TECHNICAL SUPPORT DOCUMENT FOR WASTEWATER TREATMENT: PROPOSED RULE FOR MANDATORY REPORTING OF GREENHOUSE GASES

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CONTENTS

1. Industry Description

Both domestic and industrial wastewater treatment systems may result in direct emissions of CH_4 and N_2O, depending on the treatment operations in place and the quality of the wastewater to be treated. Wastewater is treated to remove soluble organic matter, suspended solids, pathogenic organisms, and chemical contaminants. Centralized wastewater treatment systems may include a variety of processes, ranging from primary treatment for solids removal to secondary biological treatment (e.g., activated sludge, lagoons) for organics reduction to tertiary treatment for nutrient removal, disinfection, and more discrete filtration.

Methane emissions from wastewater treatment systems are primarily a function of how much organic content is present in the wastewater system and how the wastewater is treated. Methane is produced by the anaerobic decomposition of organic content, as measured by the biochemical oxygen demand (BOD) of the wastewater. The production of direct N_2O emissions from wastewater treatment depends on the amount of nitrogen (N) entering the system. For direct N_2O emissions to occur, the wastewater must first be handled aerobically where ammonia (NH_3) or organic nitrogen is converted to nitrates and nitrites (nitrification), and then handled anaerobically where the nitrates and nitrites are reduced to nitrogen gas (N_2), with intermediate production of N_2O and nitric oxide (NO) (denitrification). These emissions are most likely to occur in treatment systems designed to achieve biological denitrification.

Wastewater treatment at oil/water separators onsite at petroleum refineries can result in indirect emissions of CO_2 that are considered anthropogenic.

In the United States, approximately 79 percent of domestic wastewater is collected and treated centrally.[1] Industries that have the potential to produce significant CH_4 emissions from wastewater treatment—those with high volumes of wastewater generated and a high organic wastewater load—include pulp and paper manufacturing; meat and poultry processing; vegetables, fruits, and juices processing; starch-based ethanol production; and petroleum refining.

2. Total Emissions

As of 2004, there are 16,583 centralized wastewater treatment plants in the United States and its territories[2], and approximately 15,600 onsite wastewater treatment systems at industrial facilities in the United States.[3] Approximately 4,700 industrial wastewater treatment systems are operated at industries with a potential to produce significant CH_4 emissions.

In 2006, CH_4 emissions from domestic wastewater treatment were estimated to be 16.0 million metric tons of carbon dioxide equivalent (mmtCO_2e) and CH_4 emissions from

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[1] U.S. Census Bureau 2007

[2] Clean Watersheds Needs Survey 2004 Report to Congress

[3] 2004 Permit Compliance System data

industrial wastewater treatment were estimated to be 7.9 $mmtCO_2e$. Direct N_2O emissions from domestic wastewater treatment were 8.1 $mmtCO_2e$. Emissions at centralized plants (domestic and industrial wastewater) were 10.9 $mmtCO_2e$ CH_4 and 0.3 $mmtCO_2e$ N_2O, or 11.2 $mmtCO_2e$ in total. Wastewater treatment systems account for 4 percent of total anthropogenic CH_4 emissions and 2 percent of anthropogenic N_2O emissions in the United States.

3. Review of Existing Programs and Methodologies

For this proposal, EPA reviewed several protocols and programs for monitoring and/or estimating GHG including the 2006 IPCC Guidelines, the U.S. GHG Inventory, California AB32, California Climate Action Registry, U.S. Energy Information Administration Voluntary GHG Reporting Program (1605b), EPA Climate Leaders, The Climate Registry, UNFCCC Clean Development Mechanism, the EU Emissions Trading Scheme, and the New Mexico Mandatory GHG Reporting Program. These methodologies are primarily all based on the IPCC guidelines.

In addition, EPA reviewed programs for obtaining and recording information from wastewater treatment plants, including EPA's Clean Watersheds Needs Survey and the National Pollutant Discharge Elimination System (NPDES). These data sources do not currently collect information that could be used for the purpose of estimating GHG emissions.

4. Types of Emissions Information to be Reported

4.1 Types of Emissions to be Reported

This section includes options for reporting CH_4, direct N_2O, and indirect CO_2 (petroleum refineries only) emissions from wastewater treatment.

There are other sources of emissions that occur at facilities with onsite wastewater treatment. For reporting options for combustion (including digester gas combustion and combustion of fossil fuels used to assist digester gas combustion efficiency), refer to EPA-HQ-OAR-2008-0508-004.

In the case of industrial facilities with onsite wastewater treatment, industrial process emissions of GHG may be occurring onsite as well. Reporting options for wastewater treatment at these sites are detailed here, but for reporting options for other sources of emissions, refer to sections for that industry.

4.2 Other Information to be Reported

In order to check the reported GHG emissions for reasonableness and for other data quality considerations, additional information about the emission sources is needed. It is recommended that, in addition to N_2O and CH_4 emissions, each reporting wastewater treatment system should also report methane generation and, if applicable, CH_4

combustion annual quantities. Additionally, it is recommended that the following data also be submitted with the annual report:

Data to report

a. Type of wastewater treatment system
b. COD
c. Date of measurement of COD
d. Influent flow rate
e. Date of measurement of influent flow rate
f. B_0 value used
g. MCF used
h. Methane emissions
i. Type of oil/water separator (petroleum refineries)
j. Emissions factor for the type of separator (petroleum refineries)
k. Carbon fraction in NMVOC (petroleum refineries)
l. Indirect CO_2 emissions (petroleum refineries)

Plants with digesters

a. Total volumetric flow of biogas
b. CH_4 concentration of biogas
c. Temperature at which flow is measured
d. Pressure at which flow is measured
e. Destruction efficiency used
f. Methane destruction
g. Fugitive methane

EPA considered requiring that wastewater treatment plants over the selected threshold report CH_4 generation, any CH_4 combustion, and N_2O emissions (for POTWs), along with the input data to calculate these values. For petroleum refining wastewater treatment systems, EPA also considered that CO_2 generation be reported. EPA can use the reported input data for QA/QC purposes.

EPA considered requesting plants to report only CH_4 and N_2O emissions or generation; these options were not chosen because without reporting input data, including CH_4 combustion data, insufficient information is available for QA/QC of the reported emissions. EPA also considered reporting of only emissions and combustion data, but without reporting input data; again, insufficient information is available for QA/QC of the reported emissions.

Regarding the frequency of reporting, EPA had considered both annual and quarterly reporting. Although emissions could fluctuate seasonally at wastewater treatment systems, annual reporting of emissions is sufficient for these sources.

5. Options for Reporting Threshold

5.1 Emissions-based thresholds

In evaluating thresholds for wastewater treatment, we considered emissions-based thresholds of CH_4 generation and N_2O emissions at a wastewater treatment system ("generation threshold") and CH_4 and N_2O emissions at wastewater treatment systems ("emissions threshold") of 1,000 $mtCO_2e$, 10,000 $mtCO_2e$, 25,000 $mtCO_2e$, and 100,000 $mtCO_2e$ per year. The "generation threshold" is the amount of CH_4 and N_2O that would be emitted from the facility if no CH_4 recovery takes place. This includes all CH_4 generation from all wastewater treatment system types, including digesters, and N_2O emissions. The "emissions threshold" includes the CH_4 and N_2O that is emitted to the atmosphere from these facilities. In the emissions threshold, CH4 that is recovered and combusted at digesters is taken into account and deducted from the total CH_4 generation calculated.

This section discusses the number of facilities that meet emissions-based thresholds for wastewater treatment emissions only. For facility-level threshold analyses at industrial facilities with onsite wastewater treatment, please see the TSD for the industry.

One option analyzed would require wastewater treatment systems with combined CH_4 and N_2O (and indirect CO_2 for petroleum refineries) generation of 25,000 $mtCO_2e$ (i.e., CH_4 and N_2O generated at the wastewater treatment system) to report generation and emissions. At this threshold, facilities operating wastewater treatment systems with emissions of 25,000 $mtCO_2e$ (i.e., anthropogenic CO_2, CH_4, and N_2O emissions generated at a wastewater treatment system minus CH_4 combusted) would be required to report their emissions.

At this threshold, EPA estimates that 0 domestic wastewater treatment plants, 18 pulp and paper plants, up to 63 food processing plants, 1 ethanol refinery, and 1 petroleum refinery would be required to report under this rule when only considering emissions from the wastewater treatment system. Due to limited plant-specific data for industrial wastewater treatment plants, EPA made assumptions regarding the types of treatment systems in place at the industrial operations. In general, larger facilities tend to more often use aerobic treatment systems; therefore, these estimates can be considered a conservatively high estimate. Table 1 presents a summary of the number of facilities and emissions reported at the proposed threshold.

Table 1. Estimated Number of Facilities Reporting and Emissions Reported at a 25,000 $mtCO_2e$ Threshold

Operation	Estimated Number Facilities Reporting	Percent of All Facilities of this Type of Operation	Emissions ($mtCO_2e$)	Percent of All Emissions from this Type of Operation
Domestic wastewater treatment plants	0	0	0	0
Pulp and paper onsite wastewater treatment	18	3.2	1,100,000	28
Food processing onsite wastewater treatment	<63	<1.1	<1,600,000	40
Ethanol refineries onsite wastewater treatment	1	0.7	33,000	31
Petroleum refineries onsite wastewater treatment	1	0.7	26,000	7

This section discusses the data used to analyze domestic wastewater treatment systems, and onsite industrial wastewater treatment systems.

Domestic Wastewater Treatment. Using available activity data from EPA's Clean Watersheds Needs Survey (CWNS) database and U.S. GHG inventory methods, EPA estimated CH_4 generation and emissions and direct N_2O emissions for centralized wastewater treatment systems. The CWNS database contains information on 15,343 plants in the U.S. Although this database may not include data on all treatment plants in the U.S. (whose total number exceeds 16,000 plants), the data are considered representative of all U.S. centralized wastewater treatment systems. The database contains plant identification data, as well as information on wastewater flow, population served, and unit operations in place. The data were analyzed to determine which plants have primary sedimentation in place, whether the secondary treatment is aerobic or anaerobic, and whether the plant performs biological denitrification and/or anaerobic digestion of sludge.

EPA estimated the CH_4 generated from wastewater treatment and sludge digestion, the CH_4 combusted from sludge digestion, and the direct N_2O generated from wastewater treatment. Table 2 presents a summary of emissions as estimated for the universe of treatment systems included in the CWNS dataset. ERG next evaluated how many plants generate (includes methane generation in digesters) or emit greenhouse gases above one of four thresholds: 1,000 $mtCO_2e$, 10,000 $mtCO_2e$, 25,000 $mtCO_2e$, or 100,000 $mtCO_2e$ based on estimated greenhouse gas (CH_4 and N_2O) emissions from wastewater treatment including sludge digestion (indirect N_2O emissions associated with nitrogen discharged in the effluent from these plants are not included in these calculations). Table 3 presents a summary of this analysis. For information on assumptions and details on the analysis, please see ERG's memorandum dated July 21, 2008, *Revised Threshold Analysis for POTWs*, located in the docket.

Table 2. Greenhouse Gas Emissions from Centralized Domestic Treatment Systems

Emission Type	Methane (mtCO2e)	Direct Nitrous Oxide (mtCO2e)	Total Emissions (tCO2e)
Generated	16,820,573	201,226	17,021,799
Combusted	16,617,879	0	16,617,879
Emitted	202,695	201,226	403,920

Note: Emissions based on data from 15,343 plants in CWNS dataset. Nitrous oxide emissions do not include emissions associated with nitrogen discharged to the environment in wastewater effluent.

Table 3. Summary of Threshold Analysis for Domestic Wastewater Treatment

Threshold (mtCO2e)	# Systems	% Systems	Emissions (mtCO2e)	% Emissions[a]
Emissions Threshold				
1,000	59	0.4	120,362	30
10,000	0	0	0	0
25,000	0	0	0	0
100,000	0	0	0	0
Generation Threshold				
1,000	1,438	9.4	270,114	67
10,000	273	1.8	184,550	46
25,000	112	0.7	143,079	35
100,000	27	0.2	79,005	20

[a]The percent emissions column presents the percent of emissions from all plants in the U.S. that would be covered based on the reporting threshold.

Industrial Wastewater Treatment. Using available activity data and U.S. GHG inventory methods, EPA estimated greenhouse gas generation and emissions for certain industrial wastewater treatment systems, including those located at pulp and paper mills, meat processors, poultry processors, fruit and vegetable processors, ethanol producers, and petroleum refiners. For each industrial category, ERG first attempted to locate any plant-level datasets to directly calculate greenhouse gas emissions by plant, and count the number of facilities that would exceed the thresholds of interest. Where plant-level data were incomplete, EPA used default national-level data from the U.S. GHG Inventory to fill in missing data. Where plant-level data were unavailable, EPA instead determined the production levels for each industry that would trigger emissions over any of the thresholds of interest, and used best professional judgment to estimate how many plants would meet the production levels.

EPA estimated CH_4 emissions for the industries named above, as well as CO_2 emissions from oil/water separators at petroleum refineries. EPA did not include direct nitrous oxide emissions associated with biological denitrification treatment onsite. The number of industrial facilities in these categories using biological denitrification is likely low. In addition, there are currently no established nitrous oxide emission factors for these industries[4]. EPA estimated how many plants emit greenhouse gases above one of three thresholds: 1,000 $mtCO_2e$, 10,000 $mtCO_2e$, 25,000 $mtCO_2e$, or 100,000 $mtCO_2e$ based on estimated greenhouse gas (CH_4 and N_2O) emissions from wastewater treatment. Table 4 presents a summary of this analysis. For certain industries where EPA identified significant use of biogas collection in place, EPA also estimated how many plants have generation (includes methane generation at digesters) above the thresholds. For information on assumptions and details on the analysis, please see ERG's memorandum dated July 17, 2008, *Revised Threshold Analysis for the Estimation of Greenhouse Gas Emissions from Individual Industrial Facilities*, located in the docket.

[4] The 2006 IPCC Guidelines only briefly address direct nitrous oxide emissions from centralized wastewater treatment plants using biological denitrification, and do not discuss emissions from industrial wastewater treatment systems. In the guidelines, the only other wastewater N_2O emission factor that is offered is for domestic wastewater treatment (3.2 g N_2O per person per year). Ongoing work by the Water Environment Research Foundation (WERF) may lead to improved N_2O emission factors.

Table 4. Summary of Threshold Analysis for Industrial Wastewater Treatment

Threshold (mtCO2e)*	# Systems	% Systems	Emissions (mtCO2e)	% Emissions
Pulp and Paper – Generation and Emissions Thresholds				
1,000	23	4.1	1,144,351	30
10,000	22	3.9	1,135,278	29
25,000	18	3.2	1,065,422	28
100,000	1	<0.2	119,445	3.1
Meat Processing –Emissions Threshold				
1,000	<616	<18	<2,024,125	<100
10,000	<45	<1.3	<1,125,000	<56
25,000	<13	<0.4	>325,000	>16
100,000	1	<0.1	>100,000	>5
Meat Processing – Generation Threshold				
1,000	<616	<18	<2,024,125	<100
10,000	<45	<1.3	~1,125,000	>56
25,000	<19	<0.6	>425,000	>23
100,000	2	<0.1	>200,000	>10
Poultry Processing – Generation and Emissions Thresholds				
1,000	86	16	>1,286,000	>85
10,000	50	9.3	>1,250,000	>82
25,000	NE	NE	NE	NE
100,000	0	0	0	0
Fruit and Vegetable – Generation and Emissions Thresholds				
1,000	<100	<6%	<123,000	<100
10,000	0	0	0	0
25,000	0	0	0	0
100,000	0	0	0	0
Ethanol –Emissions Threshold				
1,000	11	7.9	67,041	64
10,000	2	1.4	50,810	48
25,000	1	0.7	32,850	31
100,000	0	0	0	0
Ethanol – Generation Threshold				
1,000	78	56	385,805	94
10,000	3	2.2	213,715	52
25,000	2	1.4	178,050	44
100,000	1	0.7	127,570	31
Petroleum Refining – Generation and Emissions Thresholds				
1,000	30	21	213,871	60
10,000	8	5.6	119,246	34
25,000	1	0.7	25,914	7.3
100,000	0	0	0	0

* Threshold analyzed is based on wastewater treatment emissions only.

NE = not estimated. Data were unavailable to estimate whether systems over this threshold occur in the U.S.

5.2 Other threshold options

EPA considered several other threshold options for reporting emissions:

1. All wastewater treatment plants regardless of size, treatment processes, or control technology.
2. All anaerobic wastewater treatment plants.
3. Plants of a certain size (influent value or population served by plant).
4. Plants of a certain design capacity.

EPA also considered other thresholds, including requiring all wastewater treatment plants regardless of size, treatment processes, or control technology to report. EPA determined that this option would result in reporting from over 15,000 wastewater treatment systems in the United States, many of whom are small emitters.

EPA also considered requiring all wastewater treatment plants with anaerobic wastewater treatment systems to report. However, wastewater treatment plants that operate anaerobic systems tend to be very small and manage wastewater for very small populations. In fact, the plants with the most potential to emit greenhouse gases are large wastewater treatment plants that operate aerobic systems, and digest their sludge on site.

EPA also considered requiring plants of a certain size to report, based on wastewater flow treated or population served by the system. However, EPA generally found that the flow and population are not highly correlated with emissions from wastewater treatment because there are many factors that influence these emissions, including system type and the amount of industrial co-discharge.

Finally, EPA considered plants of a certain design capacity to report. However, this is a weak indicator of emissions from a wastewater treatment plant, because there are many other factors that influence the emissions, including wastewater influent BOD or COD and N content, and system type.

6. Options for Monitoring Methods

One option for the monitoring method involves the use of activity data, such as measured BOD or COD, and N influent, and operational characteristics (e.g., type of management system), with the Intergovernmental Panel on Climate Change (IPCC) Tier 1 method to calculate CH_4 generation and N_2O emissions and measured values for gas combustion. This approach allows the use of default factors, such as a system emission factor, for certain elements of the calculation, and encourages the use of site-specific data wherever possible. The cost of such an approach is usually low, but the uncertainty can be high. For additional information on this method, please see IPCC 2006[5] and EPA 2008[6].

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[5] IPCC 2006. Chapter 6: Wastewater Treatment and Discharge. IPCC (Volume 5 Waste). Available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf.

6.1 Calculating Methane Generation

Domestic Wastewater Treatment. To estimate the amount of CH_4 emissions from domestic wastewater treatment, plant-specific values of BOD in the influent to the treatment system are determined by periodic sampling and testing (see the section below on Sampling and Testing Programs for more details). Next, the maximum amount of methane that could potentially be produced by the wastewater under ideal conditions is calculated by multiplying the BOD by the maximum methane producing capacity of the wastewater (B_0). The default B_0 value for wastewater is 0.6 kg CH_4/kg BOD, as shown in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories,* Volume 5, Chapter 6, Table 6.2.

Most wastewater treatment systems will not produce the maximum amount of methane possible from the BOD because the conditions in the systems are not ideal for methane production. The CH_4 producing potential of a specific system is represented by a parameter known as the methane conversion factor (MCF). This value ranges from 0 to 100 percent and reflects the capability of a system to produce the maximum achievable CH_4 based on the readily biodegradable organic matter present in the wastewater. A higher MCF equates to a higher CH_4 producing potential. MCF values for various types of treatment systems are presented in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 5, Chapter 6, Table 6.3.

The equations proposed to calculate CH_4 generation at domestic wastewater treatment systems are presented below:

$$\mathrm{CH}_4(\textit{domestic wastewater}) = \sum_{month}[Flow * BOD * Bo * MCF]$$

Where:

CH_4	= Annual CH_4 mass emissions from domestic wastewater treatment (kg/year)
Flow	= Monthly flow treated through anaerobic treatment system (m^3/month)
BOD	= Average monthly organics loading in wastewater entering anaerobic treatment system (kg/m^3)
Bo	= Maximum CH_4 producing potential of domestic wastewater (default value of 0.60 kg CH_4 /kg BOD)
MCF	= CH_4 correction factor, indicating the extent to which the organic content (measured as BOD) degrades anaerobically

In some cases, the wastewater may be treated prior to entering the anaerobic treatment step(s). When sludge is removed in these primary treatment steps, the amount of BOD treated anaerobically is less than the total BOD entering the POTW. In this situation, the facility should ensure that the BOD measurement represents the wastewater treated anaerobically.

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[6] EPA 2008. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006. Chapter 8: Waste. http://www.epa.gov/climatechange/emissions/usinventoryreport.html

Industrial Wastewater Treatment. To estimate the amount of CH_4 emissions from industrial wastewater treatment, plant-specific values of COD are determined by periodic sampling and testing (see the section below on Sampling and Testing Programs for more details). Next, the maximum amount of methane that could potentially be produced by the wastewater under ideal conditions is calculated by multiplying the COD by the maximum methane producing capacity of the wastewater (B_0). The default B_0 value for wastewater is 0.25 kg CH_4/kg COD, as shown in the ***2006 IPCC Guidelines for National Greenhouse Gas Inventories***, Volume 5, Chapter 6, p.6.21.

Most wastewater treatment systems will not produce the maximum amount of methane possible from the wastewater because the conditions in the systems are not ideal for methane production. The CH_4 producing potential of a specific system is represented by a parameter known as the methane conversion factor (MCF). This value ranges from 0 to 100 percent and reflects the capability of a system to produce the maximum achievable CH_4 based on the readily biodegradable organic matter present in the wastewater. A higher MCF equates to a higher CH_4 producing potential. MCF values for various types of treatment systems are presented in the ***2006 IPCC Guidelines for National Greenhouse Gas Inventories***, Volume 5, Chapter 6, Table 6.8.

The equation proposed to calculate CH_4 generation at industrial wastewater treatment systems is presented below:

$$\mathrm{CH}_4(\textit{industrial wastewater}) = \sum_{month} [Flow * COD * Bo * MCF]$$

Where:

CH_4	= Annual CH_4 mass emissions from industrial wastewater treatment (kg/year)
Flow	= Monthly flow treated through anaerobic treatment system (m^3/month)
COD	= Average monthly organics loading in wastewater entering anaerobic treatment system (kg/m^3)
Bo	= Maximum CH_4 producing potential of industrial wastewater (default value of 0.25 kg CH_4 /kg COD)
MCF	= CH_4 correction factor, indicating the extent to which the organic content (measured as COD) degrades anaerobically

In addition, the equation proposed to calculate indirect CO_2 emissions from oil/water separators at petroleum refineries is presented below:

$$\mathrm{ECO}_2 = \sum_{month} [EFsep * VH2O * C * 44/12 * metric\,ton/1000\,kg]$$

Where:

ECO_2	= Annual emissions of CO_2 (metric tons/yr)

EFsep	= Emissions factor for the type of separator (kg NMVOC/m^3 wastewater treated)
V_{H2O} (m^3/month)	= Monthly flow treated through oil/water separator
C	= Carbon fraction in NMVOC (default = 0.6)
44/12	= Conversion – carbon to carbon dioxide
Metric tons/1000	= Conversion factor from kg to metric tons

Sampling and Testing Programs. Samples and measurements taken for the purpose of estimating whether emissions reach a reporting threshold must be representative of the plant's activities. To develop an appropriate testing program, the following four factors need to be addressed:

1) Sampling Location. The plant must identify the sampling location that will provide a valid estimation of BOD (for POTWs) or COD (for industrial facilities) entering the wastewater treatment system. The plant should select a location where the wastewater flow is measurable and that is easily and safely accessible. The sample location should represent the wastewater influent for the time period that is monitored.

2) Sample Collection Method. There are two basic sample collection methods: "grab" and "composite." A "grab" sample is a single sample collected at a particular time and place. When the quality and flow of the waste stream being sampled is not likely to change over time, a grab sample is appropriate. A "composite" sample is a collection of individual samples. For flowing streams, such as treatment system influent, the individual samples are usually collected at a regular time or volume interval (e.g., every hour or every 1,000 liters). A composite sample is desirable when the sampled waste stream varies significantly over time. The quality and flow of POTW influent wastewater varies diurnally. For this reason, a 24-hour flow-weighted composite will provide the most representative sample of POTW influent. Industrial facilities should also collect 24-hour flow-weighted composites, unless they can demonstrate that the quality and flow into the treatment system does not vary. In this case, industrial facilities should collect 24-hour time-weighted composites to characterize changes in wastewater due to production fluctuations, or a grab sample is the influent flow is equalized resulting in little variability.

3) Monitoring Frequencies. To establish a monitoring frequency, the plant should estimate the variability of the BOD or COD concentration by reviewing existing influent data. A highly variable waste stream should be measured on a more frequent basis than a waste stream that is relatively consistent over time (particularly in terms of flow and pollutant concentration). We recommend a monitoring frequency of no less than one time per month; ideally the frequency would be weekly, with the option of reducing frequency if BOD or COD loads into the system are generally consistent throughout the year. Some facilities may already be required by their NPDES permit to collect influent BOD or COD samples on a daily or weekly basis, and should use all data available for the calculation of a monthly mean BOD or COD mass load.

At some POTWs the BOD load will vary seasonally, including plants that serve a seasonal population (such as seasonal resorts, winter retirement communities, or colleges). Flows and BOD loads may decrease in summer, when populations move to northern regions or students go on vacation. Loads may increase during the time the resort is in use. If the POTW knows it has seasonal variations, it should monitor during the season with the highest loads.

Similarly, some industrial plants undergo seasonal variations in production, such as fruit and vegetable processors that may undergo higher production activities following the harvest of a particular crop.

4) Analytical Methods. For domestic wastewater treatment systems, BOD is the most widely used parameter of organic pollution in wastewater, and is typically measured as "5-day BOD" (BOD_5). BOD measures the amount of dissolved oxygen used by microorganisms in the biochemical oxidation of organic matter. In general, the sample is seeded to provide sufficient nutrients and oxygen for the duration of the incubation period. The typical incubation is five days, and the typical temperature is 20ºC.

COD is a widely used parameter of organic pollution in industrial wastewater. Chemical oxygen demand (COD) is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as ammonia and nitrite. The basis for the COD test is that nearly all organic compounds can be fully oxidized to carbon dioxide with a strong oxidizing agent under acidic conditions.

Analytical methods for industrial and municipal wastewater pollutants must be conducted in accordance with the methods specified pursuant to 40 CFR Part 136, which references one or more of the following:

- Test methods in Appendix A of 40 CFR Part l36;
- Standard Methods for the Examination of Water and Wastewater, 18^{th} Edition;
- Methods for the Chemical Analysis of Water and Wastewater; and
- Test Methods: Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater.

6.2 Methane Combustion at Anaerobic Digesters

If the wastewater treatment plant has an anaerobic digester, such as those used to digest biosolids at domestic wastewater treatment plants, EPA proposes that the CH_4 combustion of the digester be measured. Direct measurement to determine CH_4 combustion from anaerobic digesters depends on two measurable parameters: 1) the rate of gas flow to the combustion device; and 2) the CH_4 content in the gas flow. These can be quantified by directly measuring the gas stream to the destruction device(s). The gas stream may be measured by continuous metering or monthly sampling.

For continuous metering, the recommended instrumentation measures both flow and gas concentration. Several direct measurement instruments also use a separate recorder to store and document the data. A fully integrated system that directly reports CH_4 content requires no other calculation than summing the results of all monitoring periods for a given year. Internally, the instrumentation is performing its calculations using algorithms similar to Equation B below.

For monthly sampling, the two primary instruments used are a gas flow meter and a gas composition meter. The gas flow meter must be installed as close to the gas combustion device as possible to measure the amount of gas reaching the device. Two procedures are used for data collection in the monthly monitoring method:

1. Calibrate monitoring instrument in accordance with the manufacturer's specifications.
2. Collect four sets of data: flow rate (ft^3/minute); CH_4 concentration (percent); temperature (^oR); and pressure (atm). The measurements should be taken before any treatment equipment and using a monitoring meter specifically for CH_4 gas.

The amount of CH_4 destroyed during the month is calculated using Equation B. Monthly data for V, C, T, P and t (see below) are summed to calculate an annual total.

$$C = V \times (Conc/100) \times 0.0423 \times (520/T) \times (P/1) \times (t) \times (0.454/1000)$$

Where:

V	= Total volumetric flow (ft^3/minute)
Conc	= CH_4 concentration (percent)
0.0423	= Density of methane at 520R or 60^{o}F (pounds/standard ft^3)
T	= Temperature at which flow is measured (^oR)
P	= Pressure at which flow is measured (atm)
t	= Time period since last monthly measurement (minutes)
0.454/1000	= Conversion factor, pounds to metric tons

6.3 Calculating Methane Combustion of Anaerobic Digesters

To estimate CH_4 combustion at a digester, apply the destruction efficiency of the combustion equipment to the value for C estimated above.

$$D = C \times DE$$

Where:

DE	= CH_4 destruction efficiency from flaring or burning in engine (default is 0.99)[7]

[7] EPA 1998. U.S. Environmental Protection Agency (1998) "AP-42 Compilation of Air pollutant Emission Factors." Chapter 2.4, Table 2.4-3, page 2.4-13. Downloaded from: http://www.epa.gov/ttn/chief/ap42/ch02/final/c02s04.pdf.

6.4 Nitrous Oxide Emissions

To estimate the amount of direct wastewater N_2O emissions at the treatment plant, the average annual service population is multiplied by a default emission factor and a factor to represent the contributions from industrial wastewater (default = 1.25). Note that this method does not consider N_2O emissions that may be generated from nitrogen discharged to the environment in effluent from treatment systems.

The equations proposed to calculate direct N_2O emissions from wastewater treatment systems are presented below:

$$E = N_2O_{PLANT} = N_2O_{NIT/DENIT} + N_2O_{WOUT\ NIT/DENIT}$$

$$N_2O_{NIT/DENIT} = [Pop_{ND} \times EF_2 \times F_{IND\text{-}COM}] \times 1/10^{\wedge}9$$

$$N_2O_{WOUT\ NIT/DENIT} = \{(Pop - US_{POPND} \times F_{IND\text{-}COM}) \times EF_1\} \times 1/10^{\wedge}9$$

Where:

N_2O_{PLANT}	= Annual N_2O emissions from centralized wastewater treatment plants (kg)
$N_2O_{NIT/DENIT}$	= N_2O emissions from centralized wastewater treatment plants with nitrification/denitrification (kg)
$N_2O_{WOUT\ NIT/DENIT}$	= N_2O emissions from centralized wastewater treatment plants without nitrification/denitrification (kg)
Pop	= Service population
Pop_{ND}	= Service population that is served by biological denitrification
EF_1	= Emission factor (3.2 g N_2O/person-year)
EF_2	= Emission factor (7 g N_2O/person-year)
$F_{IND\text{-}COM}$	= Factor for industrial and commercial co-discharged protein into the sewer system (default value 1.25)

6.5 Estimating Total Generation and Emissions

Generation from a wastewater treatment plant can be estimated by converting the CH_4 emissions from the system (A+B+C) and the N_2O emissions from the system (E) into common units of CO_2 equivalents, then summing them.

$$\text{Generation} = A + B + C + E$$

Emissions from a system can be estimated by adding the CH_4 emissions from the system (A+B+C) and the N_2O emissions from the system (E), then subtracting the CH_4 combustion from anaerobic digestion (D) (taking into account the destruction efficiency): All parameters should be converted to a common unit (CO_2 equivalents) before the calculation occurs.

$$\text{Emissions} = A + B + C - D + E$$

6.6 Calculating CH_4 Generation and Emissions Using Digester Gas Collection Data

EPA also considered using gas collection data (metered) and an estimate of collection system efficiency to calculate generation. The advantage of this method is that it uses metered data. However, it is difficult to estimate collection efficiency, and studies have given greatly varying values for collection efficiency.

6.7 Direct Measurement of Emissions

Direct measurement is another option EPA considered. This method allows for site-specific measurements, but it is very costly and might not be accurate if the measuring system has incomplete coverage. A direct measurement system must be complete both spatially (in that all emissions pathways are covered) and temporally (as emissions can vary greatly due to changes in influent and conditions at the plant).

7. Options for Estimating Missing Data

On the occasion that a facility lacks sufficient data to determine the emissions from wastewater treatment over a period of time, EPA considered requiring that the facility apply an average facility-level value for the missing parameter from the previous year. The rule would then require a complete record of all parameters determined from company records that are used in the GHG emissions calculations (e.g., production data, biogas combustion data, etc.).

8. QA/QC Requirements

In evaluating options for QA/QC requirements, EPA considered requiring reporters to maintain records on wastewater flow and influent BOD (for POTWs) or COD (for industrial facilities) entering the treatment system and records on gas flow and CH_4 content to any combustion device; EPA could use these data to check the estimated emissions submitted by the entity. EPA considered requesting reporters to use EPA-provided national emission factors for CH_4 and N_2O per capita and system type to check against calculated emissions, but believes there is too much variability to compare average national data to a specific system.