

MONITORING REPORT FOR METHANE CAPTURE, FLARE AND UTILIZATION AT TYSON WASTEWATER TREATMENT FACILITIES



Blue SourceTM
A Leading Climate Change Portfolio

Project Title	Methane Capture, Flare and Utilization at Tyson Wastewater Treatment Facilities
Version	2.4
Report ID	2.4
Date of Issue	24-April-2013
Project ID	14,15,16,17
Monitoring Period	01-January-2012 to 31-December-2012
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1 PROJECT DETAILS

1.1 Summary Description of Project

Blue Source is an active supplier of emission reductions sourced from geologic sequestration, conservation, transportation, and avoidance projects and entities. More recently, the company is actively involved in financing and developing these types of projects. Tyson Foods, Inc. ("Tyson") is the world's largest supplier of protein, operating poultry, swine, and beef processing plants. Wastewater from Tyson's processing plants is treated at wastewater treatment plants owned and operated by Tyson. Tyson's 100 wastewater pre-treatment and full-treatment plants treat over 100 million gallons of water a day.

During primary treatment, the wastewater is traditionally held in uncovered anaerobic lagoons. Uncovered anaerobic lagoons lead directly to the production and release of CH₄ ("biogas") into the atmosphere as a result of the anaerobic digestion process that takes place. Biogas production is due to the degradation of organic matter by acidogenic and methanogenic bacteria. The project activity involves the installation of anaerobic lagoon covers that collect the biogas, which is subsequently flared or utilized in adjacent processing facility boilers for the displacement of natural gas.

The monitoring report is prepared in accordance with the protocol, "Emission Reduction Protocol for Methane Capture, Flare and Utilization at Tyson Wastewater Treatment Facilities," for four Tyson facilities (the project), including Amarillo, TX, Joslin, IL, Lexington, NE, and Storm Lake, IA. The protocol follows methodology number ACM0014, "Avoided Methane Emissions from Wastewater Treatment," which was developed under the UNFCCC Clean Development Mechanism (CDM) program. Validation of the protocol and verification of the emission reductions associated with the project through December 2008 were completed by DNV in March 2009. Verification of the emission reductions associated with the project through for 2009 was also completed by DNV.

1.2 Sectoral Scope and Project Type

Sectoral Scope: Waste Handling and Disposal

Project Type: Avoided Methane Emissions from Wastewater Treatment

The projects are not Grouped Projects.

1.3 Project Proponent

Blue Source, LLC is the Project Proponent, having been assigned all rights to the project's emission reductions for the entire project crediting period. Blue Source is responsible for aggregating data produced by the Tyson facilities and quantifying emission reductions in accordance with the VCS. Tyson Foods Inc. is responsible for all operations at the project locations, as well as origination and reporting of site-specific data into a central recording location.

1.4 Other Entities Involved in the Project

Tyson Foods Inc. is responsible for all operations at the project locations, as well as origination and reporting of site-specific data into a central recording location.

1.5 Project Start Date

Joslin, Illinois	07/2001
Lexington, Nebraska	09/2001
Amarillo, Texas	02/2001
Storm Lake, Iowa	12/2000

1.6 Project Crediting Period

01 January, 2004 – 31 December, 2013

1.7 Project Location

Amarillo, Texas

Joslin, Illinois

Lexington, Nebraska

Storm Lake, Iowa

1.8 Title and Reference of Methodology

UNFCCC Clean Development Mechanism (CDM), ACM0014, "Avoided Methane Emissions from Wastewater Treatment," Version 01

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

The project was fully operational at all locations during the monitoring period.

No abnormal leaks or repairs were reported for any site during the monitoring period.

Amarillo

In Amarillo, it should be noted that the effluent flow from the anaerobic lagoons is often noticeably higher than the influent flow to the lagoons. This is due to several streams of non-process water that enter the lagoons. These streams have very little BOD loading, so they should not be counted toward the influent flow as this would overstate $COD_{In,m}$ and would overstate emission reductions. The most accurate treatment of these flows in the calculations would be to deduct them from the effluent flows before calculating $COD_{Out,m}$; however, for conservativeness these flows have been left in the effluent flow measurement (has the effect of overstating $COD_{Out,m}$, which lowers emission reductions).

During the June 29 calibration, the flare flow meter was found to be underreporting by an average of 5.74%. Since underreporting of flare flow rates would overstate emission reductions, all flare volume values from January through June have been increased by 5.74%.

Lexington

In a previous monitoring period, the Lexington facility installed an Innova gas analyzer and began monitoring its methane concentration on a weekly basis, whereas it had previously performed quarterly chromatography analyses. Weekly measurements are used in this monitoring period's calculations as well. The Innova analyzer was, however, not in operation from 5/23/12 to 7/18/12. The unit was removed from service on 5/23/12 and sent into the manufacturer for repair. During the time period of 6/20/12 to 7/11/12, gas samples were sent to an outside contractor for testing purposes. In order to combat the downtime problem, a secondary unit was purchased, and is now kept in stock as a back-up unit. This unit can be used if the functional unit must be sent in for repair at any time. During the reporting period the unit did record several values that were uncharacteristically high, some being entirely erroneous at over 100%. To address these errors, any value measured at over 81.38% (the highest quarterly average recorded for any previous monitoring period) has been excluded from the averaging calculations.

During the reporting period the Lexington facility added an additional 30 horse power, positive displacement, aeration blower to the biogas operational equipment list. In the past, the facility had always had one aeration blower running with one being used as a spare. Due to current operational parameters and operating conditions, the site is being forced to use both of the aeration blowers most of the time to keep the system operating properly. Therefore, an additional 30 hp has been added to the load ratings for the Lexington facility as if they are both used 100% of the time.

On March 8, 2012 the Lexington facility installed a new wastewater influent flow meter upstream of the anaerobic lagoon. The previous influent flow meter was verified on November 7, 2011 and would not have had its re-verification due until November 7, 2012. Since the newly installed meter was brand new and is deemed to be accurate as provided from the factory, a verification is not required until March 8 of 2013. Therefore, influent flows throughout the reporting period are deemed to be accurate.

Storm Lake

At the Storm Lake Facility, the Q3 biogas analysis resulted in an abnormally low methane concentration reading of 47.8%. The facility estimates that some leaky pipes (subsequently repaired) on the suction side of the blower may have introduced air into the system, which could have the effect of lowering the measured CH₄ content. It may also have increased the measured volume of biogas. The impact on the emission reduction calculations would be a balancing effect since project emissions are calculated based on total biogas volume multiplied by methane concentration: A decrease in methane content tends to increase emission reductions, while an increase in volume tends to decrease emission reductions. As a reminder there are no emission reductions from beneficial use at the Storm Lake facility. As such, it is not anticipated that this issue has any effect, positive or negative, on emission reduction calculations.

2.2 Project Description Deviations

During the previous monitoring period, it was determined that following manufacturer's recommendations for calibration and/or verification frequency of all flow meters should be implemented rather than stipulating more frequent checks. As such, the QA/QC procedures for parameters $FV_{RGf,m}$, $FV_{RGb,m}$ and $TM_{RGf,m}$ have been updated to reflect that the original quarterly calibration checks or the manufacturer's recommended calibration frequency may be followed. This deviation does not impact applicability of the methodology, additionality or the appropriateness of the baseline scenario.

2.3 Grouped Project

This section intentionally left blank.

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data Unit / Parameter:	B_0
Data unit:	mtCH ₄ / mtCOD
Description:	Maximum methane producing capacity, expressing the maximum amount of CH ₄ that can be produced from a given quantity of chemical oxygen demand (COD)
Source of data:	2006 IPCC Guidelines
Value applied:	Despite IPCC recommendations of 0.25, the default value chosen by CDM ACM0014 is 0.21 (lbs CH ₄ / lbs COD) due to the uncertainty of the value.
Purpose of the data:	Baseline Emissions
Any comment:	NA

Data Unit / Parameter:	A								
Data unit:	Ft ²								
Description:	Surface area of the uncovered lagoons								
Source of data:	Engineering blue prints of the lagoons								
Value applied:	<table> <tr> <td>Amarillo, TX</td><td>538,078</td></tr> <tr> <td>Joslin, IL</td><td>190,962</td></tr> <tr> <td>Lexington, NE</td><td>204,800</td></tr> <tr> <td>Storm Lake, IA</td><td>171,000</td></tr> </table>	Amarillo, TX	538,078	Joslin, IL	190,962	Lexington, NE	204,800	Storm Lake, IA	171,000
Amarillo, TX	538,078								
Joslin, IL	190,962								
Lexington, NE	204,800								
Storm Lake, IA	171,000								
Purpose of the data:	Baseline Emissions								
Any comment:	Parameter represents total open surface area at each site. Accounts for multiple lagoons of varying sizes where applicable.								

Data Unit / Parameter:	$f_{\text{COD, aer}}$
Data unit:	mtCOD / ha month
Description:	Quantity of COD degraded to CO ₂ under aerobic conditions per surface area of the lagoon
Source of data:	Expert engineering opinions from both internal and third party assessment
Value applied:	0.1582 lbs COD / ft ² / month = 92.7 mtCOD / ha / yr
Purpose of the data:	Baseline Emissions
Any comment:	The grease cap present in the pre-project case, as described in Section 4.0 – Baseline Assessment, forms a completely oxygen-tight barrier over the entire lagoon surface, which eliminates all COD

	removal due to aerobic activity at the lagoon surface. However, since no experiments have been conducted to date, the default values described above are used in accordance with the CDM methodology. Experiments may be conducted in the future to determine if different values are more accurate.
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Data Unit / Parameter:	D
Data unit:	ft
Description:	Depth of the lagoon
Source of data:	Engineering blue prints of the lagoons
Value applied:	Amarillo, TX 19 Joslin, IL 17 Lexington, NE 27 Storm Lake, IA 17
Purpose of the data:	Baseline Emissions
Any comment:	NA

Data Unit / Parameter:	EF _{CO₂,FF,Boiler}
Data unit:	mtCO ₂ / MMBtu
Description:	CO ₂ emission factor of the fossil fuel type used in the boiler (natural gas) for heat generation in the absence of the project activity
Source of data:	2006 IPCC Guidelines
Value applied:	0.05919
Purpose of the data:	Baseline Emissions
Any comment:	NA

Data Unit / Parameter:	NCV _{CH₄}
Data unit:	Btu/ft ³
Description:	Net Caloric Value of Methane
Source of data:	2006 IPCC Guidelines
Value applied:	922.45
Purpose of the data:	Baseline Emissions
Any comment:	NA

Data Unit / Parameter:	η _{Boiler}
Data unit:	%
Description:	Efficiency of the boiler that would be used for heat generation in the absence of the project activity
Source of data:	NA (see comment)
Value applied:	100%

Purpose of the data:	Baseline Emissions
Any comment:	U.S. EPA and IPCC guidelines suggest values of 98% and 99.5% respectively; however, a value of 100% is conservative and is therefore used.

Data Unit / Parameter:	GWP _{CH4}
Data unit:	mtCO ₂ e / mtCH ₄
Description:	Global warming potential for CH ₄
Source of data:	IPCC
Value applied:	21
Purpose of the data:	Baseline Emissions, Project Emissions
Any comment:	NA

Data Unit / Parameter:	COD/BOD
Data unit:	lbs COD / lbs BOD
Description:	BOD to COD Conversion Factor
Source of data:	2006 IPCC Guidelines
Value applied:	2.4
Purpose of the data:	Baseline Emissions
Any comment:	NA

Data Unit / Parameter:	W _S
Data unit:	mg/L
Description:	Average Concentration of Chemically Oxidative Substance (Sulfate) present in the treated wastewater
Source of data:	On-site measurements
Value applied:	231
Purpose of the data:	Baseline Emissions
Any comment:	Most conservative value chosen from available data

Data Unit / Parameter:	R _S
Data unit:	lbs COD / lbs Sulfate
Description:	Specific Reduction of Chemical Oxygen Demand by Sulfate
Source of data:	Engineering factors for oxidizing BOD
Value applied:	1.3333
Purpose of the data:	Baseline Emissions
Any comment:	NA

Data Unit / Parameter:	t_{detect}
Data unit:	seconds (days)
Description:	Maximum time that a leak would go undetected based on frequency of inspection at each site
Source of data:	Standard Tyson Operating Procedures for lagoon cover monitoring
Value applied:	Amarillo, TX 86,400 (1) Joslin, IL 302,400 (3.5) Lexington, NE 86,400 (1) Storm Lake, IA 86,400 (1)
Purpose of the data:	Project Emissions
Any comment:	NA

Data Unit / Parameter:	n_L
Data unit:	-
Description:	Maximum number of leaks reported in a given year
Source of data:	Reports from wastewater superintendents
Value applied:	5
Purpose of the data:	Project Emissions
Any comment:	Most conservative value chosen from all site reports

Data Unit / Parameter:	EF_{Propane}
Data unit:	mtCO ₂ e/gallon
Description:	Emission factor of Propane
Source of data:	U.S. EPA Guidelines
Value applied:	0.00574
Purpose of the data:	Project Emissions
Any comment:	Calculated from carbon content and energy content of Propane

Data Unit / Parameter:	WC_{Propane}
Data unit:	kg C / MMBtu
Description:	Carbon content of Propane
Source of data:	U.S. EPA Guidelines
Value applied:	17.20
Purpose of the data:	Project Emissions
Any comment:	IPCC values not available for Propane

Data Unit / Parameter:	EC_{Propane}
Data unit:	MMBtu / Barrel
Description:	Energy Content of Propane

Source of data:	U.S. EPA Guidelines
Value applied:	3.824
Purpose of the data:	Project Emissions
Any comment:	IPCC values not available for Propane

Data Unit / Parameter:	f_p
Data unit:	-
Description:	Uncertainty Factor for Propane Usage
Source of data:	NA (parameter no longer in use)
Value applied:	2
Purpose of the data:	Project Emissions
Any comment:	Used for previous years in which actual Propane usage data is not available

Data Unit / Parameter:	ρ_{CH_4}
Data unit:	lbs/ft ³ (kg/cm ³)
Description:	Density of Methane at Ambient Conditions
Source of data:	NA
Value applied:	0.0447 (6.8 x 10 ⁻⁷)
Purpose of the data:	Project Emissions
Any comment:	NA

Data Unit / Parameter:	η_{Flare}								
Data unit:	%								
Description:	Permitted Flare Efficiency								
Source of data:	State Air permits for each facility								
Value applied:	<table border="0"> <tr> <td>Amarillo, TX</td><td>98.0%</td></tr> <tr> <td>Joslin, IL</td><td>96.3%</td></tr> <tr> <td>Lexington, NE</td><td>98.0%</td></tr> <tr> <td>Storm Lake, IA</td><td>98.0%</td></tr> </table>	Amarillo, TX	98.0%	Joslin, IL	96.3%	Lexington, NE	98.0%	Storm Lake, IA	98.0%
Amarillo, TX	98.0%								
Joslin, IL	96.3%								
Lexington, NE	98.0%								
Storm Lake, IA	98.0%								
Purpose of the data:	Project Emissions								
Any comment:	NA								

Data Unit / Parameter:	L_f								
Data unit:	hp (MW)								
Description:	Load Rating of the Centrifugal Blowers used to transport biogas to the flare								
Source of data:	Equipment nameplates								
Value applied:	<table border="0"> <tr> <td>Amarillo, TX</td><td>125 (0.09325)</td></tr> <tr> <td>Joslin, IL</td><td>10 (0.00746)</td></tr> <tr> <td>Lexington, NE</td><td>45 (0.03357)</td></tr> <tr> <td>Storm Lake, IA</td><td>7.5 (0.00559)</td></tr> </table>	Amarillo, TX	125 (0.09325)	Joslin, IL	10 (0.00746)	Lexington, NE	45 (0.03357)	Storm Lake, IA	7.5 (0.00559)
Amarillo, TX	125 (0.09325)								
Joslin, IL	10 (0.00746)								
Lexington, NE	45 (0.03357)								
Storm Lake, IA	7.5 (0.00559)								
Purpose of the data:	Project Emissions								

Any comment:	Blowers typically operated near half load. Full load used in calculations for conservativeness. Verifier to verify equipment configurations and power ratings to ensure any future changes are accounted for.
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Data Unit / Parameter:	L _b
Data unit:	hp (MW)
Description:	Load Rating of the Centrifugal Blowers used to transport biogas to the boiler
Source of data:	Equipment nameplates
Value applied:	Amarillo, TX 125 (0.09325) Joslin, IL 100 (0.0746) Lexington, NE 105 (0.07833) Storm Lake, IA N/A
Purpose of the data:	Project Emissions
Any comment:	Blowers typically operated near half load. Full load used in calculations for conservativeness. Verifier to verify equipment configurations and power ratings to ensure any future changes are accounted for.

Data Unit / Parameter:	L _{H2S}
Data unit:	hp (MW)
Description:	Load Rating of the H ₂ S Scrubbing System
Source of data:	Equipment nameplates
Value applied:	Amarillo, TX 150 (0.1119) Joslin, IL 127 (0.0947) Lexington, NE 189 (0.1402) Storm Lake, IA 140 (0.1044)
Purpose of the data:	Project Emissions
Any comment:	Full load used in calculations for conservativeness. Some equipment only runs very rarely, but all loads are accounted for full time for conservativeness. Verifier to verify equipment configurations and power ratings to ensure any future changes are accounted for.

Data Unit / Parameter:	t _{H2S,m}
Data unit:	hours
Description:	Hours of operation of the H ₂ S scrubbing system in month, m.
Source of data:	Tyson Standard Operating Procedures
Value applied:	Amarillo, TX 730 Joslin, IL 730

	Lexington, NE 730 Storm Lake, IA 730
Purpose of the data:	Project Emissions
Any comment:	H ₂ S system runs 24 hours per day, 7 days per week (728 hours per month) at all sites

Data Unit / Parameter:	EF _{Grid}
Data unit:	mtCO ₂ / MWh
Description:	Grid emission factor
Source of data:	CDM "Tool to calculate project emissions from electricity consumption" Version 01.
Value applied:	1.3
Purpose of the data:	Project Emissions
Any comment:	NA

Data Unit / Parameter:	TDL
Data unit:	%
Description:	Average Transmission and Distribution Losses in the Grid
Source of data:	U.S. Climate Change Technology Program
Value applied:	7.2%
Purpose of the data:	Project Emissions
Any comment:	NA

3.2 Data and Parameters Monitored

Data Unit / Parameter:	COD _{In,m} COD _{Out,m}
Data unit:	lbs COD / month
Description:	- Chemical Oxygen Demand entering the anaerobic lagoon - Chemical Oxygen Demand leaving the anaerobic lagoon and entering secondary and tertiary processes
Source of data:	Measured
Description of measurement methods and procedures to be applied:	Concentration is measured 2-3 times per week at the inlet and outlet of the anaerobic lagoons. Flow is monitored continuously by a totalizing magnetic flowmeter. All sampling is carried out by on-site, state-certified laboratories adhering to recognized procedures.
Frequency of monitoring/recording:	Weekly
Value monitored:	NA
Monitoring equipment:	On-site laboratories (concentration) and wastewater flow meters (flow)

QA/QC procedures to be applied:	On-site Tyson laboratories are State-certified.
Calculation method:	BOD (mg/l) x Flow (mgal) x 8.34 x COD/BOD
Any comment:	BOD is measured and converted to COD per IPCC guidelines. Per ACM0014.

Data Unit / Parameter:	$F_{PJ,m}$
Data unit:	mgal / day
Description:	Monthly quantity of wastewater treated in the anaerobic lagoons in the project activity
Source of data:	Measured
Description of measurement methods and procedures to be applied:	Flow is monitored continuously by a totalizing magnetic flowmeter.
Frequency of monitoring/recording:	Continuously monitored. Data aggregated into weekly and monthly totals.
Value monitored:	NA
Monitoring equipment:	Magnetic Flow Meter
QA/QC procedures to be applied:	Flowmeters are verified by certified third parties on an annual basis.
Calculation method:	Influent and Effluent flows are averaged. At certain facilities, other operational flows upstream or downstream of relevant flow meters are added or subtracted to arrive at accurate flows of process water into and out of the anaerobic lagoons. For Amarillo influent totalizer readings: For most instances, the prior week ending date flow is subtracted from the accumulated flow from the current week ending date. If the meter was reset during the week, the flow meter value from the day prior to the reset is noted. Then the value from the week prior ending flow is subtracted, while the value of the current week ending date flow (which will have accumulated from zero) is added. This method is conservative because any flow occurring between the time the totalizer value was last recorded and the time the meter was reset is unaccounted for, thereby understating anaerobic influent flows.
Any comment:	NA

Data Unit / Parameter:	$COD_{Sedim,m}$
Data unit:	lbs COD
Description:	Monthly quantity of Chemical Oxygen Demand

	accumulated as sedimentation
Source of data:	Measured
Description of measurement methods and procedures to be applied:	Depth measurements from cover hatches
Frequency of monitoring/recording:	Annually
Value monitored:	Amarillo 0 Joslin 0 Lexington 0 Storm Lake 0
Monitoring equipment:	On-site laboratories
QA/QC procedures to be applied:	NA
Calculation method:	Volume of sludge removed during the project activity (gal) x COD concentration of sludge (lbs/gal)
Any comment:	To date Tyson has not observed any sedimentation except for the Lexington facility which performed a removal in 1995 and again in June and July of 2011. Sludge depth will be monitored annually to verify that this remains unchanged year over year. If any accumulation is observed, core samples will be taken and analyzed for COD content. In the 2012 depth tests, results indicated a decreased volume of sludge compared to the 2011 results for each site.

Data Unit / Parameter:	HG _{PJ,m}
Data unit:	MMBtu
Description:	Monthly thermal energy generated with biogas from the covered lagoons that displaces fossil fuel combustion
Source of data:	Calculated
Description of measurement methods and procedures to be applied:	NA
Frequency of monitoring/recording:	Continuously monitored. Data aggregated into weekly and monthly totals.
Value monitored:	NA
Monitoring equipment:	Thermal mass flow meter
QA/QC procedures to be applied:	Biogas flowmeters are calibrated by certified third parties on a quarterly basis or as recommended by manufacturer's specifications.
Calculation method:	Based on gross volume of biogas used for heat generation, the methane content of the gas and the NCV of methane as per equation 6-8

Any comment:	NA
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Data Unit / Parameter:	fv _{CH4}				
Data unit:	%				
Description:	Volumetric Fraction of CH4 in Biogas				
Source of data:	Gas Chromatography Samples. For Amarillo, the energy content of the biogas (BTU) is converted to percentage CH4 given that energy content of pure CH4 is 922.45 Btu/ft3.				
Description of measurement methods and procedures to be applied:	Third party lab analysis or Daniel “Danalyzer” BTU Chromatograph				
Frequency of monitoring/recording:	Historically, Tyson used a single third-party measured reference point. Now, quarterly measurements are taken, except at sites where online continuous monitors are active, in which case the volumetric fraction will be monitored continuously.				
Value monitored:	Volumetric Fraction of CH4 in Biogas				
	fv_CH4	2012 (Q1)	2012 (Q2)	2012 (Q3)	2012 (Q4)
	Amarillo, TX	83.44%	79.06%	68.59%	73.78%
	Joslin, IL	70.30%	77.20%	75.30%	74.70%
	Lexington, NE	69.00%	70.35%	78.85%	78.55%
	Storm Lake, IA	81.50%	75.0%	47.80%	75.3%
	Monitoring equipment:				
QA/QC procedures to be applied:	Quarterly measurements are to be performed by certified third parties. Facilities are also permitted to monitor methane concentration more frequently if equipment upgrades allow. In this monitoring period both Amarillo and Lexington used on-site gas analyzers.				
Calculation method:	NA				
Any comment:	NA				

Data Unit / Parameter:	PE _{ME}
Data unit:	mtCO ₂ e
Description:	Project Emissions associated with cover leakage due to major events
Source of data:	Tyson standard operating procedures for lagoon inspection and repair records
Description of measurement methods and procedures to be applied:	Calculated in accordance with Equations 4-10, 4-11 and 4-12.

Frequency of monitoring/recording:	Monitored as major events occur.
Value monitored:	0 for all facilities during the monitoring period
Monitoring equipment:	NA
QA/QC procedures to be applied:	Records are kept in biogas logbooks. Records are kept in biogas logbooks.
Calculation method:	Calculated in accordance with Equations 4-10, 4-11 and 4-12.
Any comment:	Records contain the following: Description of the event including size of tear or other feature, whether the cover maintained or lost its ability to retain biogas, whether the gas was drawn down completely before the event (only applicable to planned events), whether the wastewater flow was shut off to the lagoon, and how long the repair took.

Data Unit / Parameter:	$FV_{RG,m}$, F_{biogas}
Data unit:	ft^3
Description:	Monthly gross volume of biogas collected in the outlet of the covered lagoons
Source of data:	Calculated based on the sum of the biogas flared and the biogas sent to the boilers.
Description of measurement methods and procedures to be applied:	NA
Frequency of monitoring/recording:	Continuously monitored. Data aggregated into weekly and monthly totals.
Value monitored:	
Monitoring equipment:	Thermal Mass Flow Meter
QA/QC procedures to be applied:	Biogas flowmeters are calibrated by certified third parties on a quarterly basis or as recommended by manufacturer's specifications.
Calculation method:	$FV_{RGf,m} + FV_{RGb,m}$
Any comment:	NA

Data Unit / Parameter:	$FV_{RGf,m}$
Data unit:	ft^3
Description:	Monthly gross volume of biogas flared
Source of data:	Measured
Description of measurement methods and procedures to be applied:	Biogas flow is monitored continuously by an inline thermal mass flowmeter
Frequency of monitoring/recording:	Continuously monitored. Data aggregated into weekly and monthly totals.
Value monitored:	NA
Monitoring equipment:	Thermal Mass Flow Meter

QA/QC procedures to be applied:	Biogas flowmeters are calibrated by certified third parties on a quarterly basis or as recommended by manufacturer's specifications.
Calculation method:	NA
Any comment:	NA

Data Unit / Parameter:	$FV_{R\text{Gb},m}$
Data unit:	ft^3
Description:	Monthly gross volume of biogas utilized in on-site boilers
Source of data:	Measured
Description of measurement methods and procedures to be applied:	Biogas flow is monitored continuously by an inline thermal mass flowmeter
Frequency of monitoring/recording:	Continuously monitored. Data aggregated into weekly and monthly totals.
Value monitored:	NA
Monitoring equipment:	Thermal Mass Flow Meter
QA/QC procedures to be applied:	Biogas flowmeters are calibrated by certified third parties on a quarterly basis or as recommended by manufacturer's specifications.
Calculation method:	NA
Any comment:	NA

Data Unit / Parameter:	$TM_{R\text{Gf},m}$
Data unit:	lbs CH_4
Description:	Monthly total mass of methane combusted in the flare
Source of data:	Calculated based on gross monthly volume of biogas flared, volumetric fraction of methane in the biogas and the density of methane per equation 6-14.
Description of measurement methods and procedures to be applied:	NA
Frequency of monitoring/recording:	Continuously monitored. Data aggregated into weekly and monthly totals.
Value monitored:	NA
Monitoring equipment:	Thermal Mass Flow Meter
QA/QC procedures to be applied:	Biogas flowmeters are calibrated by certified third parties on a quarterly basis or as recommended by manufacturer's specifications.
Calculation method:	NA
Any comment:	NA

Data Unit / Parameter:	$EC_{P\text{J},m}$
------------------------	--------------------

Data unit:	MWh
Description:	Monthly electricity consumed by the project activity
Source of data:	Calculated based on load ratings for biogas blowers and H ₂ S scrubbing equipment and hours of operation for each
Description of measurement methods and procedures to be applied:	NA
Frequency of monitoring/recording:	Hours of operation continuously monitored on CEMS systems
Value monitored:	NA
Monitoring equipment:	CEMS System
QA/QC procedures to be applied:	CEMS systems self-calibrate daily and also receive annual calibration by certified third party.
Calculation method:	NA
Any comment:	Project activity not metered separately

Data Unit / Parameter:	$t_{f,m}$
Data unit:	hours
Description:	Monthly hours of operation of the blowers transporting biogas to the flare
Source of data:	Measured
Description of measurement methods and procedures to be applied:	Measured by CEMS system
Frequency of monitoring/recording:	Hours of operation continuously monitored on CEMS system. Data aggregated into weekly and monthly totals.
Value monitored:	NA
Monitoring equipment:	CEMS System
QA/QC procedures to be applied:	CEMS systems self-calibrate daily and also receive annual calibration by certified third party.
Calculation method:	NA
Any comment:	In some data sets, hours of boiler utilization ($t_{b,m}$) and flare time ($t_{f,m}$) are combined. In such cases, the load rating of the boiler blowers (L_b) is used for the entire time for conservativeness.

Data Unit / Parameter:	FC _{Propane}
Data unit:	Gallons
Description:	Annual quantity of propane used in the flares as pilot fuel
Source of data:	Measured
Description of measurement methods and procedures to be applied:	Purchase records by volume

Frequency of monitoring/recording:	Monthly	
Value monitored:	Propane Usage as Pilot Fuel (Jan-Dec 2012)	
	FC_Propane	gal
	Amarillo, TX	7,149
	Joslin, IL	6,700
	Lexington, NE	8,211
	Storm Lake, IA	7,400
Monitoring equipment:	Purchase Records	
QA/QC procedures to be applied:	NA	
Calculation method:	NA	
Any comment:	NA	

3.3 Description of the Monitoring Plan

3.3.1 Overview of Types of Data and Information

The BOD₅ test is a method of approximating the amount of dissolved oxygen utilized by microorganisms in the biochemical oxidation of organic matter. Biological oxidation is a slow process and theoretically takes an infinite amount of time to go to completion. The oxidation of carbonaceous organic matter is approximately 95 to 99 percent complete in 20 days. Wastewater treatment operations typically cannot wait 20 days for results of the BOD test so a shorter test is used. The BOD₅ test is used instead to receive results in a more timely fashion. The oxidation of organic matter is approximately 60 to 70 percent complete at the end of 5 days. The anaerobic biodegradation of organic matter does not utilize oxygen; however, approximations are made between the biogas generated and the value of the BOD₅ analysis. Historically, Tyson experiences carbonaceous BOD removal rates in the primary anaerobic lagoons in excess of 85%.

The estimation of greenhouse gas emission reductions relies heavily on data provided by Tyson. Tyson provides spreadsheets containing the flow rates and BOD concentrations of wastewater treated, volumes of biogas captured, flared and utilized, and hours of operation for all components requiring electricity consumption. This data is monitored in accordance with the parameters defined herein and is totaled in daily, weekly and monthly values. All data is stored on Continuous Emissions Monitoring System (CEMS) data collection systems at each location except for Amarillo, where totaled data is entered into collection spreadsheets manually.

Data is initially gathered by the wastewater treatment operators, who are trained and supervised by the wastewater superintendent. The data is then aggregated by the superintendent, where it is then formalized and forwarded to the Secretary of the Director of Fresh Meats EHS Operations. An inclusive report for all facilities is then distributed to operations management personnel within the Fresh Meats group. Included in this distribution group is Tyson Foods' New Technology Manager for the EHS Group, who then submits the data to Blue Source for integration into the emission reductions calculations.

All flowmeters (both wastewater and biogas) are calibrated and/or verified by certified third parties on a quarterly or annual basis, as recommended by the manufacturer's specifications. The CEMS systems self-calibrate daily and also undergo annual third party calibration by certified parties. At Amarillo, Tyson monitors gas composition of the biogas treated and flared with a Daniel "Danalyzer" BTU Chromatograph.

Readings on gas composition and heating value are generated continuously on the Intellution software and can be checked at any time during operation. A third-party gas analysis firm, performs tests at the other three facilities to determine the gas composition of the biogas being flared. In 2011 the Lexington facility also installed an Innova gas analyzer allowing it to increase the frequency of its gas chromatography and to perform this in house.

Tyson follows preventative maintenance procedures as recommended by equipment manufacturers for all monitoring equipment. During the quarterly calibration checks, in the event that a flowmeter were to be found to be out of spec, it would be repaired or replaced immediately.

3.3.2 Monitoring Methodologies

Tyson gathers several different types of data from multiple locations throughout the wastewater and biogas streams to ensure accurate and measurable emission reductions. Specific locations, data types and units are identified for Project Stages 1 and 2 in Figures 3-1 and 3-2, respectively.

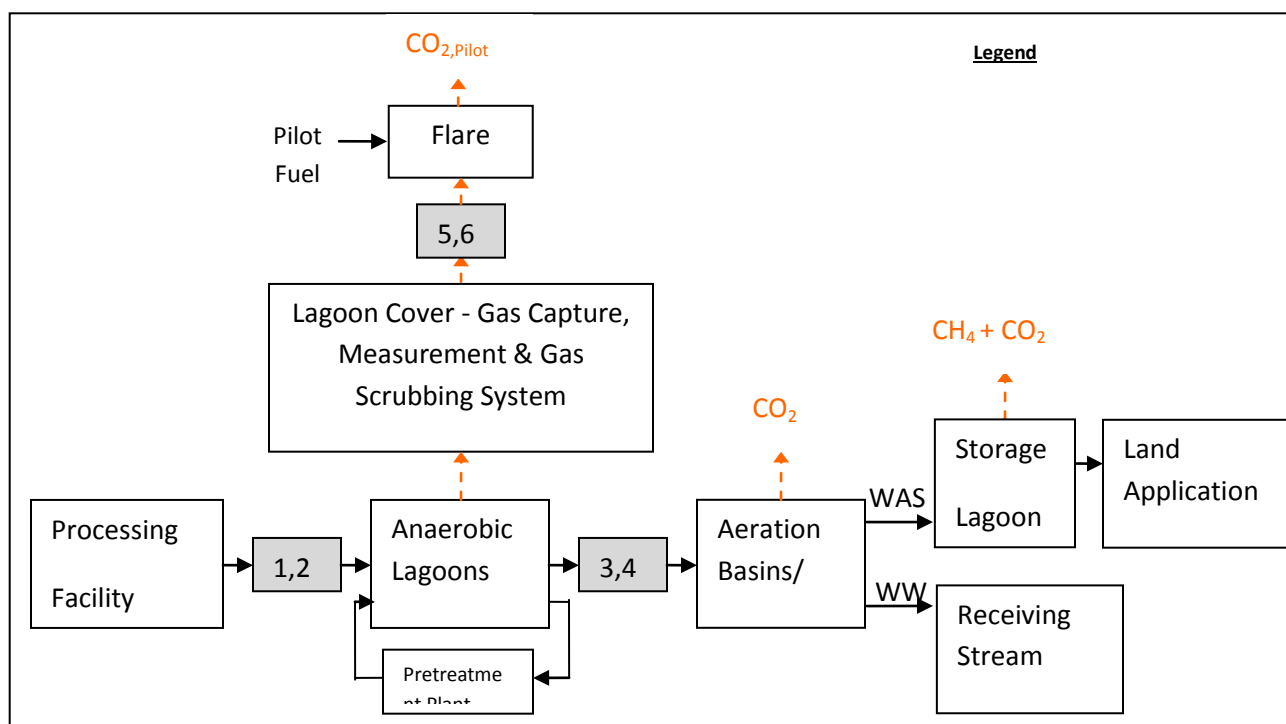


Figure 3-1: Process flow diagram and data monitoring locations after completion of Stage 1

The measured values and instrumentation shown in Figure 3-1 are as follows:

1. Wastewater effluent flow into the anaerobic lagoon (Mgal/d)
2. BOD concentration at inlet to the anaerobic lagoon (mg/l)
3. Wastewater effluent flow out of the anaerobic lagoon (Mgal/d)
4. BOD concentration at outlet of the anaerobic lagoon (mg/l)
5. Biogas CH₄ content (volumetric fraction)
6. Biogas flow rate to the flare (ft³/min)

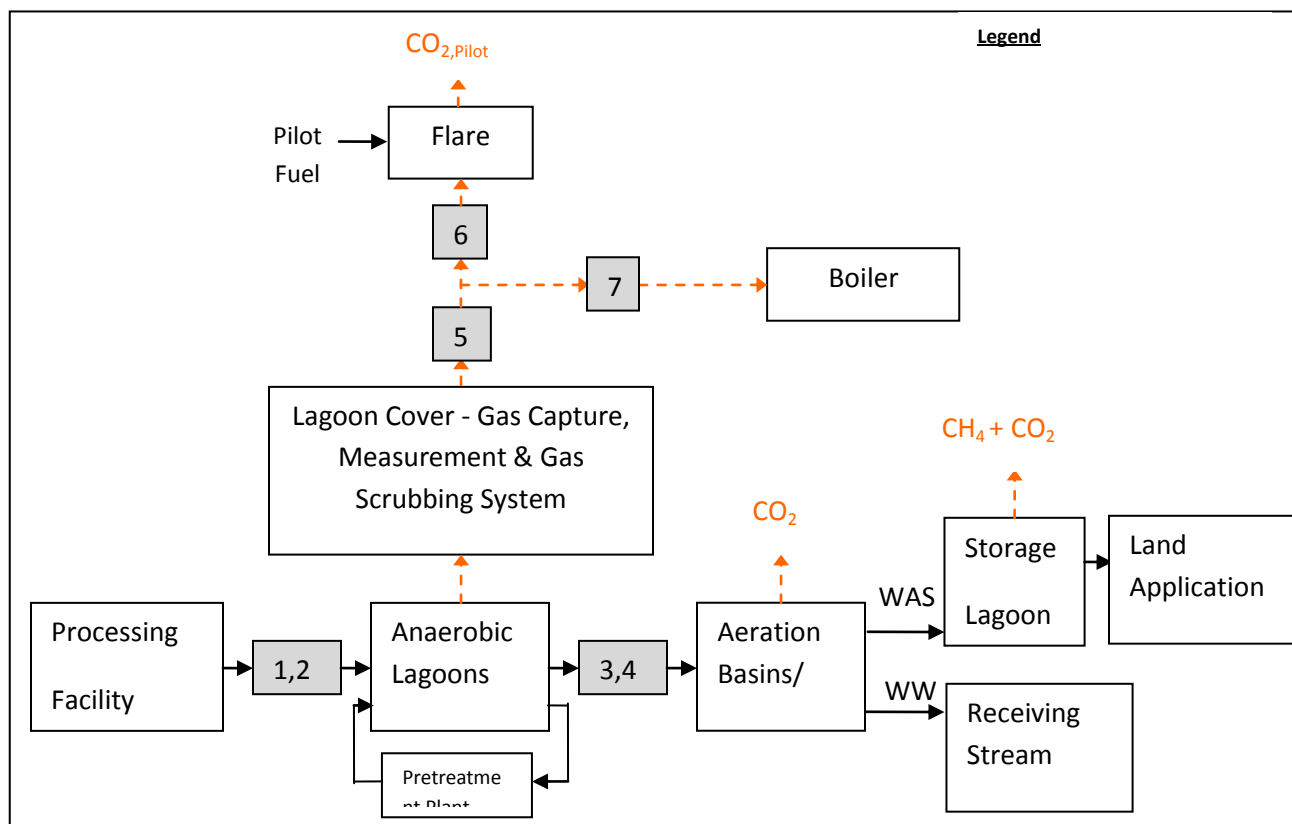


Figure 3-2: Process flow diagram and data monitoring locations after completion of Stage 2

The measured values shown in Figure 3-2 are as follows:

1. Wastewater effluent flow into the anaerobic lagoon (Mgal/d)
2. BOD concentration at inlet to the anaerobic lagoon (mg/l)
3. Wastewater effluent flow out of the anaerobic lagoon (Mgal/d)
4. BOD concentration at outlet of the anaerobic lagoon (mg/l)
5. Biogas CH_4 content (volumetric fraction)
6. Biogas flow rate to the flare (ft^3/min)
7. Biogas flow rate to the boiler (ft^3/min)

3.3.3 Special Notes for Monitoring Period

Per Section 3.3 – Monitoring Plan, all necessary checkpoints have been completed as described below.

3.3.3.1 Equipment Checks

L_f During the reporting period the Lexington facility added an additional 30 horse power, positive displacement, aeration blower to the biogas operational equipment list. In the past, the facility had always had one aeration blower running with one being used as a spare. Due to current operational parameters and operating conditions, the site is being forced to use both of the aeration blowers most of the time to keep the system operating properly. Therefore, an additional 30 hp has been added to the load ratings for the Lexington facility as if they are both used 100% of the time. L_f has been increased by 30 hp for Lexington.

All other facilities reported that no related equipment has been changed during the monitoring period.

L_b During the reporting period the Lexington facility added an additional 30 horse power, positive displacement, aeration blower to the biogas operational equipment list. In the past, the facility had always had one aeration blower running with one being used as a spare. Due to current operational parameters and operating conditions, the site is being forced to use both of the aeration blowers most of the time to keep the system operating properly. Therefore, an additional 30 hp has been added to the load ratings for the Lexington facility as if they are both used 100% of the time. L_b has been increased by 30 hp for Lexington.

All other facilities reported that no related equipment has been changed during the monitoring period.

L_{H2S} The load ratings of the H₂S scrubbing systems have not changed at any facility.

3.3.3.2 Major Events

PE_{ME} Major events that affected biogas leakage from the cover systems are catalogued below:

No abnormal leaks or repairs were reported for any site during the monitoring period.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

The net emission reductions are calculated using the following equations:

$$Net\ ERC = BE - PE \quad (4-1)$$

Where:

Net ERC = Net Emission Reduction Credit (expressed as metric tonnes CO₂e)
 BE = Baseline Emissions
 PE = Project Emissions

4.1 Baseline Emissions

$$BE = BE_{CH_4} + BE_{HG} \quad (4-2)$$

Where:

BE_{CH_4} = CH₄ emissions generated by the uncovered anaerobic lagoons (mtCO₂e)
 BE_{HG} = CO₂ emissions associated with fossil fuel combustion in the boilers that is displaced by the project (mtCO₂e)
 NOTE: Before Stage 2 of the project is implemented, baseline boiler emissions, BE_{HG} , are equal to the Project Emissions for the boiler, PE_{HG} . These values, therefore, negate one another and are not accounted for until Stage 2 is implemented.

4.1.1 Lagoon Baseline (BE_{CH_4}) Calculations

Baseline emissions from anaerobic treatment, BE_{CH_4} , are calculated using the organic removal ratio method, which expresses the fraction of COD degraded anaerobically in the uncovered lagoons less that which is decomposed aerobically, oxidatively or lost due to sedimentation within the lagoon.

$$BE_{CH_4} = \sum_{m=1}^{12} (COD_{BL,m} - COD_{Aer,m} - COD_{OX,m} - COD_{Sedim,m}) \times B_O \times \frac{21}{2204.62} \quad (4-3)$$

Where:

$COD_{BL,m}$ = Monthly Chemical Oxygen Demand that would be treated in the uncovered lagoons in the absence of the project activity (lbs COD/month)
 $COD_{Aer,m}$ = Monthly Chemical Oxygen Demand that would degrade aerobically in the lagoon (lbs COD/month)
 $COD_{OX,m}$ = Monthly Chemical Oxygen Demand that would be chemically oxidized through sulfate in the wastewater (lbs COD/month)
 $COD_{Sedim,m}$ = Monthly Chemical Oxygen Demand lost through sedimentation in the lagoon (lbs COD/month)
 B_O = Maximum methane producing capacity. The IPCC default value for B_O is 0.21 (lbs CH₄/lbs COD)
 NOTE: Despite IPCC recommendations of 0.25, the default value chosen by CDM ACM0014 is 0.21 (lbs CH₄/lbs COD)¹. Additionally, Tyson's standard operating procedure samples and reports BOD concentration instead of COD. Per the same IPCC recommendations, COD is calculated to be 2.4 times BOD.²
 21 = Global Warming Potential of Methane³
 2204.62 = lbs/mton

¹ UNFCCC CDM Methodology ACM0014 Version 01, page 22

² 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5 – Waste, Chapter 6 – Wastewater Treatment and Discharge, Page 6.12

³ IPCC, Climate Change 1995: The Science of Climate Change, 1996

$$COD_{BL,m} = COD_{PJ,m} = COD_{In,m} - COD_{Out,m} \quad (4-4)$$

Where:

$COD_{PJ,m}$ = Monthly Chemical Oxygen Demand treated in the covered anaerobic lagoon (lbs COD/month)
 NOTE: The project activity does not change the wastewater volume or COD loading directed toward the anaerobic lagoons. The baseline COD corresponds to the COD that is treated under the project activity.

$COD_{In,m}$ = Chemical Oxygen Demand entering the anaerobic lagoon (lbs COD/month)

$COD_{Out,m}$ = Chemical Oxygen Demand leaving the lagoon and entering secondary and tertiary processes (lbs COD/month)

$$COD_{Aer,m} = A \times f_{COD,aer} \quad (4-5)$$

Where:

A = Surface area of the uncovered lagoon (ft²)

$f_{COD,aer}$ = Quantity of Chemical Oxygen Demand degraded under aerobic conditions due to surface oxygenation (lbs COD/ft²/month)

$$COD_{OX,m} = F_{PJ,m} \times w_s \times R_s \times 2.4 \quad (4-6)$$

Where:

$F_{PJ,m}$ = Monthly quantity of wastewater treated in the digester (mgal)

w_s = Average concentration of chemically oxidative substance (Sulfate) present in the treated wastewater (mg/l). Sulfate is primarily sourced from deep freshwater wells. Sulfate values typically range from 250 mg/l to 375 mg/l as Sulfate (SO₄) (83 mg/l to 125 mg/l as Sulfur) in the influent to the anaerobic lagoons. An analysis of Sulfur mass balances at Tyson's lagoons indicates the average concentration of Sulfate in the influent to be 329 mg/l, with an average effluent concentration of 144 mg/l. This data yields an average Sulfate concentration available to reduce COD of 185 mg/l; however, for conservativeness, the highest average value reported of 231 mg/l SO₄ is used in the calculations.

R_s = Specific reduction in Chemical Oxygen Demand by Sulfate (lbs COD / lbs Sulfate). Engineering design information for calculations associated with loadings to activated sludge facilities that have relatively high soluble sulfide values use a factor of 2 lbs Oxygen for 1 pound of soluble Sulfide to convert to Sulfate. Engineering factors for oxidizing BOD are 1.5 pounds of oxygen to 1 pound of BOD. The reduction factor, R_s , is then given by $2/1.5 = 1.3333$ for oxidation of BOD by Sulfur-reducing bacteria in an anaerobic lagoon. It is then necessary to convert BOD to COD as described for Equation 4-3.

COD_{Sedim,m} Determination

In accordance with Appendix II of CDM Methodology ACM0014⁴, the first step in characterizing COD_{Sedim,m} is to determine the likelihood of any sedimentation actually taking place. Tyson's lagoons are highly anaerobically active, keeping all material that would sediment in a permanent state of suspension.

⁴ UNFCCC CDM Methodology ACM0014 Version 01, page 34

This material is then anaerobically degraded. The lost COD due to sedimentation, if any, can then be determined by any change of lagoon depth over time. Tyson's lagoons are designed not to have any accumulation of organic matter sedimentation, and as such, periodic depth measurements made by accessing the lagoons from various hatch points have not shown any change in depth of the lagoons over time. This is further verified by observations made during Tyson's periodic purging of the pipes and pumps at the bottom of the lagoons. The only accumulated material observed by Tyson has been sand, silt and other inorganic materials. Therefore, COD lost due to sedimentation, $COD_{Sedim,m}$, is determined to be zero.

4.1.2 Boiler Baseline (BE_{HG}) Calculations

$$BE_{HG} = \sum_{m=1}^{12} \frac{HG_{PJ,m} \times EF_{CO_2,FF,boiler}}{\eta_{boiler}} \quad (4-7)$$

Where:

$HG_{PJ,m}$ = Monthly thermal energy generated with biogas from the covered lagoon that displaces fossil fuel combustion (MMBtu)
 $EF_{CO_2,FF,boiler}$ = CO_2 emission factor for fossil fuel used in boiler = $0.05919 \text{ mtCO}_2/\text{MMBtu}^5$
 η_{boiler} = Efficiency of the boiler that would be used for heat generation in the absence of the project activity. While U.S. EPA and IPCC guidelines suggest values of 98%⁶ and 99.5%⁷ respectively, a value of 100% is conservative and is therefore used.

$$HG_{PJ,m} = FV_{Rg,b,m} \times fv_{CH_4} \times NCV_{CH_4} \div 1,000,000 \quad (4-8)$$

Where:

$FV_{Rg,b,m}$ = Gross monthly volume of biogas combusted in the boiler (ft^3)
 fv_{CH_4} = Volumetric fraction of methane in the biogas (%)
 NCV_{CH_4} = Net Caloric Value of Methane = 922.45 Btu/ft^3 ⁸
 $1,000,000$ = Btu/MMBtu

4.2 Project Emissions

Project emissions occur from lagoon cover leakage, flaring, electricity consumption in the gas collection and scrubbing systems and fossil fuel combustion. As described in Section 3.2 - Pre-Project Conditions, the project implementation has not resulted in any change in organic material loading or wastewater quantity directed to secondary and tertiary processes. Thus, project emissions from effluent entering these processes are identical to the equivalent baseline emissions. Project emissions are characterized by the following equation:

⁵ 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 – Energy, Chapter 1 – Introduction, Table 1.4. $56,100 \text{ kgCO}_2/\text{TJ}$ factor converted to $\text{mtCO}_2/\text{MMBtu}$.

⁶ United States Environmental Protection Agency, AP 42, Table 2.4-3

⁷ Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Module 1 Energy, Table 1-4

⁸ 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2 – Energy, Chapter 1 – Introduction, Page 1.2. 48.0 TJ/Gg factor converted to Btu/ft^3 .

$$PE = PE_{CH_4,digest} + PE_{Flare} + PE_{EC} + PE_{FC} \quad (4-9)$$

Where:

$PE_{CH_4,digest}$	= Physical biogas leakage from the lagoons' cover systems (mtCO ₂ e)
PE_{Flare}	= Emissions from flaring biogas generated in the lagoon (mtCO ₂ e)
PE_{EC}	= Indirect emissions associated with electricity consumption from the project activity (mtCO ₂ e)
PE_{FC}	= Emissions from fossil fuel combustion (mtCO ₂ e)

4.2.1 Physical leakage Calculations

Tyson employs rigorous inspection protocols to ensure that biogas leakage from the lagoon cover systems is minimized. All facilities inspect the covers daily (Joslin, IL, the one exception, inspects two to four times per week). Since Tyson uses both 80 and 100 mil thickness HDPE in its covers, it is very rare that leaks occur. Most facilities report only several leaks per year, with one facility even reporting no leaks in a 2-1/2 year time span. When leaks do occur, they are repaired immediately using special tape, which stops the leak until the cover contractor arrives to do a more permanent repair. Most leaks are reported as being slits less than 1 inch in length, but some facilities have reported slits up to 2 inches long.

In order to calculate a worst-case physical leakage scenario, Bernoulli's equation is used to estimate flow velocity across a rectangular tear measuring 0.25" x 2" (much larger than actual worst case tear sizing). The mass of leaking CH₄ is then calculated using the maximum volumetric fraction of methane in the biogas combined with the longest time a leak could go undetected. Bernoulli's equation states the following:

$$v = \sqrt{\frac{\Delta P}{\rho_{CH_4}}} \quad (4-10)$$

Where:

v	= Flow velocity (cm/sec)
ΔP	= Change in pressure (kg _f /cm ²). Pressure monitoring indicates that the maximum pressure under the covers rarely exceeds 0.1" H ₂ O. For conservativeness and uncertainty management, a value of 2" H ₂ O = 0.00508 kg _f /cm ² is used.
ρ_{CH_4}	= Density of methane at ambient conditions = 6.8 x 10 ⁻⁷ kg/cm ³

$$M = v \times a \times \rho_{CH_4} \times fv_{CH_4} \quad (4-11)$$

Where:

M	= Mass flow rate of Methane (kg/sec)
a	= Cross-sectional area of worst-case tear = 3.23 cm ²
fv_{CH_4}	= Volumetric fraction of methane in the biogas (%)

$$PE_{CH_4,digest} = M \times t_{detect} \times n_L \times 0.001 \times 21 + PE_{ME} \quad (4-12)$$

Where:

t_{detect}	= Maximum time that a leak would go undetected based on frequency of inspection at each site (sec). 1 day used for all sites except Joslin, which is 3.5 days.
n_L	= Maximum number of leaks reported in a given year = 5 leaks per year is used for conservativeness
PE_{ME}	= Project emissions associated with cover leakage due to major events (mtCO ₂ e). Occasionally, Tyson's facilities experience major events that result in additional leakage from the cover systems. Such events might include large tears, de-anchoring of the covers due to extreme winds, or a partial cover removal to unclog pipes. These major events typically only occur once every four to five years or less for any given site. When such an event does occur, wastewater flow to the digester is typically shut off immediately and the repair is made within a few days or less. For conservativeness, when such an event occurs, if the lagoon loses the ability to retain biogas, the methane production associated with one period of lagoon residence time is added to the project emissions for that month.

4.2.2 Flare Calculations

Project emissions due to flaring are calculated according to the CDM "Tool to Determine Project Emissions from Flaring Gases Containing Methane."⁹

$$PE_{\text{Flare}} = \sum_{m=1}^{12} TM_{RGf,m} \times (1 - \eta_{\text{Flare}}) \times \frac{21}{2204.62} \quad (4-13)$$

Where:

$TM_{RGf,m}$	= Monthly total mass of methane in the residual gas from the anaerobic lagoons combusted in the flare (lbs)
η_{Flare}	= Methane destruction efficiency of the flare

At each facility, Tyson operates Varec 244W waste gas burners able to achieve 99% combustion efficiency. Each site's minimum allowable flare efficiency was calculated for its respective air permit for the purposes of ensuring the destruction of any H₂S that might be present in the biogas. H₂S combustion efficiency is a requirement under the permits and cannot be obtained without first achieving the same destruction efficiency of CH₄, thereby guaranteeing equal or greater methane destruction efficiency.

Additionally, under permit, Tyson flares or utilizes 100% of the biogas collected, meaning there is no uncombusted gas vented at any time. Whenever there is downtime due to maintenance or other issues, biogas accumulates in the collection system until it can be flared or utilized once more. The flares come complete with an electronic sensor and controls package that verifies pilot operation and subsequent flare operation. The controls are electronically interlocked with the biogas blowers to ensure the blowers will automatically shut down in the event the sensors indicate the flare or pilot flame is not operating properly. There is also an alarm system linked with the flare that will contact facility operators in the event of system failure.

⁹ Equations 6-13 and 6-14 reference UNFCCC CDM Tool to Determine Project Emissions from Flaring Gases Containing Methane, pages 9 and 11

All flares are operated in accordance with the manufacturer's guidelines for maximum efficiency and meet the requirements of 40 CFR 60.18 and AP-42 2.4-3. These standards specify requirements for Btu content and exit velocity that must be met in order to achieve 99% flare efficiency. The minimum Btu content specified is 300 Btu/ft³ with a maximum exit velocity of 60 ft/sec. The minimum Btu content achieved by the Tyson biogas is 679 Btu/ft³, while the typical exit velocities average 47 ft/sec and never exceed 60 ft/sec. Although 99% flare efficiency is likely achieved at all sites as a result of the flare selection and operating procedures, the permitted efficiency values, which are checked and reported to regulatory bodies on a regular basis, have been used for conservativeness. The permitted flare efficiency for each site is shown in Section 4.2.

$$TM_{RGf,m} = FV_{RGf,m} \times fv_{CH4} \times \rho_{CH4} \quad (4-14)$$

Where:

$FV_{RGf,m}$ = Gross monthly volume of biogas flared (ft³)
 fv_{CH4} = Volumetric fraction of methane in the biogas (%)
 ρ_{CH4} = Density of methane at normal conditions = 0.0447 (lbs/ft³)

4.2.3 Electricity Calculations

Electricity consumption from the project activity includes electricity used by the blowers in the transport of gas to the flare and boiler as well as the H₂S scrubbing system. Project emissions associated with this consumption are calculated in accordance with the CDM "Tool to Calculate Project Emissions from Electricity Consumption – Case A."¹⁰

$$PE_{EC} = \sum_{m=1}^{12} EC_{PJ,m} \times EF_{grid} \times (1 + TDL) \div 2204.62 \quad (4-15)$$

Where:

$EC_{PJ,m}$ = Monthly electricity consumed by the project activity (MWh)
 EF_{grid} = Grid CO₂ emissions factor for electricity consumed at the project site (lbsCO₂/MWh)¹¹
 TDL = Average transmission and distribution losses in the grid = 7.2%¹²
 $EC_{PJ,m} = L_f \times t_{f,m} + L_b \times t_{b,m} + L_{H2S} \times t_{H2S,m}$ (4-16)

Where:

L_f = Load rating of the blowers used to transport biogas to the flare (MW)
 $t_{f,m}$ = Hours of operation of the blowers transporting biogas to the flare in month m
 L_b = Load rating of the blowers used to transport biogas to the boiler (MW)

¹⁰ Equation 6-15 references UNFCCC CDM Tool to Calculate Project Emissions from Electricity Consumption, page 2

¹¹ United States Environmental Protection Agency, eGRID2006 Version 2.1, 2004 Data

¹² United States Climate Change Technology Program, Technology Options for the Near and Long Term, Page 34

$t_{b,m}$	= Hours of operation of the blowers transporting biogas to the boiler in month m . NOTE: In some data sets, hours of boiler utilization ($t_{b,m}$) and flare time ($t_{f,m}$) are combined. In such cases, the load rating of the boiler blowers (L_b) is used for the entire time for conservativeness.
L_{H_2S}	= Load rating of the H_2S scrubber system (MW). Each site employs different types of H_2S scrubbing systems. A breakdown of equipment for each site can be found in Appendix A
$t_{H_2S,m}$	= Hours of operation of the H_2S scrubber system in month m

Load ratings are calculated based on the nameplate horsepower for each blower. Even though the blowers typically operate at approximately half load, electricity consumption is calculated based on full load for conservativeness. An example calculation for MW conversion for a 15 hp blower is shown below:

$$L = 15 \text{ hp} \times \left(\frac{0.746 \text{ kW}}{\text{hp}} \right) \times \left(\frac{1 \text{ MW}}{1000 \text{ kW}} \right) = 0.01119 \text{ MW} \quad (4-17)$$

4.2.4 Fossil Fuel Calculations

Pilot fuel used in the flares represents the sole fossil fuel emission from the project activity. In order to ensure safe and proper startup and operation of the flare, propane is used as a pilot fuel in the flares. Project emissions are calculated according to the CDM “Tool to Calculate Project or Leakage CO_2 Emissions from Fossil Fuel Combustion – Option B.”

$$PE_{FC} = FC_{Propane} \times EF_{Propane} \times f_p \quad (4-18)$$

Where:

$FC_{Propane}$	= Annual quantity of propane used in the flares as pilot fuel (gal)
$EF_{Propane}$	= Emission factor of propane = 0.00574 mt CO_2 e/gal NOTE: The CDM “Tool to Calculate Project or Leakage CO_2 Emissions from Fossil Fuel Combustion” recommends calculating emission coefficients based on IPCC factors; however, no such IPCC factors exist for Propane. As such, U.S. EPA factors are used instead. ¹³ It is possible to use the IPCC factors for Liquefied Petroleum Gas, a mixture of Propane and Butane, but the EPA factor used is higher and therefore more conservative.
f_p	= Uncertainty factor = 1. Propane usage data was previously only available for 2007, so an Uncertainty factor of 2 was used in the first monitoring period because of the unavailability of the data. As part of the monitoring plan, Tyson agreed to record Propane usage monthly going forward. For 2008, actual purchase records were provided showing the exact amount of propane used at each site, thus the Uncertainty factor has been lowered to 1.

$$EF_{Propane} = w_{C,Propane} \times EC_{Propane} \times 44/12 \div 42 \div 1000 \quad (4-19)$$

Where:

$w_{C,Propane}$	= Carbon content of Propane per unit energy = 17.20 kgC/MMBtu
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¹³ U.S. EPA, Inventory of Greenhouse Gas Emissions and Sinks: 1990 – 2005 (2007), Annex 2.1, Table A-40

EC_{Propane} = Energy Content of Propane per volume = 3.824 MMBtu/Barrel
 44/12 = Molar mass ratio of Carbon Dioxide, CO₂, to Carbon, C.
 42 = Gallons/Barrel
 1000 = kg/mt

4.3 Leakage

The project activity is not known to create any leakage emissions.

4.4 Summary of GHG Emission Reductions and Removals

Calculated emission reductions by facility for the crediting period are shown in Table 4-1.

Table 4-1 Breakdown of Baseline Emissions, Project Emissions, and Emission Reductions by Facility for January 1, 2012 – December 31, 2012

Jan-Dec 2012	Net ERC	BE	PE
Amarillo	98,126	102,350.10	4,223.66
Joslin	36,970	39,208.43	2,238.77
Lexington	105,829	108,837.89	3,008.99
Storm Lake	31,594	33,396.68	1,802.68
TOTAL	272,519	283,793.09	11,274.10

5 ADDITIONAL INFORMATION

H₂S Scrubbing Equipment List and Power Ratings by Facility

Amarillo H ₂ S Scrubbing System Components	Load Rating (hp)	# of Units in Operation
Press Wash Pump	7.5	1
Scrubber Feed Pump	15	1
Air Blower	25	2
Regen Feed Pump	15	1
Air Compressor	20	1
Condensate Pump	3	1
Larox press	20	1
Water pump on Larox	7.5	1
Outside sump	7.5	1
Roof exhaust	1.5	1
Air handling Unit	3	1

Total hp	150
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Joslin H2S Scrubbing System Components	Load Rating (hp)	# of Units in Operation
Regen feed pump	10	1
Filter Feed pump	15	1
Scrubber feed pump	10	1
Air Compressor	20	1
Make-up air unit	1.5	2
Blower room ex fan	0.75	1
Regenerated air blower	30	1
Electric Unit heaters	0.25	6
Water booster pump	7.5	1
Larox press Hyd pump	20	1
Larox press H2O pump	5	1
Roof exhaust	1.5	1
Air handling Unit	3	1
Total hp	127	

Lexington H2S Scrubbing System Components	Load Rating (hp)	# of Units in Operation
Scrubber Feed Pump	15	1
Reactor Feed Pump	15	1
PD Aeration Blowers	30	1
PD Fuelgas Blower	75	1
Centrifugal Biogas Blower	15	1
Air Compressor	20	1
Well Water Pump	7.5	1
Roof Exhaust	1.5	1
Air Handling Unit	6	1
Fuelgas Chiller Refrigeration Unit	1	1
Condensate Pot Pump	0.75	2
Lift Station Sump Pump	1.6	1
Total hp	189	

Storm Lake H2S Scrubbing System Components	Load Rating (hp)	# of Units in Operation
Bio-Gas blowers	7.5	1
Reactor feed pumps	15	1
scrubber feed pumps	15	1
condensate pumps	0.25	2

PD blowers	20	1
air compressor	20	1
recycle pumps	15	1
filtrate pumps	10	1
Pressure pumps	7.5	1
press(bio-gas larox)	20	1
press(bio-gas larox)	5	1
Roof exhaust	1.5	1
Air handling Unit	3	1
Total hp	140	