TECHNICAL PAPER #0803

GREENHOUSE GAS MANAGEMENT AT A WASTEWATER TREATMENT PLANT WITH SLUDGE INCINERATION: A CASE STUDY

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For Presentation at:

WEFTEC® 2008
Chicago, IL

18-22 October 2008

WESTON SOLUTIONS®

08P-1409-2

Greenhouse Gas Management at a Wastewater Treatment Plant with Sludge Incineration: A Case Study

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ABSTRACT

Management of greenhouse gasses begins with an inventory of greenhouse gas emissions within an organization's operational and organizational boundaries. The internationally accepted protocol for inventory construction is the Corporate Accounting and Reporting Standard (CARS) of the GHG Protocol, developed by the World Resources Institute and the World Business Council for Sustainable Development. The sole existing compliance reporting in the US, California's General Reporting Protocol, has largely adopted CARS, as has the popular voluntary US protocol EPA Climate Leaders.

Wastewater treatment plants (WWTPs) present some unique challenges for emissions quantification and management. Process and fugitive emissions may be significant and quantification may be further complicated by the need to distinguish biological and fossil carbon. This paper examines emissions quantification challenges for a plant with aerobic digestion and sludge incineration. The plant waste stream includes effluent from a refinery which contributes organic compounds of fossil origin.

Specific challenges addressed include:

1. Methods to estimate fugitive CO_2 emissions of biologic vs. fossil origin from aerobic processes.
2. Methods to estimate incinerator CO_2 emissions of biologic vs. fossil origin.
3. Fugitive methane emissions.

INTRODUCTION

With the promulgation of California's General Reporting Protocol (GRP), the framework for assigning greenhouse gas emissions at an organizational level has been established in the US. GRP designates two broad categories of emissions that must be counted in an organizations core emissions: direct (gasses emitted on site from stationary, mobile, process, and fugitive sources) and indirect (gasses emitted as a result of purchased energy). All six Kyoto gasses must be counted for both categories: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), HFCs (a group of gasses largely used in refrigeration systems), PFCs (a group of gasses used in certain industrial processes), and sulfur hexafluoride (SF_6), though in practice, certain gasses from some sources are omitted as de minimus.

The GRP largely follows the international standard, The Greenhouse Gas Protocol, developed by the World Resources Institute, and the voluntary U.S. standard developed by EPA, the Climate Leaders Protocol. These latter two are more comprehensive than GRP and include guidelines for calculating emissions from non core sources such as business travel and waste disposal. Just as with the other standards, GRP distinguishes between fossil CO_2 and CO_2 of recent biological origin such as that from agricultural and forest products. GRP suggests inclusion of biological CO_2 in reporting but it is not assigned as greenhouse gas emissions to the organization.

These protocols are supplemented in some cases by industry specific guidance; however, sector guidance has yet to be promulgated for wastewater treatment operations (WWTOs). The literature on wastewater process emissions refers to accounting methods established by the Intergovernmental Panel on Climate Change (IPCC) in Source Category 6B (IPCC) designed for country-level emissions calculations. This method has been adopted by EPA for its Inventory of U.S. Greenhouse Gas Emissions and Sinks (EPA). It focuses on methane emissions and calculates these as a function of treatment type (aerobic or anaerobic), BOD, and flow. Although adequate for country level emissions, this method is not sufficiently detailed to capture the impacts of variations in process among WWTOs. Process specific methods are essential not only to fairly assign emissions to particular operations, but to identify best practices as regards greenhouse gas mitigation from waste water treatment.

This case study can be of value in several ways. First, it can assist WWTOs seeking to develop their own inventories by illustrating some of the challenges, procedures, and methods associated with this task. Second, it contributes to the particularization of emissions based on processes employed at WWTOs through the development of two methods. Better emissions calculations at the WWTO level are important for individual facilities as they face impending carbon regulation but are also key to improvement of processes in the industry as a whole. Finally, intensity metrics developed for the case study WWTO provide some context for the processes employed relative to other WWTOs and processes.

The paper by no means addresses all of the challenges faced in accounting for emissions from WWTOs. Notably it does not address emissions quantification associated with the various forms of anaerobic digestion which are commonly employed in treatment processes. Sludge disposal emissions are based on incineration which is a relatively uncommon practice. Perhaps most importantly, the identification of best practices for waste water treatment must be based on a full life cycle analysis which takes into account not only WWTO direct and indirect emissions but also so called Scope 3 emissions. These arise from tertiary activities such as waste disposal through land filling, transportation of inputs and outputs of the process, etc., all of which are beyond the scope of this study.

THE CASE STUDY

Project Profile

The Delaware County Regional Water Control Authority (DELCORA) is a county authority charged with the collection and treatment of wastewater in Delaware County, PA. DELCORA's operations encompass the Western Regional Treatment Plant (WRTP), numerous pumping stations, fleet operations, and an administrative building. A schematic of DELCORA's service area is shown in Figure 1-1.

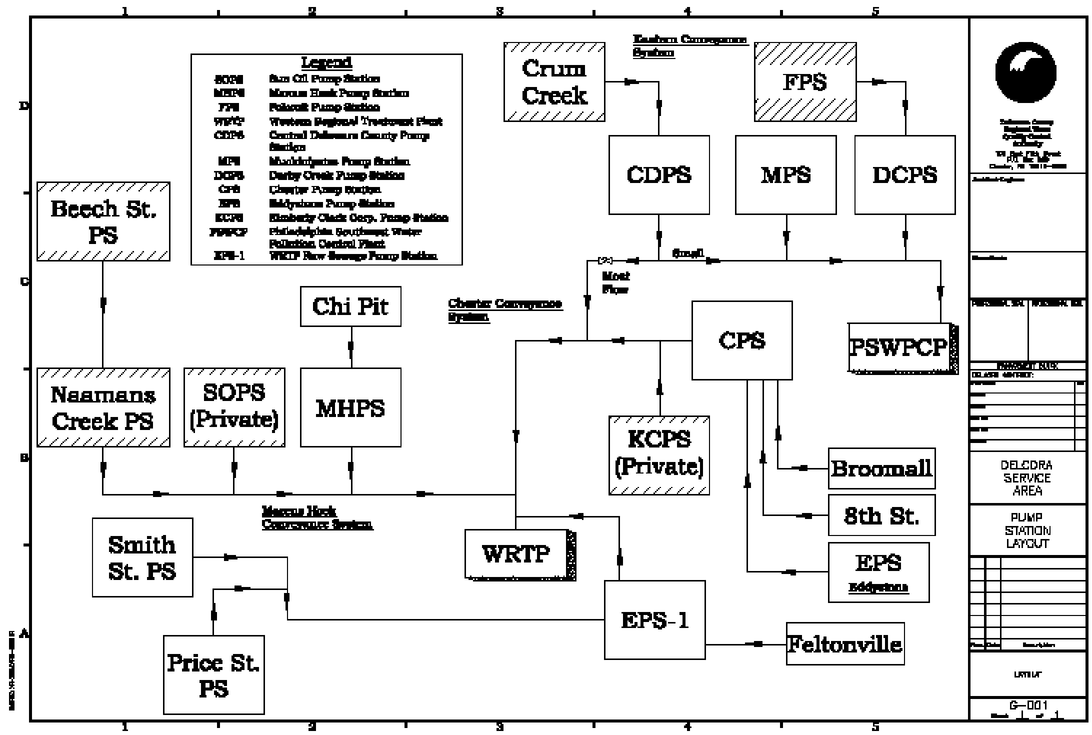


Figure 1-1. Delaware County Regional Water Control Authority (DELCORA) Service Area.

In late 2007 DELCORA decided to establish a baseline for its greenhouse gas emissions and to use 2006 as the baseline year. DELCORA had several concerns which led to the decision to conduct an inventory and establish a baseline.

As a highly regulated entity, management at DELCORA is quite sensitive to emerging regulatory issues. Both the IPCC and the EPA consider wastewater treatment to be a significant source of greenhouse gas emissions. According to EPA's 1990-2005 Inventory of U.S. Greenhouse Gas Emissions and Sinks, wastewater treatment accounts for just under 5% of US methane emissions (EPA), a significant contribution to global warming emissions, as methane has 23 times the global warming potential of carbon dioxide. As states and the federal government continue to press towards regulating GHG emissions, DELCORA believed it prudent to gain an understanding of their emissions profile.

In addition, under California's AB32 and most other GHG regulation under consideration, early action in managing emissions is encouraged. Establishment of a baseline permits organizations to gain recognition for emissions management action taken prior to imposition of regulation. For this reason DELCORA elected to develop a protocol compliant inventory and have the results certified by a CCAR approved verifier.

Weston Solutions Inc. (WESTON) was retained by DELCORA to develop the baseline inventory. This work was produced as two documents, an Inventory Management Plan (IMP) and an inventory with associated calculation sheets. These were constructed following the World Resources Institute (WRI) and the World Business Council for Sustainable Development's (WBCSD) accounting principles of relevance, completeness, consistency, transparency, and accuracy. The Corporate Accounting and Reporting Standard (CCARS) of the Greenhouse Gas Protocol was followed in the inventory development. Sector specific guidance for WWTPs is quite limited and the literature focuses on methane emissions from anaerobic plants using country level quantification methods. Guidance in the estimation of process CO_2 emissions from WWTOs is essentially non existent as these are normally considered of biological origin.

DELCORA's WRTP is an activated sludge plant providing secondary treatment of municipal and industrial wastes generated within its designated service area. The sludge is combusted in two on site incinerators and ash is land filled. As can be seen in Figure 1 -1, two private pump stations contribute industrial waste to the facility. Kimberly Clark (KCPS) contributes industrial effluent consisting primarily of paper waste. Sun Oil (SOPS) contributes effluent from its refining operations. Influent from Sun Oil is separately metered and tested and in the baseline year of 2006 influent from Sun comprised about 15% by volume of the WRTP load. DELCORA's process can be visualized in Figure 1 -2.

DELCORA's process configuration is relatively unusual in the US WWTP industry. With the emissions concerns and control requirements of modern air quality regulations, most plants have moved away from incineration as a sludge disposal method. Only four other plants in the U.S. have a similar process. Amid this small subset of WWTPs, DELCORA may be unique in that it receives significant influent from a refinery.

The Inventory Management Plan

An Inventory Management Plan (IMP) contains all of the documentation to fully understand how the inventory was constructed and what inaccuracies and omissions it may contain. The IMP details all of the methods used to calculate emissions. It should contain sufficient information for an informed third party to make a determination of the inventory's accuracy for verification purposes.

The IMP also describes certain choices made in defining the organizational and operational boundaries of the organization. It documents the selection of the base year and handling of base year adjustments. The base year is the year from which future performance is measured. In emissions reduction regimes, goals are established relative to the declared base year.

Base Year Selection: Barring requirements of a particular compliance or voluntary program, choice of a base year is left to the organization for whom the inventory is being constructed. Protocol guidance for base year selection suggests choosing the earliest year for which good data is available however organizations are likely to have additional concerns in base year selection.

Protocols require that base year emissions be adjusted for organization structural changes (acquisitions, divestitures, etc.). An earlier base year may instigate a need for significant

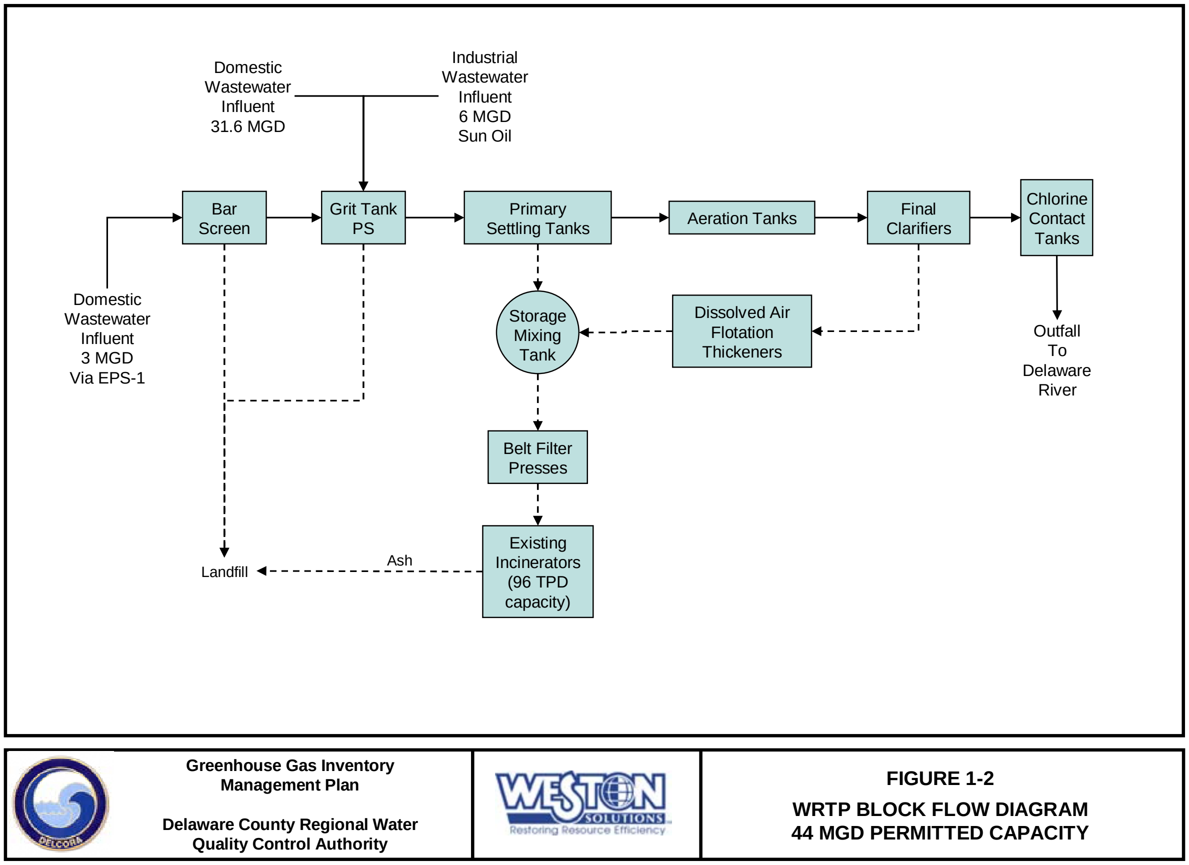


Figure 1-2.ppt

Figure 1-2. WRTP block flow diagram 44-MGD permitted capacity.

recalculations in subsequent years if structural changes have occurred. This effort and expense may not be justified barring other reasons for using an early base year.

In some cases an earlier base year will allow organizations to capture prior investment in emissions reductions and this advantage must be weighed against the burden of locating data from an earlier period as well as potentially triggering base year recalculation requirements in subsequent years. Although DELCORA had made some significant efficiency investment in earlier years, they elected to use 2006 as a base year. This decision was predicated on ease of access to data as well as a desire to understand current emissions, rather than historic ones, as a first step in emissions management.

DELCORA's policy on base year adjustment, as stated in the inventory management plan and in compliance with the Corporate Accounting and Reporting Standard, is as follows:

> In the event of an acquisition of a facility that existed during the base year (2006) the facility's 2006 emissions will be added to DELCORA's base year emissions. If the facility did not exist in the base year no adjustment to DELCORA's baseline will be made.

In the event of a divestiture of a facility that existed during the base year (2006) the facility's 2006 emissions will be subtracted from DELCORA's base year emissions. If the facility did not exist in the base year no adjustment to DELCORA's baseline will be made.

In the event of outsourcing of activities with material emissions that were included in the base year emissions, the base year will be recalculated by subtracting these emissions.

In the event of insourcing of activities with material emissions that were not included in the base year emissions, these emissions will be added to the base year provided the sources existed during the base year.

In the event of organic growth (increase in throughput, opening of new plants, et. al.) or organic decline (decrease in throughput, closing of plants, et. al.) no adjustments will be made to the baseline.

Boundaries: Organizational as well as operational boundaries must be established in the initial inventory. The WRI/WBCSD Greenhouse Gas Protocol outlines several approaches which may be used to define organizational boundaries. DELCORA selected the Protocol's *Control* approach using *Financial Control* criteria as the method which best reflected actual power of control. The decision to include facilities/activities in the inventory was based on the ability to direct financial and operating policies for the benefit of DELCORA.

For inventory year 2006, the *Financial Control* approach defined DELCORA's organization as the Western Regional Treatment Plant, the Administration Building, ten pump stations, one lift station, and one pit station. The boundary can be visualized in Figure 1 -1, which graphically represents the piping system and facilities. Cross hatched pump stations and the Philadelphia Southwest Water Pollution Control Plant (PSWPCP) are financially controlled by others and excluded from DELCORA's boundary. DELCORA outsourced treatment of approximately 9,487.6 million gallons of wastewater to PSWPCP in 2006.

The operational boundaries for the inventory extend to all six of the Kyoto gasses, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydro fluorocarbons (HFCs), per fluorocarbons (PFCs), and sulfur hexafluoride (SF_6) emitted from direct (Scope 1) and indirect (Scope 2) sources in the organizational boundary. As noted in the Introduction, DELCORA chose to focus on Scope 1 and Scope 2 emissions for the initial inventory as these are emissions over which they have direct control and are considered as the core reportable emissions for organizations in the California Climate Action Registry.

METHODS

Emissions from mobile and stationary sources, including the sludge incinerators, were based on emission factors and throughput (fuel, sludge). The factors were drawn from the Greenhouse Gas Protocol, California's General Reporting Protocol V 2.2, EPA Climate Leaders Protocol, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, and EPA AP-42.

Carbon dioxide emissions from aerobic treatment and sludge incineration would normally be excluded from DELCORA's greenhouse gas inventory as municipal waste is "short cycle" carbon of biologic origin (BIO CO_2). However, as noted previously, refinery effluent is a significant portion of DELCORA's total inflow. Refinery effluent is likely composed of some conventional municipal waste blended with refinery carbon in unknown proportions. Lacking the data to characterize the refinery effluent, DELCORA elected to treat all refinery effluent as fossil origin, a conservative approach since the actual petroleum contribution is likely less than 100%.

Two methods were developed to estimate carbon dioxide from refinery carbon based on the available data. The process flow and testing diagram (Figure 1-3) shows the points at which analytical data are collected.

Method 1: Fossil Carbon Dioxide Emissions from Sludge Incineration
The total carbon dioxide emissions from incineration were calculated using sludge throughput and emission factors derived from Equation 5.3 "2006 IPCC Guidelines for National Gas Inventory, Chapter 5 – Incineration and Open Burning of Waste":

$$EF = CL \times OF \times 44/12$$

Where

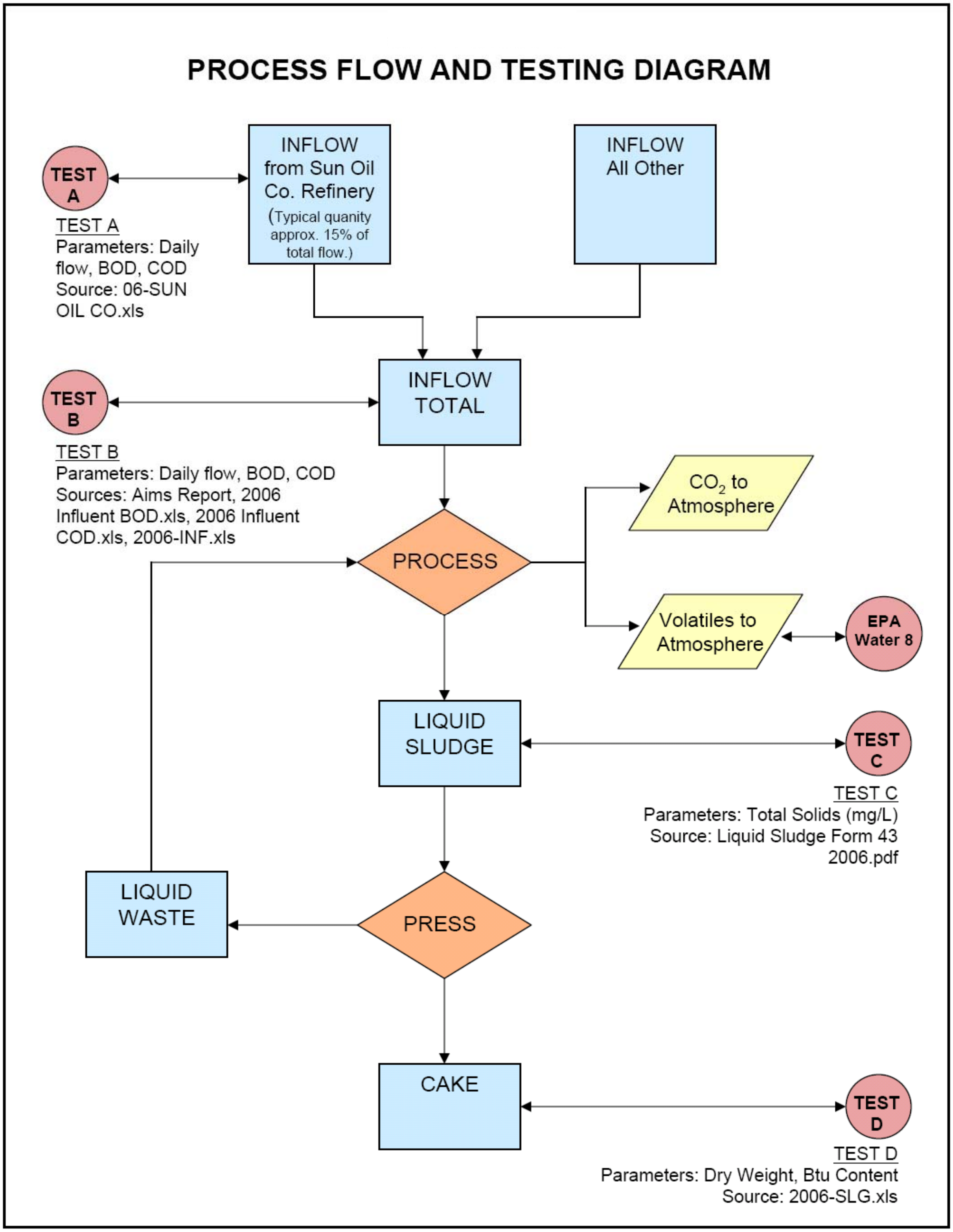
- EF = CO_2 emissions from incineration
- CL = carbon content of sewage (45% from Table 5.2 of the IPCC guidance)
- OF = oxidation factor (100% from Table 5.2 of the IPCC guidance)
- 44/12 = conversion from C to CO_2

The proportion of this quantity assignable to fossil carbon was calculated based on the average COD and volume of refinery influent as a fraction of the total influent average COD and flow:

Fossil CO2 = total incinerator CO2 * (total refinery inflow * average refinery COD) / (total WWTP inflow * average inflow COD)

<u>Potential Sources of Error</u>
In addition to minor uncertainty associated with dry mass of sludge combusted, this calculation has uncertainty associated with total carbon content of the sludge and the assignment of the fraction attributable to carbon of fossil origin (refinery effluent). Elemental testing to determine carbon content of the sludge cake, the refinery flow, and the total flow is not currently performed. Carbon content of the sludge cake was assumed to be 45% which is the mid range of the IPCC estimate for sludge (40 to 50% carbon). The carbon content of the cake can substantially influence emissions and elemental analysis would reduce this uncertainty.

The apportionment of fossil carbon to biological carbon in the emissions from sludge incineration is based on the proportional COD demand of refinery effluent to total effluent. The cake carbon composition may vary from this as a result of selective respiration however based on the BOD to COD ratios during the inventory year in the refinery effluent (0.366) and total effluent (0.334) this is not likely to be significant. Of more significance may be volatilization of



DELCORA Greenhouse Gas Inventory(13).xls Page 1 of 1 Appendix D

Figure 1-3. Process flow and testing diagram.

carbon compounds during process prior to incineration. The Water 8 model used to estimate process VOC emissions produced an approximation of 31 tons for the inventory year. There is uncertainty both in the model estimate and in the source of these volatiles. They are likely to be primarily of fossil origin and this would have some effect, estimated at < 2%, on fossil CO_2 from incineration. If carbon compound volatilization is significantly greater than estimated by Water 8, the effect could be commensurately larger.

Method 2: Fossil Carbon Dioxide Emissions from Process Aerobic Respiration
This method of estimating CO_2 emissions from the activated sludge process is based on estimating the mass of organic matter removed in the process and relating potential CO_2 evolution to the organic removal using conventional bioprocess concepts from the wastewater design literature. The process flow diagram is reproduced in Figure 1-3; the aeration tanks consist of 4 tanks arranged in two parallel trains of 2 each. Panel Diffusers are used for aeration and mixing. Table 1 briefly summarizes pertinent operating data.

Table 1. Operating data used for CO_2 estimate for DELCORA WRTP 2006.

Parameter	Average Value
Flow, mgd[a]	40.58
BOD_5, mg/L, Influent[a]	162
Primary BOD_5 removal by settling	30%
BOD_5, mg/L, Secondary Effluent[a]	8

In order to estimate CO_2 emissions, calculations were performed using conventional kinetic design principles for aerobic biological treatment systems. Conceptually, aerobic biodegradation of organic matter in a wastewater treatment system can be described as follows:

$$\text{Organic Matter} + O_2 \;\text{----------------->}\; CO_2 + H_2O + \text{Biomass} \qquad (1)$$

and net biomass production is related to the amount of organic matter degraded by an observed Yield coefficient:

$$Y_o = \frac{\text{Biomass Produced}}{\text{Organic Matter Removed}} = \frac{\Delta X}{\Delta S} \qquad (2)$$

Where

Y_o = observed cell yield, mass/mass
ΔX = net biomass (sludge) produced, mass/time
ΔS = net organic matter removed, i.e. ΔBOD_5, mass/time

Therefore, as a first approximation, and subject to the qualifications discussed below, it may be possible to estimate net CO_2 produced from influent and effluent wastewater data.

BOD removal can be calculated as:

$$\Delta BOD_5 = Q(S_o) + Q_R S_R - QS_e \quad (3)$$

Where

Q	=	Influent flow rate, volume/day
Q_R	=	Return flow rate, volume/day
S_o	=	Influent substrate concentration, mg BOD_5/L
S_e	=	Effluent substrate concentration, mg BOD_5/L
S_R	=	Return flow substrate concentration, mg BOD_5/L

Neglecting relatively minor losses such as evaporation, the effluent flow rate is taken as equal to the influent flow rate. Return flow for the WRTP would include, for example, thickener decant, and filter press filtrate. Since the aqueous phase of these streams is essentially treated wastewater it would be assumed that $S_R \sim S_e$. However for this very first approximation it is assumed that the magnitude of this flow, and therefore the mass contribution from these streams, is minor. Biomass produced is then

$$\Delta X = Y_o(Q)(S_i - S_e) \quad (4)$$

The observed yield, Y_o, is a function of operating conditions, in particular the mean cell residence time (θ_c) for the system. However, for purposes of this first approximation and without sufficient data to estimate θ_c, an assumed Y_o value is used:

$$Yo = 0.54 \text{ mg VSS/mg } BOD_5$$

<u>2006 DELCORA Results:</u>

1. At the WRTP's current loading conditions as assumed in Table 1, the estimated mass of BOD_5 removed is approximately 35,700 lb/day.
2. Assuming an Observed Yield value of 0.54 as shown above, it is estimated that BOD_5 conversion results in the generation of approximately 19,300 lb/day (9.7 tpd) of biomass as secondary sludge volatile solids
3. By difference the estimated oxygen consumption for respiratory utilization of BOD (i.e. BOD_5 expressed) is 16,400 lb/day
4. The approximate CO_2 equivalent of the oxygen "consumed" by respiration would be approximately 22,550 lb/day.

To estimate the potential component of the total CO_2 emissions which may be derived from petroleum-based BOD_5 sources to the WRTP, the mass fraction of BOD_5 from the refinery source was estimated from Sun Oil Company Data. These data show an average flow of 6.2 MGD at a BOD_5 concentration of 261 mg/L (average) (Table 2). This constitutes approximately 25% of the mass loading of BOD_5 to the plant:

Table 2. Estimated component of CO_2 emissions from petroleum-based BOD_5 sources.

Source	Flow, MGD	BOD_5, mg/L	BOD_5, lb/day
WRTP Total	40.58	162	54,024
Sun Oil	6.2	261	13,504

Assuming the same process parameters apply to the petroleum-derived BOD_5, the approximate CO_2 equivalent derived from petroleum BOD_5 would be approximately 5,637 lb/day.

Potential Sources of Error

As a first approximation and based on limited data this calculation has a number of uncertainties. To some extent these uncertainties can be reduced by further analysis of historical data supplemented if necessary by certain additional process measurements. However a determination as to the end use and the necessary accuracy of this estimate should be made prior to initiating those efforts. The following items summarize some of the uncertainties and indicate at least theoretically, additional data that might help reduce uncertainty if such efforts are warranted.

1. Uncertainty in the assumed WRTP operating values.

2. Uncertainty in the assumed sludge yield (Yo) value. Note that in principle it should be possible to partially cross check this calculation if an independent estimate of secondary waste sludge is available (i.e., the measured yield could be approximated). However at present, the available data are for total sludge incinerated which include primary and other inert solids.

3. As noted above, return flow in the WRTP constitutes an additional loading, though likely small, on the aerobic process, by reprinting to the head of the plant some BOD that would otherwise be disposed with the sludge (i.e., filtrate BOD). A very rough estimate of the magnitude of this contribution indicates that it would affect the estimate by only less that 0.1%. While additional evaluation of return flows could be conducted, it is not likely to affect this estimate significantly. Note: the assumption that return flows exhibit a low BOD_5 would not strictly hold if there were anaerobic digestion processes at the plant. Likewise, if operations personnel have reason to think that return flows exhibit significant strength, this can be revisited.

4. It may be possible to partially "cross check" these estimates by obtaining oxygen consumption data for the WRTP. There are two possibilities for this effort:

    a. Batch (small scale) respirometry (oxygen uptake testing for the WRTP, using bench scale methods.

    b. An effort to estimate full scale oxygen consumption from blower operating records and mixed liquid DO readings.

It should also be noted that CO_2 "production" can be difficult in an open system due to potential changes in carbonate equilibrium among the various phases. However, assuming that the WRTP operates in a relatively steady state and that there are not significant changes in carbonate sources or sinks during routine operations, these uncertainties may not have major impact.

Outcomes

Summary data for DELCORA's 2006 inventory are shown in Figures 1 -4 and 1 -5. As might be expected for an activated sludge plant, the largest single emission source is electricity use, primarily for pumping and aeration. Non CO_2 emissions from incineration of sludge, CH_4 and

Annual Emissions Report

Report Date: 1/18/2008 15:44

Delaware County Regional Water Control Authority (DELCORA)

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Contact:	Robert Hindt, Technical Services Manager HindtR@delcora.org
Industry Type	Municipal Wastewater Treatment
NAIC Code:	221320 Sewage Treatment Facilities
SIC Code:	4952 Trans. & Utilities-Sewerage Systems
Description:	Delaware County Regional Water Control Authority (DELCORA) is a county authority charged with the collection and treatment of wastewater in Delaware County, PA. The authority is made up of fourteen (14) facilities including 1 regional treament plant, 10 pump stations, 1 administration building, 1 lift station and 1 pit.
Primary Calculation Methodologies:	Emissions Factor, Engineering Calculations

EMISSIONS INFORMATION

Reporting Year	2006
Reporting Scope	US
Reporting Protocol	Corporate Accounting and Reporting Standard, World Resources Institute and World Business Council for Sustainable Development (March 2004)
Baseline Year (Direct Emissions):	2006
Baseline Year (Indirect Emissions):	2006

Direct Emissions	CO_2e [1]	CO_2	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6	BIO CO_2 [3]	Unit
Mobile Combustion	346.9	339.2	0.0	0.0	0.0	0.0	0.0	0.0	metric ton
Stationary Combustion	13,912.4	8,364.3	45.1	15.2	0.0	0.0	0.0	18,052.1	metric ton
Process Emissions	933.2	933.2	0.0	0.0	0.0	0.0	0.0	2,800.1	metric ton
Fugitive Emissions	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	metric ton
TOTAL DIRECT	15,192.4	9,636.7	45.1	15.3	0.0	0.0	0.0	20,852.3	metric ton

Indirect Emissions	CO_2e [1]	CO_2	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6	BIO CO_2 [3]	Unit
Purchased Electricity	9,731.5	9,684.2	0.2	0.1	0.0	0.0	0.0	0	metric ton

Total Emissions	CO_2e [1]	CO_2	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6	BIO CO_2 [3]	Unit
TOTAL DIRECT & INDIRECT	24,923.9	19,320.9	45.3	15.4	0.0	0.0	0.0	20,852.3	metric ton

[1] Non CO_2 gases are converted to CO_2e by applying a Global Warming Potential (GWP) factor unique to each gas.

[2] HFCs and PFCs are classes of greenhouse gases that include many compounds. These columns reflect the total emissions of multiple HFC and PFC compounds, each of which has a unique Global Warming Potential (GWP).

[3] BIO CO_2 is carbon of recent biological origin which is not considered as a cumulative contribution to greenhouse gas emmissions.

Emissions Intensity

EMISSIONS INTENSITY 1.68 metric ton/MMGal

CERTIFICATION INFORMATION

Certification Company:

Basis of Certification Opinion:

DELCORA Draft Document 2008 Page 1 of 3 Emissions Inventory

Figure 1-4. DELCORA Annual Emissions Report data.

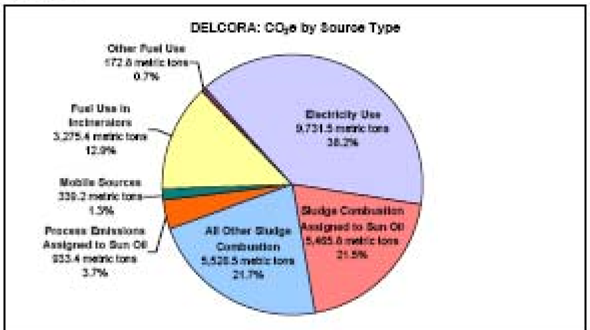
Annual Emissions Report
Report Date: 1/18/2008 15:44

Delaware County Regional Water Control Authority (DELCORA)

CO_2e EMISSIONS SUMMARY BY FACILITY AND SOURCE TYPE

Facility	Mobile	Stationary	Process	Fugitive	Indirect	Total	Unit	% of Total
31 Western Reg Trtmt Plant	346.9	13,832.9	933.2	0.0	6,944.1	22,057.0	metric ton	88.5
11 Administration	0.0	0.0	0.0	0.0	84.8	84.8	metric ton	0.3
Pumping Stations	0.0	79.5	0.0	0.0	2,702.6	2,782.1	metric ton	11.2
TOTAL	346.9	13,912.4	933.2	0.0	9,731.5	24,923.9	metric ton	100.0
PERCENT OF TOTAL	1.4	55.8	3.7	0.0	39.0	100.0		

* Values are in metric tons CO_2e



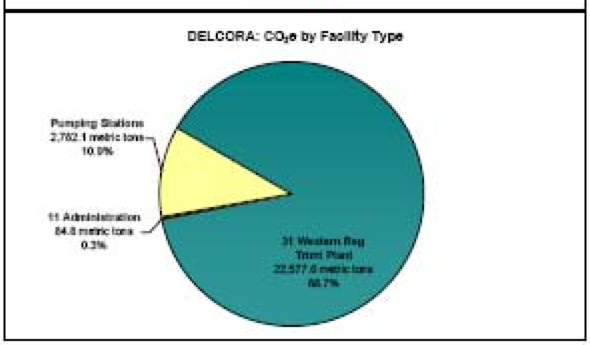


Figure 1-5. DELCORA Annual Emissions Report data by facility and source type.

N_2O, are very significant (22%) and when combined with emissions from incinerator fuel use (13%), nearly equal those from electricity use. If the fossil CO_2 component of incinerator emissions is included, the incinerators become the single largest GHG source in the WWTO.

The process CO_2 emissions from the refinery are quite small relative to total emissions, falling below the five percent threshold for materiality. In future years, DELCORA could consider treating these as de minimus; however, the uncertainty in the calculations and the potential variability in BOD and total refinery influent suggest that this emission estimate will need to be revisited annually.

SUMMARY

Wastewater treatment is a significant contributor to global greenhouse gas emissions and as such will almost certainly receive additional attention amid greater efforts to manage emissions worldwide. Methods to quantify wastewater emissions developed by the IPCC and the EPA are intended for country level inventories and are too coarse for meaningful use at an organizational level. The lack of comprehensive methodology is recognized by both industry groups (Tri-TAC) and the California Climate Action Registry (Markolf). Many technical issues remain to be addressed in order to have a meaningful way to evaluate the full life cycle emissions impact of various wastewater treatment options.

For wastewater authorities, greenhouse gas impacts will likely play an ever larger role in plant management and process selection. A quality greenhouse gas inventory is an essential management tool for decision making in this regard. A verified inventory also establishes a baseline which can allow authorities to gain recognition for early management efforts.

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