

DCWASA's Certifiable, Utility-Wide GHG Inventory

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ABSTRACT

In response to increased emphasis on sustainability and the reduction of carbon/greenhouse gas (GHG) emissions, The District of Columbia Water and Sewer Authority (DCWASA) and its program managers have developed comparisons of options intended to lower the AWTP's GHG inventory (also called "carbon footprint"). These comparisons have used different assumptions as to the carbon density of various functions (electricity, chemical and fuel use). This paper details a recommended first step for all utilities and the results of that effort: development of a utility-wide GHG inventory for DCWASA.

This paper summarizes the DCWASA utility-wide GHG inventory that was developed in conformance with the Climate Registry's General Reporting Protocol (Climate Registry, 2008). The inventory is being prepared for a subsequent audit in preparation for potential certification by the Climate Registry. The completed audit would serve to "ratify" the criteria assumptions and magnitude determinations while providing context for all future DCWASA-specific GHG evaluations. The audited inventory further arms the utility with knowledge, allowing appropriate responses to GHG or carbon cap-and-trade regulation. The relative contributions of DCWASA's wastewater treatment, wastewater conveyance, water distribution, and fleet/support operations will be discussed herein as well as the inventory's sensitivity to various key assumptions.

KEYWORDS

GHG Inventory; Efficiency enhancements; electrical power; green house gases; carbon credits.

INTRODUCTION

DCWASA will soon begin two major upgrades to the 370-mgd Blue Plains Advanced Wastewater Treatment Plant (AWTP):

1. Replacing the aging lime stabilization sludge-treatment process with Class-A anaerobic digestion using thermal hydrolysis. This upgrade will produce electricity and process heat from a renewable fuel (digester gas) while reducing biosolids hauling by between 50 and 60 percent and eliminating the use of lime. The biosolids reduction will also reduce the amount of carbon sequestration and nitrogen fertilizer offsets currently attributed to land application.
2. Enhanced Nutrient Removal (ENR) Upgrades will reduce the effluent total nitrogen to 3.5 mg/L or roughly half the current discharge load while using additional electricity and additional methanol as a denitrification carbon source.

The DCWASA Board of Directors, management, and engineering and operations staffs are motivated to advance their role as stewards of the environment beyond regulatory compliance and desire to understand the implications of these projects in the broader context of global GHG emissions reductions and increases. The first, context-critical step in this process is to determine the utility's overall GHG inventory for recent years. Developing the utility-wide inventory provides an understanding of how much each element of DCWASA's business contributes to their overall emissions.

OVERVIEW OF SELECTED GHG INVENTORY PARAMETERS

The inventory presented herein has been developed using available factors and according to the Climate Registry's GRP. The GRP is in turn based off of two other primary references, namely the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (2006) and the World Resources Institute (WRI)/ World Business Council for Sustainable Development (WBCSD) GHG Protocol (2007) calculation tools and calculation guidance. The GRP requires that all of an entities Scope 1 (direct) and Scope 2 (indirect associated with electricity use) be reported in the GHG inventory. Scope 3 emissions are not required to be submitted.

DCWASA has included all Scope 1 and Scope 2 emissions in their inventory, as well as significant Scope 3 emissions. Significance was determined to be those elements that potentially represented more than 1 percent of the overall inventory. It was interesting to note that DCWASA could possibly reduce the impact of these Scope 3 factors with either management or construction improvements. The Scope 3 elements included in the inventory are as follows:

1. Manufacture of Methanol for Denitrification.
2. Manufacture of Lime for Lime Stabilization of Biosolids.
3. Fuel Emissions from Contracted Biosolids Hauling.
4. Landfill Emissions Evolving from Landfill Disposal of Biosolids.

The GRP identifies Tiers for data accuracy and provides direction on the preferred methods for emission qualification as follows: "In this system, "Tier A" designates the preferred, or most accurate, approach for a given emissions source; "Tier B" represents an alternative second-best approach; and "Tier C" represents the least accurate, but still acceptable approach" (Climate Registry GRP, 2008 - page 56). Tier A usually represents directly measured emissions data, whereas lesser tiers represent application-specific assumed emissions factors either based on fuel carbon content (preferable) or fuel heating value (less preferable).

In a number of cases lower Tier options were chosen to avoid potentially-erroneous application of relatively limited sets of data over a period of time that might overemphasize their significance. One example of using lower-tier quantification is the use of a population-based nitrous oxide (N₂O) emission factor for process-evolved N₂O instead of extrapolating data collected over three days in March of this year. This approach was deemed prudent as the winter data were all that was available; summer sampling is planned; and the correlations between operational modes and monitored liquid-stream parameters is not yet certain.

As our understanding of the direct measurements and their relationship to historical trending data improves; lower-tier, assumption-based quantifications will be replaced with higher-tier, directly-

measured quantifications. This will be required not only for future quantifications but retroactively for baseline and historical reporting years for consistency's sake.

DCWASA GHG INVENTORY DEVELOPMENT AND FINDINGS

The overall GHG inventories for 2007 and 2008 are 184,932 and 192,261 MT of carbon dioxide equivalents (CO₂e), respectively. Figure 1 shows the overall monthly emissions totals for those calendar years, disaggregated by reporting Scope.

Figure 2 shows the total monthly GHG emissions disaggregated by DCWASA operation/facility. In particular, the following operations/facilities are represented:

- **Department of Sewer Services (DSS).** This facility grouping includes the sanitary sewer pumping stations that are not powered off the Blue Plains electrical meter. Only Scope 2 electrical emissions are included in these totals.
- **Department of Water Services (DWS).** This facility grouping includes all of potable water distribution booster stations. Only Scope 2 electrical emissions are included in these totals.
- **Blue Plains AWTP.** This total includes electrical power at the AWTP as well as consumption of all methanol, natural gas, and refrigerants. Process emissions of N₂O and evolution of N₂O from discharged nitrogen species are also included.
- **Biosolids.** This category includes contracted biosolids hauling, lime consumption, and methane (CH₄) evolution from land-filled biosolids.
- **Fleet/General.** This group summarizes all of the general uses that are not captured by one of the other operational groups. In summary they include Scope 1 direct emissions associated with combustion of vehicle compressed natural gas (CNG), vehicle diesel fuel no. 1 and 2, and vehicle motor gasoline.

The global warming potentials used for N₂O and CH₄ are 310 and 21, respectively (Climate Registry, 2008). Table 1 summarizes each of the component emissions and 2007 and 2008 magnitude in the DCWASA GHG inventory. Each source's quantification method is summarized; a reference is provided for the used emission factors and approach; and the assigned scope and method quantification tier are identified.

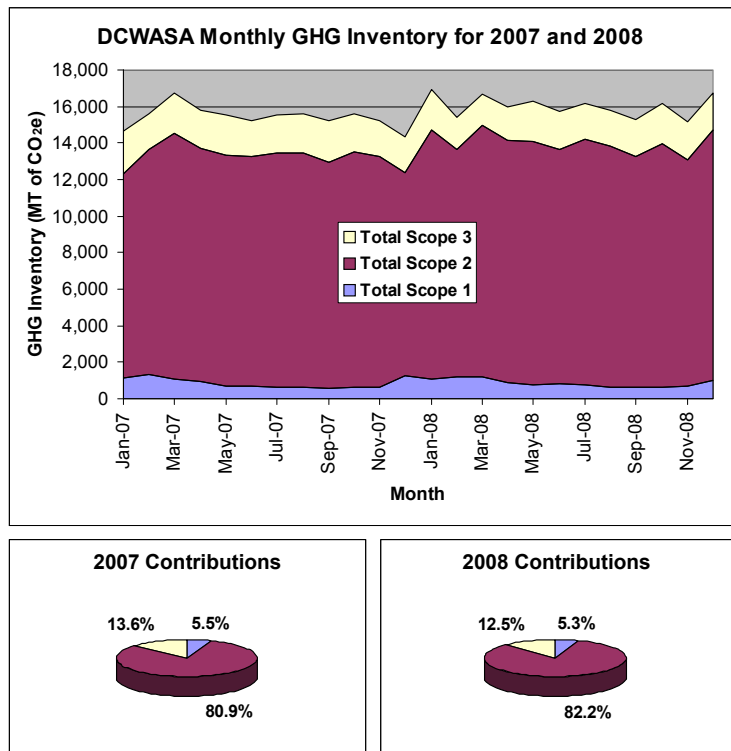


Figure 1: DCWASA GHG Inventory

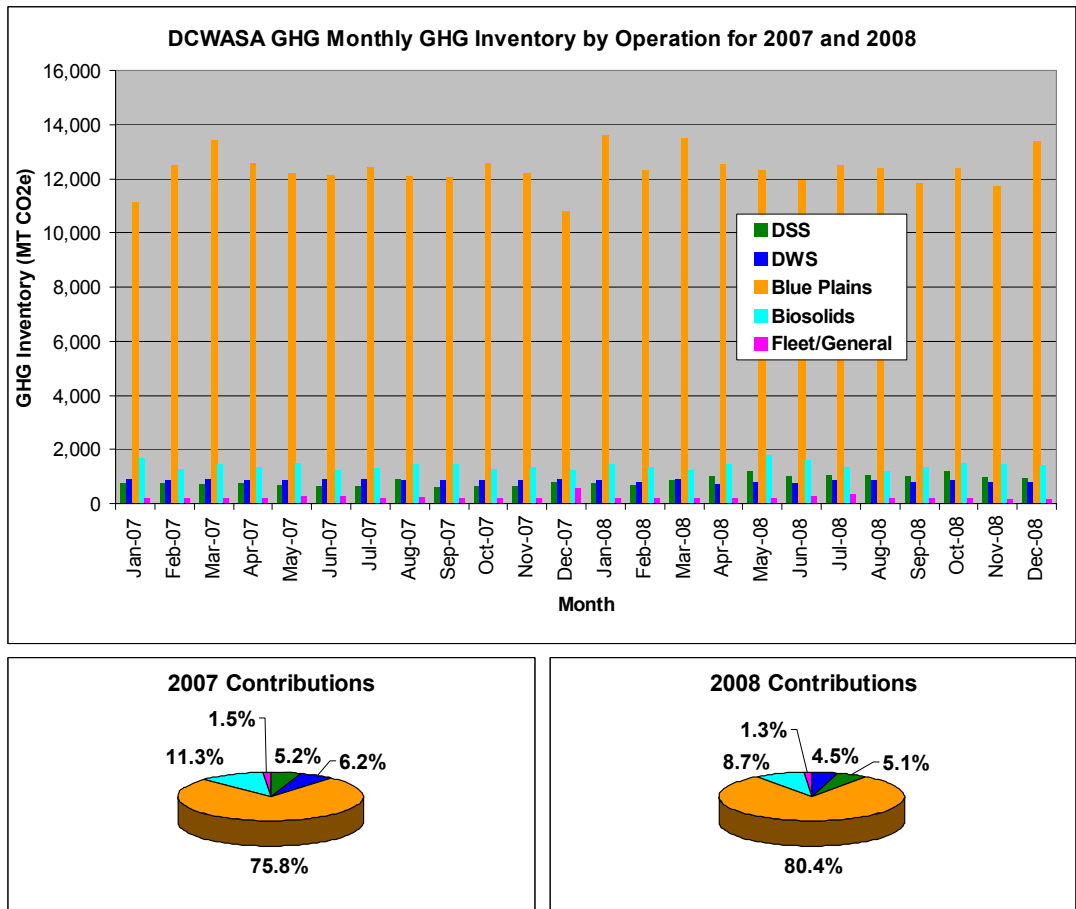


Figure 2: Monthly GHG Inventory by Operation/Facility

OBSERVATIONS REGARDING SENSITIVITY TO CRITERIA ASSUMPTIONS

Electrical Power. 81 to 82 percent of the DCWASA GHG inventory is attributable to purchase of electrical power. The magnitude and overall percentage attributable to electricity are closely tied to the assumed carbon intensity of that power. For the inventory presented herein, an integrated (includes emissions of CH₄ and N₂O as well as CO₂ normalized to CO₂e) carbon intensity of 1,143 lb CO₂e/megawatt-hour (MWh) was used (eGRID, 2007 – RFC East).

Two other options that were considered for use in the inventory included carbon intensity factors of 2,441 lb CO₂e /MWh consolidated from eGRID 2007 for power produced in the District of Columbia or 3,614 lb CO₂e /MWh from eGRID 2006 (not consolidated as eGRID 2006 did not include emissions factors for CH₄ or N₂O) for power produced in the District of Columbia. Figure 3 shows how the DC eGRID 2006 factor of 3,614 lb CO₂e /MWh would have significantly changed the overall inventory and the proportion of the inventory attributable to electricity purchase. The GHG inventory would have increased from approximately 190,000 MT CO₂e to approximately 520,000 MT CO₂e for a 180 percent increase in the utility’s overall inventory. The overall percentage contribution of electricity would have increased from 81 to 82 percent to roughly 93 percent of the overall inventory.

The justification for using regional rather than the smaller-geography, DC-based intensity factors arises from two sources:

Emission Source	2007 Quantity	2008 Quantity	Summary of Quantification Method	Reference	Scope/Tier
Natural Gas	2,127	2,005	Sum of CO ₂ , CH ₄ & N ₂ O emissions factors of 53.06kg/MMBtu, 1g/MMBtu, & 0.1g/MMBtu	The Climate Registry, 2008	1/C
Vehicle Compressed Natural Gas (CNG)	0	0	CO ₂ emissions factor of 0.054kg/scf	The Climate Registry, 2008	1/B
Vehicle Diesel Fuel No. 1 and 2	1,190	1,041	CO ₂ emissions factor of 10.15kg/gal	The Climate Registry, 2008	1/B
Vehicle Motor Gasoline	1,799	1,545	CO ₂ emissions factor of 8.81kg/gal	The Climate Registry, 2008	1/B
Refrigerants	109	142	Varies by HFC and PFC; usage tracked in lbs	The Climate Registry, 2008	1/A
Nitrification / Denitrification (process emissions)	3,472	3,472	7g N ₂ O/person/year	CARB 2008	1/NA
Effluent Discharge (process emissions)	1,462	2,010	0.005kg N ₂ O/kg discharged-N	CARB 2008	1/NA
DSS Electricity	8,587	11,887	Sum of CO ₂ , CH ₄ & N ₂ O emissions factors of 1139.07, 0.03027, & 0.01871lbs/MWh	eGRID2007	2/B
DWS Electricity	10,502	9,854	Sum of CO ₂ , CH ₄ & N ₂ O emissions factors of 1139.07, 0.03027, & 0.01871lbs/MWh	eGRID2007	2/B
DWT Electricity	130,515	136,259	Sum of CO ₂ , CH ₄ & N ₂ O emissions factors of 1139.07, 0.03027, & 0.01871lbs/MWh	eGRID2007	2/B
Biosolids hauling (fuel usage)	1,809	2,417	CO ₂ emissions factor of 10.15kg/gal	The Climate Registry, 2008	3/C
Lime	14,210	14,883	0.75MT of CO ₂ /MT of high-calcium lime	The Climate Registry, 2009	3
Methanol	8,601	6,747	0.67MT of CO ₂ /MT of methanol for conventional steam reforming without primary reformer	IPCC Guidelines for National Greenhouse Gas Inventories, 2006	3
Biosolids Landfill Emissions	548	0	0.18MT of CH ₄ /MT of landfilled biosolids	Brown & Leanard, 2004	3
Totals:	184,932	192,261			

Table 1: Quantification Summary for DCWASA GHG Inventory

1. The GRP and closer evaluation of the eGRID-reported production histories. The GRP states that “Because emission factors vary by location, you should be sure to use appropriate region-specific factors for each facility. For facilities in the U.S., you should use emission factors specific to your regional power pool rather than your state/province because transmission and distribution grids do not adhere to state/province boundaries.” (Climate Registry GRP, 2008 - page 99)

2. Table 2 summarizes the historical eGRID power production and carbon intensity factors for DC and the RFCE (current nomenclature) and MAAC (previous nomenclature) sub-regions. Of particular interest are the extreme variations in both production (36,487 to 243,975MWh) and carbon intensity (1,128 to 3,614 lb CO₂e /MWh) for the DC geography. Also of interest is the relatively small continuous generation capacity within the District. At continuous production rates ranging from 4 to 28MW of produced power, the entire DC production capacity would only service a fraction of DCWASA’s 35-MW power consumption. The sub-regional data are much more consistent, providing stability to present and future electricity-related emissions factors.

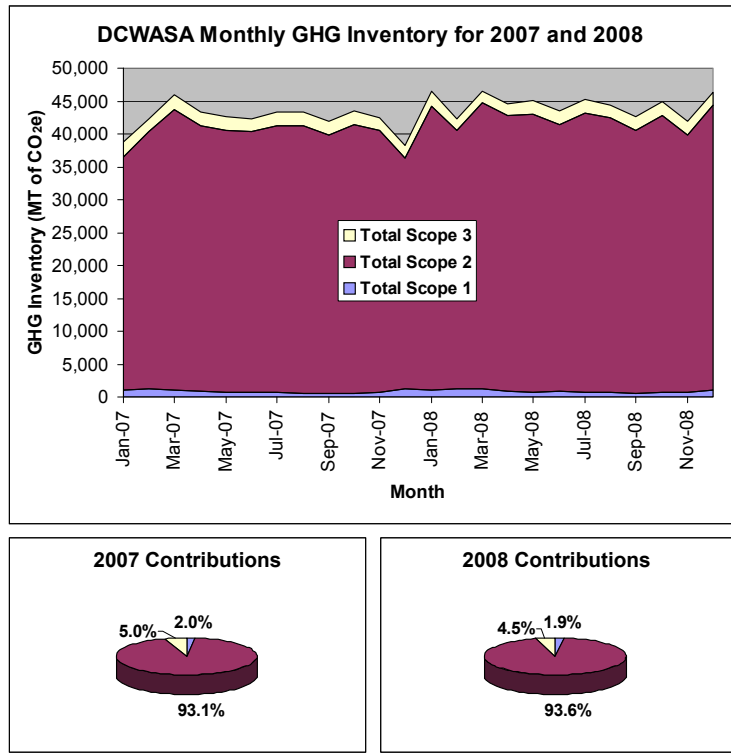


Figure 3: DCWASA GHG Inventory with Carbon Intensity of Power of 3,614 lb CO₂e /MWh (eGRID, 2006 for DC)

This discussion documents an extreme sensitivity to a single factor used in development of DCWASA’s inventory. As such, it is recommended

Year	eGRID Power Generation Emissions for DC				eGRID Power Generation Emissions for RFCE			
	Power, MWh	Average Production, MW	Associated CO ₂ , ton/yr	Carbon Intensity of Power, lbs. CO ₂ /MWh	Power, MWh	Average Production, MW	Associated CO ₂ , ton/yr	Carbon Intensity of Power, lbs. CO ₂ /MWh
1996 ^A	109,809	13	61,916	1,128	238,402,036	27,215	160,154,819	1,344
1997 ^A	70,661	8	101,372	2,869	241,718,120	27,593	157,279,971	1,301
1998 ^A	243,975	28	302,552	2,480	262,169,473	29,928	157,177,594	1,199
1999 ^A	230,003	26	307,201	2,671	261,888,412	29,896	150,913,703	1,153
2000 ^A	144,374	16	191,797	2,657	264,901,230	30,240	145,371,821	1,098
2001 ^B	NA	NA	NA	NA	NA	NA	NA	NA
2002 ^B	NA	NA	NA	NA	NA	NA	NA	NA
2003 ^B	NA	NA	NA	NA	NA	NA	NA	NA
2004 ^C	36,487	4	65,937	3,614	273,924,233	31,270	150,110,480	1,096
2005 ^C	226,042	26	274,901	2,432	282,979,630	32,304	161,166,803	1,139

^A Values from 1996 to 2000 are for NERC subregion "MAAC"

^B Values from 2001 to 2003 are not available on eGRID

^C Values from 2004 and 2005 are for NERC subregion "RFCE"; eGRID data beyond calendar 2005 are not yet available

Table 2: eGRID Electricity Production Data for DC and DCWASA’s NERC Sub-region

that a utility-wide inventory be developed and at least audited before conducting carbon-based alternatives evaluations for future upgrades. In DCWASA's case, evaluation of anaerobic digestion and CHP options that could offset Blue Plains' fossil-fuel-derived electrical power consumption could be dramatically affected by different carbon intensity criteria for traditional power.

Nitrous Oxide (N₂O). N₂O production from nitrification and denitrification processes has been aggressively researched by the Water Environment Research Foundation (WERF) over the past two years (Chandran, 2008). DCWASA measured nitrous oxide (N₂O) emissions from the Blue Plains AWTP in February of 2009. The effort was conducted by Kartik Chandran of Columbia University in association with WERF. The collected data show that winter emissions from the plant are likely to be significantly larger than the corresponding per-capita criteria for process evolution of N₂O (CARB, 2008) of only 7 g N₂O/person/year (or 3,472 MT of N₂O/year at the Blue Plains AWTP which equates to N₂O and CO₂ emissions rates of 0.00102 and 0.0317 MT/million gallons treated, respectively, at average plant flows of 300 mgd).

Land Application of Biosolids Nutrient and Sequestration Offsets. Unlike previous DCWASA publications (Peot, 2008), this GHG inventorying effort does not take credit/consider offsets for either fertilizer offsets or carbon sequestration attributable to land application of biosolids as such considerations are not specifically allowed under GRP protocol. In 2007, these offsets were estimated to be roughly 25,000 MT CO₂e for carbon sequestration and approximately 5,000 additional MT CO₂e for nitrogen fertilizer offsets (Peot, 2008). DCWASA and Brown and Caldwell will discuss the scientific basis for these claims and approach with the Climate Registry and encourage the adoption of these protocols in the GRP. The discussion will be reinforced by data collected by Dr. Sally Brown (Brown, 2009) on long-term land application and restoration sites.

OUTSTANDING ISSUES AND OPPORTUNITIES

A number of uncertainties exist for water and sewer utilities with respect to GHG inventories. While protocols such as the Climate Registry's GRP, IPCC, and WRI/WBCSD and their associated assumptions/factors/criteria allow for quantification of GHG inventories today, the science is rapidly evolving and many of the fundamental assumptions are being investigated. The Climate Registry's GRP accounts for this phenomenon and encourages use of direct measurement (Tier A) of emissions over use of acceptable assumptions (Tiers B and C). One benefit of certification with the Climate Registry is the maintenance and "living" nature of the registered information. As higher-tier criteria and better understanding become available, they can be used to retro-actively update current and previous-year inventories. Some factors that are likely to change DCWASA's GHG inventory as the science evolves include:

- **Understanding of N₂O emissions and production factors** discussed in the preceding section. As direct emissions monitoring and correlation to historically monitored liquid stream parameters become more refined, then the population-based assumptions currently included in the inventory will be replaced.
- **Carbon offsets from biosolids land application** have not been vetted and accepted in the reporting protocols. An active discussion with the Climate Registry is planned related to potential carbon offsets associated with biosolids land application nitrogen fertilizer offsets and carbon sequestration.

- **Methane evolution from a variety of potential sources** has not been included in this inventory. Some of the potential sources currently under investigation include:
 - **Collection system methane.** Initial studies suggest that significant methane evolves from collection systems (Guisasolla, et. al., 2008 and 2009) and methods for quantifying these emissions are evolving.
 - **Process evolved methane.** Research is only beginning to consider and collect data on CH₄ emissions from in-plant processes such as headworks, primary sedimentation, anoxic and anaerobic reactors, as well as other potential sources (refs forthcoming).
 - **Future digestion fugitive or un-combusted methane.** While the Blue Plains AWTP does not currently have anaerobic digestion, plans are in place to implement an advanced digestion system with digester-gas-fueled combined heat and power (CHP). The science is developing on better estimating techniques and approaches for these potential methane sources. It is currently assumed that detrimental effects of these emissions will be dwarfed by the environmental benefit derived by their implementation.

CONCLUSIONS

The first step in any GHG/carbon comparison is to establish the utility baseline and have that baseline audited (and possibly certified). The audit and certification are recommended so that the baseline assumptions can be checked and confirmed by a third party. Once these independent reviews are complete and comments addressed, the value of comparisons conducted using the certified assumptions will be more certain and provided within a relevant context that considers the impact on the whole utility.

DCWASA's initial GHG inventories have been estimated at 182,805 and 190,256 MT CO₂e, for calendar years 2007 and 2008, respectively. The Authority is currently evaluating whether to fully certify the inventory with the Climate Registry or to wait for future data and better understanding of the regulatory direction and economic markets associated with CO₂.

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