emissions presented in this table are not comparable to the results of the four configurations evaluated in October 2007 because their boundary conditions differ. See the boundary condition sections and the Appendices for the assumptions used in each evaluation.

Figure 5 Comparison of Annual CO_2e Emissions for the Baseline and Preferred Configuration



APPENDIX A - ANALYSIS ASSUMPTIONS FOR THE FOUR CONFIGURATIONS EVALUATED IN OCTOBER 2007

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Electricity Consumption for Operations

- All electrical consumption results are calculated in the SFPUC O&M.xls file and are linked to the "Energy Consumption" worksheet in this file.

Chemical Consumption for Operations at Build-Out

- Chemicals considered are only those consumed at build-out in 30 years.
- Chemical consumption rates are based on SFPUC average doses during 2004, 2005, and 2006, unless otherwise noted.
- Chemical consumption rates for solids in all configurations are calculated assuming 27,740 dry tons of biosolids are generated annually at Build-Out.
- All wet weather flows will receive primary treatment.
- Wet weather flow receiving only primary treatment will receive hypochlorite, while wet weather flows receiving secondary treatment will receive UV disinfection.
- UV Disinfection and HPO power consumption is captured in the O&M estimates for power consumption.
- Not including the chemicals used for MBR cleanings.
- Hypochlorite is added at 12.5% concentration.
- Bisulfite is added at 25% concentration.
- Ferric/Ferrous chloride is added at ~40% concentration.
- Hydrogen Peroxide is added at 50% concentration.
- Polymer is added at ~0.30% concentration.
- Existing calculations include ~60,000 cubic feet of natural gas consumed daily at OSP.
- Odor control assumption - Hypo for the existing and baseline, Hydrogen Peroxide for project configurations.
- Hydrogen Peroxide (50% - 350 gal/day) was added to SEP in 2006 for odor control, in place of Hypochlorite.

- Collection system chemical consumption for configurations is equal to the baseline consumption (see "Chemical Consumption" worksheet for specific chemical injection site information).

Chemicals Handling Resulting from the Operations

- Number of deliveries per chemical per year are calculated relative to the projected annual amount of chemical consumed.

Biosolids Handling Resulting from Operations

- Trucks hauling the biosolids hold 22 tons (Jack Macy, DOE).
- Trucks achieve 5.65 mpg if consuming diesel (Bonnie Jones), 4.5 mpg if consuming B20 fuel, and 2.5 mpg if consuming LNG (Mike Crosetti, SFRD).
- Existing biosolids generated based on 2006 data, ~18,000 dry tons/year are produced at SEP & OSP - which is ~81,000 wet tons (refer to San Francisco Long-Term Biosolids Management Plan, Table 1-1, June 2007).
- At build-out ~27,740 dry tons/year are produced at Bayside or Oceanside biosolids center - which is ~131,020 wet tons based on current % solids at SEP & OSP (refer to San Francisco Long-Term Biosolids Management Plan, Tables 2-3 & 2-4, June 2007).
- "Delivery Location Sites" are the same for the Baseline and Build-Out as they were for the Existing system, in addition to the same distribution of solids among them (refer to San Francisco Long-Term Biosolids Management Plan, Table 1-2, June 2007).

Renewable Energy Production (Credits)

Existing Renewable Energy Production

- Not considering construction phase of power generating equipment.
- Southeast Plant provides 300,000 kWh/Year of solar power

Build-Out Renewable Energy Production

- Not considering construction phase of power generating equipment.
- Southeast Plant provides 300,000 kWh/Year of solar power.
- North Point Facility provides 251,000 kWh/year of solar power.
-

Food Waste (Organic Waste)
Existing Disposal of Organic Waste

- All solids will start at the XFR station at Tunnel Ave & Beatty Rd
- Waste is hauled 6 days per week per Jack Macy (SFPUC - 6/11/07).
- Total MSW Stream is ~638,000 tons and it is assumed that 26.8% of it is organic waste per 2005 Waste Composition Study (provided by Jack Macy - 06/11/07).
- Percentage of Green Bin wastes that are considered organic waste is based on info from Jack Macy (SFPUC - 6/11/07) & agree with 6/4/07 Meeting Minutes.
- Trucks hauling the solids hold 22 tons and achieve 5.65 mpg.
- Garbage disposal wastes are included in the wastewater stream and not included in these calculations.
- Landfill biogas generated from organic waste produces 3.5 million BTUs per ton (UC Davis and Will Brinton (Norcal) - per Chris Choate (Norcal)).

Landfill Organic Waste

- Source: U.S. EPA, Solid Waste Management & GHGs, A Life-Cycle Assessment of Emissions and Sinks (Ch 6, Landfilling), 3rd Ed, 9/2006
- Net GHG emissions from methane generation for food discards is 0.445 (MTCE/Wet Ton).
- 10% of methane emissions from the landfill are oxidized to carbon dioxide.
- 20% of emissions are captured and put to beneficial use - remaining 80% are emitted to the atmosphere. Based on "Comments to the CARB on Landfills' Responsibility for Anthropogenic GHGs and the Appropriate Response to those Facts" by Peter N. Anderson.
- Biogas is 50% methane, 50% carbon dioxide - carbon dioxide is considered biogenic and is NOT considered in the inventory.
- 3.5 million Btu's are generated per ton of organic waste based on research done at UC Davis and Will Brinton's work for NorcaL.

Digestion of Organic Waste at Biosolids Center

- Assumptions largely based on "Status on Organic Waste Processing" memo by Perry Schafer 3/30/07 & phone conversation on 6/7/07.

- Not considering the emissions resulting from the construction phase of the new Organic Waste digesters.
- All "Green Bin" wastes are source separated organics (SSO) and will undergo thermophilic digestion.
- SSO is assumed to be 30% solids and 85% VS/TS.
- Trucks hauling the solids hold 22 tons and achieve 5.65 mpg.
- 10% of the organic waste received at BBC will be rejected before digestion.
- Organic waste is diluted to 10% (6-10% range) solids for digesters.
- Organic waste is treated separately from wastewater biosolids.
- Organic Waste is assumed to be delivered to BBC 6 days per week.
- 15 (15-18 range) day hydraulic residence time for digestion.
- 2.5 million gallon tanks will be used for organic waste digestion.
- Power consumed for digestion of organic waste is similar to biosolids digestion - ~2,300,000 kWh per digester per year.
- Volatile Solids Reduction for organic waste is 70% (55-80% range).
- Digested dewatered Organic Waste will be 30% solids and ~25% VS/TS.
- 16 (12-16 range) cu ft of biogas is generated per pound of volatile solids (VS) destroyed.
- Energy value of biogas is ~600 Btu/cu ft.
- Power production is estimated to be 9000 Btu/kWh.
- Dewatering Polymer - 12 lbs/dry ton digested organic waste.
- Odor Control - Sodium Hypochlorite (5 mg/L) and Caustic demand equals that for the solids digested.

APPENDIX B - ANALYSIS ASSUMPTIONS FOR THE PREFERRED CONFIGURATION EVALUATED IN NOVEMBER 2008

APPENDIX B - ANALYSIS ASSUMPTIONS FOR THE PREFERRED CONFIGURATION EVALUATED IN NOVEMBER 2008

Chemical Handling

Below is a complete list of assumptions applied to estimate the GHG emissions resulting from the production and transport of chemicals consumed for odor control and proper treatment of wastewater.

- Chemicals considered for the baseline and preferred configuration are based on 2007 consumption data.
- Chemical consumption rates for solids treatment for the preferred configuration are calculated assuming 27,740 dry tons of biosolids are generated annually at build out (per Technical Memorandum B4, Tables 2-3 & 2-4).
- All wet weather flows will receive primary treatment at a minimum.
- Wet weather flow receiving only primary treatment will receive hypochlorite, while wet weather flows receiving secondary treatment will receive UV disinfection.
- UV Disinfection and high purity oxygen (HPO) energy consumption is captured in the O&M estimates for energy consumption.
- Sodium hypochlorite is added at 12.5% concentration.
- Sodium bisulfite is added at 25% concentration.
- Ferric chloride is added at approximately 40% concentration.
- Ferrous chloride is added at approximately 33% concentration.
- Hydrogen peroxide is added at 50% concentration.
- SEP gravity belt thickener polymer is delivered at 4% concentration and is added at 0.35% concentration and the centrifuge dewatering polymer is added at 0.25%concentration.
- OSP gravity belt thickener polymer is delivered at 4% concentration and is added at 0.20% concentration and the belt filter press dewatering polymer is added at 0.14% concentration.
- Existing natural gas consumption is assumed to be approximately 60,000 cubic feet (cu ft) daily at OSP.

- Baseline system natural gas consumption is estimated using the existing consumption of approximately 60,000 cu ft per day at OSP (17 MGD) and scaling it to a 15 MGD flow.

- Preferred Configuration natural gas demand at build-out is assumed to remain the same as OSP demand reported in the 2003 Baseline Facilities Report - approximately 20% of average total biogas production. The average biogas production rate at BBC is assumed to be 803,000 KSCF/year (2,200 KSCF/day) based on the "San Francisco Long-Term Biosolids Management Plan" (Technical Memorandum B4).

- Hydrogen peroxide is assumed to be consumed for odor control for the baseline and the preferred configuration (sodium hypochlorite is on hand for backup).

- Hydrogen peroxide (at 50% - 350 gal/day) is added to SEP for odor control, in place of sodium hypochlorite.

- Collection system chemical consumption for the preferred configuration is equal to the baseline consumption (see "Chemical Consumption" worksheet for specific chemical injection site information).

- This evaluation is not including the chemicals used for MBR cleanings.

- The number of deliveries per chemical per year for the preferred configuration is calculated based on the projected increase in annual amount of chemical consumed.

Biosolids Handling

Estimates of GHG emissions generated from the handling (transport) of biosolids are based on the type of truck used, the type of fuel consumed, and the distance to the land application site provided by the SFPUC, in addition to the assumptions listed below.

- Trucks hauling the biosolids hold 23 tons of material (Natalie Sierra, SFPUC).

- Trucks achieve 5.65 miles per gallon if consuming diesel (Bonnie Jones, SFPUC), 4.5 miles per gallon if consuming B20 fuel, and 2.5 miles per gallon if consuming LNG (Mike Crosetti, SFRD).

- Baseline biosolids generated is based on 2007 data - 17,519 dry tons (84,487 wet tons) per year are produced at SEP & OSP (Natalie Sierra, SFPUC).

- For the preferred configuration at buildout, approximately 27,740 dry tons per year will be produced at the Bayside Biosolids Center - which is approximately 131,020 wet tons based on the percent solids at SEP & OSP (per San Francisco Long-Term Biosolids Management Plan (Technical Memorandum B4), Tables 2-3 & 2-4).

- Land application sites are the same for the baseline and preferred configuration (based on 2007 information), in addition to the same allocation of biosolids among them (Natalie Sierra, SFPUC).

This analysis can also include those emissions generated at a landfill should that be an option considered. In that case, the following assumptions would be applied:

- Estimates show that at least 10% of methane emissions from the landfills are oxidized to carbon dioxide (which are considered biogenic and therefore not included in this inventory) according to the text by U.S. EPA, Solid Waste Management & GHGs, A Life-Cycle Assessment of Emissions and Sinks (3rd Edition, September 2006, Chapter 6: Landfilling).

- If gas capture is employed at the landfill, 20% of emissions are assumed to be captured and put to beneficial use and the remaining 80% are emitted to the atmosphere. This assumption is based on "Comments to the CARB on Landfills' Responsibility for Anthropogenic GHGs and the Appropriate Response to those Facts" by Peter N. Anderson.

Renewable Energy

There are two sources of renewable energy considered in this estimate - energy derived from photovoltaic panels and digester gas. The data provided by the SFPUC were used to estimate avoided indirect GHG emissions (offsets) had SFPUC purchased electricity equivalent to the energy produced by the solar panels and digester gas.

The SFPUC provides data for on-site solar power generation for the baseline and the preferred configuration at build out. The following assumptions are applied:

- Production and construction phase of power generating equipment is not considered.

- Southeast Plant provides 300,000 kWh/Year of solar power for both the baseline and preferred configuration.

- North Point Facility provides 251,000 kWh/year of solar power for the preferred configuration only.

Estimates of avoided GHG emissions, for the baseline and the preferred configuration at build out, resulting from biogas generated during the anaerobic digestion of biosolids are largely based on data provided by the SFPUC and the San Francisco Long-Term Biosolids Management Plan (Project Memorandum B4). The following assumptions are applied:

- This inventory does not consider the emissions resulting from the construction phase of new digesters.

- Biogas is 50% methane, 50% carbon dioxide - carbon dioxide is considered biogenic and therefore is not considered in the inventory.
- Fifteen-day (15-18-day range) hydraulic residence time is considered for digestion.
- Power consumed for digestion of biosolids is approximately 2,300,000 kilowatt-hours (kWh) per digester annually.
- Sixteen (12-16 range) cubic feet of biogas is generated per pound of volatile solids (VS) destroyed.
- Volatile solids reduction is 55%.
- Energy value of biogas is approximately 600 British thermal units per cubic foot (Btu/cu ft).
- Power production is estimated to be 9,000 Btu/kWh from biogas.