KENT COUNTY REGIONAL RESOURCE RECOVERY FACILITY

2017 GREENHOUSE GAS (GHG) EMISSION INVENTORY

FEBRUARY 2018

INTRODUCTION

Greenhouse gases (GHG) are believed to contribute to the global warming phenomenon that is placing the Earth in jeopardy. There are a variety of gases which emitted into the atmosphere are thought to cause the greenhouse effect. GHGs of concern are: carbon dioxide, methane, nitrous oxide and fluorinated gases. Carbon dioxide is used as the baseline gas and the other three gases are translated in carbon dioxide equivalents. Each of the gases has a different global warming potential. Methane has twenty times more potential than carbon dioxide, nitrous oxide has 300 times more potential and fluorinated gases have several thousand times more potential. The one redeeming fact for these other gases is that they are released in significantly less quantities than carbon dioxide.

Under most of sustainability reporting protocols, GHGs are reported in one of three categories defined as Scope 1, Scope 2, and Scope 3. Scope 1 gases are those gases emitted from direct operations at the facility, such as burning fuels to operate heavy equipment used on site, burning fuels on site to operate machinery and fugitive emissions that occur on the site. Scope 2 emissions are those directly related to the use of electricity at the facility, where electricity is not generated at the site. Scope 3 includes all other emissions, such as those used to manufacture chemicals used at the facility, the transportation of the chemicals from the manufacturing facility to the treatment plant, and employee commuting.

This report presents a GHG emission inventory covering the years 2008-2011. It further discusses the inventory rationale and results, details how the emissions were calculated, and provides information on areas where changes have been made or are expected to be made from the baseline year of 2008 in order to reduce GHG emissions at the Kent County Regional Resource Recovery Facility (KCRRRF).

The KCRRRF treats wastewater and solids in a variety of processes. The wastewater is first treated with influent screens to remove large items, hair, etc. They require electricity to operate. The wastewater then flows by gravity through grit chambers to remove sand, gravel, etc. The grit chambers operate based on gravity and centrifugal force, but require electricity to operate the augers that remove the grit to the dumpsters. The water then flows by gravity through two 10 million gallon basins where air is added to support biological treatment of the wastewater. Two to three 500 hp blowers add air to the basins and provide mixing in the basin. The blowers are the largest users of electricity at the treatment plant. Ferric chloride is added to the basins to promote phosphorous removal. The treated wastewater is then treated in one of four clarifiers. The clarifiers use electricity to operate the scraper arms. In 2008, the wastewater was then disinfected using chlorine gas stored in 1 ton cylinders. Sulfur dioxide gas was added to ensure that no free chlorine was discharged to nearby waters. In 2010, the chlorine gas/sulfur dioxide gas system was replaced using an innovative microwave based, ultraviolet (UV) disinfection system. The UV system requires electricity to operate. In 2016 a new sand filter was added to the facility to remove additional solids and nitrogen. An additional 2 clarifiers were also added to allow the KCRRRF to treat up to 20 MGD. The addition of the sand filter has resulted in a much cleaner effluent being discharged to the Murderkill

River; however, because the sand filter requires that the wastewater be pumped about 30 feet above ground surface, additional electricity is needed.

The solids obtained from the clarifiers are either returned to the treatment basins (~90%), or wasted (~10%) and sent to the biosolids treatment system. In the biosolids treatment system, the 1-2% solids content biosolids stream has ferric chloride, anionic and/or cationic polymers added to it to improve dewatering. It is then dewatered using one of three belt filter presses to 18-20% solids content. Lime is added to raise the pH to above 12 to kill pathogens that are in the biosolids. The resulting mixture is then sent to one of two indirect thermal dryers and then on to a third dryer to increase the solids content to around 50%. The final biosolids product, referred to as Kentorganite, is then transported to local farms where it is applied as a soil amendment. The filter presses, conveyors and dryers all use electricity. The dryers use a heat transfer fluid (Dowtherm Q) which is heated by one of two natural gas fired boilers. The thermal fluid is pumped throughout the system using electricity. The Kentorganite is transported and spread using vehicles powered by diesel fuel. A passive solar biosolids drying facility that can treat about 15-20% of the biosolids generated by the facility came on line in August 2011. The passive system consists of three greenhouses and a solar driven floor heating system. There are intentions to expand this operation to treat all of the biosolids generated by the facility by 2017. This change will eliminate the majority of the natural gas usage and lime added and reduce further greenhouse gas emissions due to the biosolids operations.

Additional on site sources of electricity include emergency generators that are either powered by diesel fuel or B20 biodiesel and most recently a 1.2 MW photovoltaic solar farm that began operation in February 2011.

GHGs RELEASED AT THE KCRRRF

The KCRRRF has GHG emissions from all three scope levels. Table 1 presents a list of the GHG emissions from operations at the KCRRRF by scope.

Table 1. Types of GHG Emissions at KCRRRF

Scope 1	Scope 2	Scope 3
Burning of natural gas in the biosolids dryers	Electricity purchased from the DE Electric Cooperative for KCRRRF operations	Chlorine manufacture and transportation replaced by the UV system im 2010)
Diesel fuel use for maintenance trucks, plant trucks, agricultural operations and emergency generators		Sulfur Dioxide manufacture and transportation (replaced by the UV system in 2010)
Gasoline use at KCRRRF for lawn mowing and other similar equipment		Lime manufacture and transportation (used in the biosolids treatment system)

		Ferric Chloride manufacture and transportation (used for both wastewater and biosolids treatment)
		Polymer manufacture and transportation (used for biosolids treatment)

GHG EMISSION FACTORS AND RATIONALE

Once the types of GHG emissions have been identified, it is necessary to determine the actual emission factors for each of them. The following discussion is based on a number of sources. Chlorine, sulfur dioxide, electricity and gasoline emission factors were based upon Internet searches and engineering calculations and are detailed below. GHG emission factors for diesel fuel, polymer, lime and ferric chloride were based upon information contained in a paper titled, "A Greenhouse Gas Emissions Accounting Model for Biosolids Management Planning," by Mark Gould, Richard Tsang and Ravi Tej Bandi, presented at the 2008 NC AWWA-WEF Annual Conference. Table 2 provides a summary of the factors presented in the referenced paper. In addition to the manufacturing estimates, GHG emissions associated with transporting the major manufactured products including chlorine, sulfur dioxide, ferric chloride, lime and polymers from the manufacturer's warehouse to the KCRRRF were calculated and based on the distance traveled and estimated vehicle mileage of 10 miles per gallon.

Table 2. GHG Emission Factors for Biosolids Operations

Resource	**Units**	**GHG Factors**
Diesel fuel	Gallons	0.0119
Natural gas	1000 cubic ft (mcft)	0.0603
Polymer manufacture	Tons	1.69
Lime manufacture	Tons	0.364
Ferric Chloride manufacture	Tons	0.48

Chlorine Emission Factor

The major resource needed to manufacture chlorine from sodium chloride is electricity. Based upon an Internet search, about 3.4 Mw of electricity is required to manufacture 1 metric ton of chlorine gas. Based upon conversions and other engineering calculations, 2.4 pounds of GHGs are emitted for every pound of chlorine manufactured.

Sulfur Dioxide Factor

Sulfur dioxide manufacture is heavily dependent on electricity. Sulfur dioxide is primarily the product of electric production at power plants. Based on an Internet search, about $3.5x10^9$ kwh of electricity will produce 10,000 tons of sulfur dioxide. Based upon conversions and other engineering calculations, 277 pounds of GHG are emitted for every pound of sulfur dioxide manufactured.

Electricity Emission Factor

A search of the US EPA's GHG web pages provides details of an emission factor for electricity based upon the specific region in which the electricity is produced. Reviewing the EPA information, 0.00069 tons of GHG are emitted per kilowatt hour of electricity produced.

Gasoline Emission Factor

The primary gasoline usage at the KCRRRF under Scope 1 is for lawn maintenance. Lawn mowers emit considerably more GHGs than automobiles. A search of relevant Internet sites, including the US EPA's web pages for lawn mowing operations, indicates that a GHG emission factor of 0.009 tons per gallon of gasoline expended is appropriate.

GHG EMISSION CONSIDERATIONS AT KCRRRF

The following discussion will present the rationale for estimating the GHG emissions associated with the various KCRRRF activities and are presented by scope.

Scope 1 Estimation

As presented in Table 1, Scope 1 activities included burning natural gas to support the biosolids dryers, burning diesel fuel to cover the various diesel fueled vehicles operated by the KCRRRF and the emergency generators, and burning gasoline to support lawn maintenance activities.

Natural Gas Usage

Daily natural gas meter readings have been kept for several years. Monthly estimates were made and have been imported into the US EPA's Energy Star Portfolio Manager System. The readings were then summed over the course of each of the years, 2008 through 2017. The yearly totals were then entered into the GHG Spreadsheet. The passive biosolids dryer will use an innovative solar heating system to heat the floor of the passive solar greenhouses. The solar heating system is supplemented by natural gas boilers to maintain the water temperature during nights and on cloudy days. This will replace the indirect dryers currently used to dry the biosolids. A reduction in natural gas usage has occurred as a result of the addition of the passive solar dryers, which began operation in August 2011.

Diesel Fuel Usage

Diesel fuel is used for the emergency generators located at the KCRRRF, to fuel maintenance vehicles that support the pump station and other off-site maintenance activities, and to fuel the tanker trucks and heavy equipment operated by the Agricultural Operations Section. Diesel fuel for use on site is stored in a 1,000 gallon aboveground storage tank. This tank is periodically filled. Records of filling of the tank were reviewed and an assumption was made, that the amount added at each filling was the amount used between fillings. These values were then estimated on a yearly basis for 2008 through 2017. The yearly totals were then entered into the GHG spreadsheet.

Gasoline Usage

Gasoline for use on site is stored in a 1,000 gallon aboveground storage tank. This tank is periodically filled. Records of filling of the tank were reviewed and an assumption was made, that the amount added at each filling was the amount used between fillings. These values were then estimated on a yearly basis for 2008 through 2017. The yearly totals were then entered into the GHG spreadsheet.

Scope 2 Estimates

Electricity Usage

Electricity is provided by the Delaware Electric Cooperative (DECO). A request was made to the cooperative for monthly totals. Monthly totals were imported into the US EPA's Energy Star Portfolio Manager System. The readings were then summed over the course of each of the years, 2008 through 2017. The yearly totals were then entered into the GHG Spreadsheet. Beginning in April 2011, the 1.2 MW photovoltaic solar farm has come on line and electric usage is lower for subsequent years, with the solar farm generating approximately 7.5 gigawatt hours since its startup in 2011. The solar farm accounts for approximately 15% of the yearly electricity being used at the plant. The solar energy is not included in the GHG estimates. The majority of the electric usage is required by the basin aeration system, which consists of five 500 hp blowers of which 2-3 are used at any one time. A detailed study of the aeration system was comleted and new project to replace the older centrifugal blowers with energy efficient turbo blowers is underway.

Scope 3 Estimates

For the KCRRRF, Scope 3 emissions cover the manufacture and transportation of chemicals used as an integral part of the wastewater treatment process. Scope 3 chemicals covered by this inventory include: chlorine, sulfur dioxide, ferric chloride, lime and polymers. Chlorine and sulfur dioxide have been used since the 1970's to disinfect the wastewater. In October 2010, chlorine and sulfur dioxide were removed from the site as an innovative ultraviolet (UV) disinfection system became operational. Lime, ferric chloride and polymers are directly used to treat the biosolids to make the product Kentorganite. In addition, ferric chloride is added to the wastewater basins to treat and remove phosphorous from the wastewater stream. This section looks at the rationale for estimating each of the various Scope 3 resources covered under this inventory.

Chlorine

Until October 2010, chlorine gas, stored in 1 ton cylinders, was the means of disinfecting the wastewater before discharging it into the Murderkill River. For the monthly NPDES Discharge Monitoring Report (DMR), daily chlorine usage was recorded in pounds. The DMR spreadsheet was reviewed and yearly totals were determined in order to derive the 2008, 2009, and 2010 totals. The yearly totals were then entered into the GHG Spreadsheet. Transportation emission estimates were based on the transportation of 4 cylinders per truck traveling from Middletown, Pa (approximately 130 miles, based on a Mapquest search) with each cylinder containing 2,000 pounds of chlorine gas. No chlorine gas has been used since 2010

Sulfur Dioxide

Until October 2010, sulfur dioxide gas, stored in 1 ton cylinders, was the means of reacting out the residual chlorine in the wastewater before discharging it into the Murderkill River. For the monthly NPDES Discharge Monitoring Report (DMR), daily sulfur dioxide usage was recorded in pounds. The DMR spreadsheet was reviewed and yearly totals were determined to derive the 2008, 2009, and 2010 totals. No sulfur dioxide has been used since 2010. The yearly totals were then entered into the GHG Spreadsheet. Transportation emission estimates were based on the transportation of 4 cylinders per truck traveling from Middletown, Pa (approximately 130 miles, based on a Mapquest search) with each cylinder containing 2,000 pounds of sulfur dioxide gas.

Lime

Lime is used to assist with the treatment of biosolids by raising the ph of the filter pressed biosolids to above 12. There is no recording of lime usage; therefore estimates of usage were based on the number of shipments of lime to the KCRRRF. Each shipment was assumed to have unloaded 25 tons of lime. The number of shipments for each year was determined based upon current shipment records and it was further assumed that each shipment was fully consumed in the year it was received. The 2008 through 2017 totals were entered into the GHG Spreadsheet and then the GHG emissions were estimated using the emission factor found in Table 2. The transportation emissions were based on the lime coming either from Morgantown, WV (2009-2012, 293 miles) or Strasburg, VA (2008-2009, 194 miles).

Ferric Chloride

Ferric chloride is used to either condition the biosolids prior to the belt filter presses or added to the wastewater basins to promote the treatment of phosphorous. There is no recording of ferric chloride usage; therefore estimates of usage were based on the number of shipments of ferric chloride to the KCRRRF. Each shipment was assumed to have unloaded 4,000 gallons of ferric chloride. The gallons were then converted to pounds based on the product density data provided in the ferric chloride MSDS. The number of shipments for each year was determined based upon current shipment records and it was further assumed that each shipment was fully consumed in the year it was received. The 2008 through 2017 totals were entered into the GHG Spreadsheet and then the GHG emissions were estimated using the emission factor found in Table 2. The transportation emissions were based on the ferric chloride coming Edgemoor, PA (335 miles). The travel distance was based on a Mapquest search.

Polymers

Various polymers are used to condition the biosolids prior to the belt filter presses. There is no recording of polymer usage; therefore estimates were made based on the number of shipments of polymers to the KCRRRF. Each shipment was assumed to consist of 6 pallets 50, 40-pound bags weighing a total of 12,000 pounds of polymers.

The pounds were converted to tons. In the past three years, polymers have been provided by three different vendors. The number of shipments for each year was determined based upon current shipment records and it was further assumed that each shipment was fully consumed in the year it was received. The 2008 through 2017 totals were entered into the GHG Spreadsheet and then the GHG emissions were estimated using the emission factor found in Table 2. The transportation emissions were based on the majority of the polymers coming from Baltimore, MD (90 miles). The travel distance was based on a Mapquest search.

GHG INVENTORY SUMMARY

This section of the report presents a discussion of the GHG inventory for 2008 through 2017 and provides a discussion of the results. Table 3 presents the historic GHG emissions from 2008 through 2017. There was a marked reduction with the elimination of chlorine and sulfur dioxide by the UV system. GHG emissions from electricity werr reduced when the photovoltaic solar system began operation in 2011. GHG emissions increased in 2016 when the sand filter came on line.

Charts that cover GHG emissions by ton and per million gallon treated are included as Figures 1 and 2. The results for the years prior to 2017 were discussed in detail and in previous reports. This report presents a detailed discussion only of the 2017 GHG emissions.

Table 3: GHG Emissions 2008-2017

Year	Tons	Tons/MG
2008	22393	5.52
2009	26208	5.87
2010	25534	4.95
2011	10907	2.48
2012	11329	2.71
2013	9585	2.09
2014	10674	2.19
2015	8916	1.94
2016	12035	2.6
2017	12399	2.77

2017 GHG Emissions

Several operations had an effect on GHG emissions during 2017. The use of electricity continued to remain high due to the use of the sand filter system. However, electricity was reduced when the plant was forced to operate on one basin due to issues related to a basin liner. A workshop was held in July 2017 sponsored by the US Department of Energy's Better Plants program which did suggest operating on one basin and the value of this is reflected in reduced electricity use. The facility also replaced old air diffuser in the operating basin with a more energy efficient design. Biosolids operations have struggled with GHG issues because of the age of the equipment being used, specifically the dryers, and with an excessive level of solids in the plant influent during the summer and early fall. The excessive solids level affected the use of natural gas, polymer, ferric chloride and lime.

Figure 1. GHG Emissions in Tons

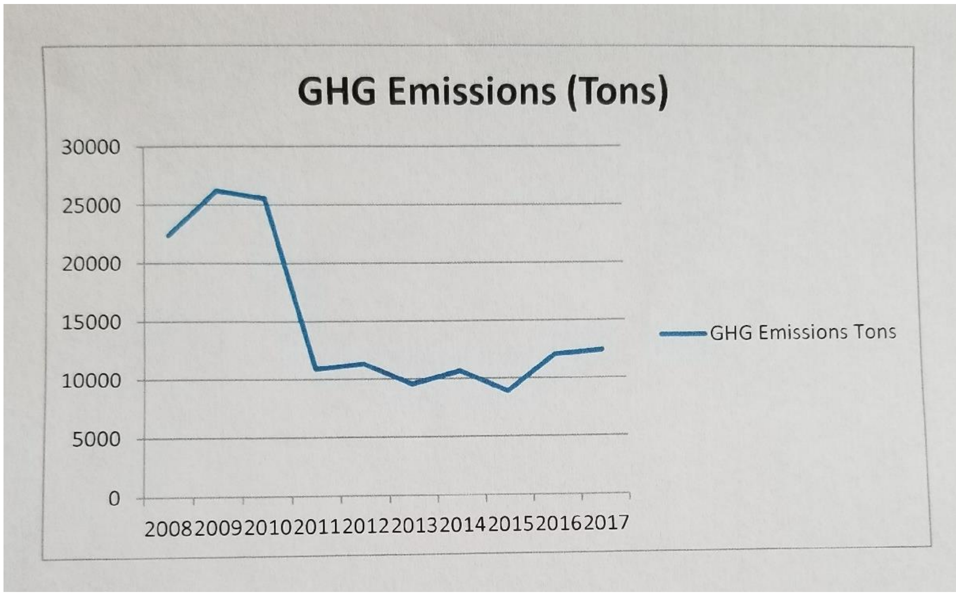
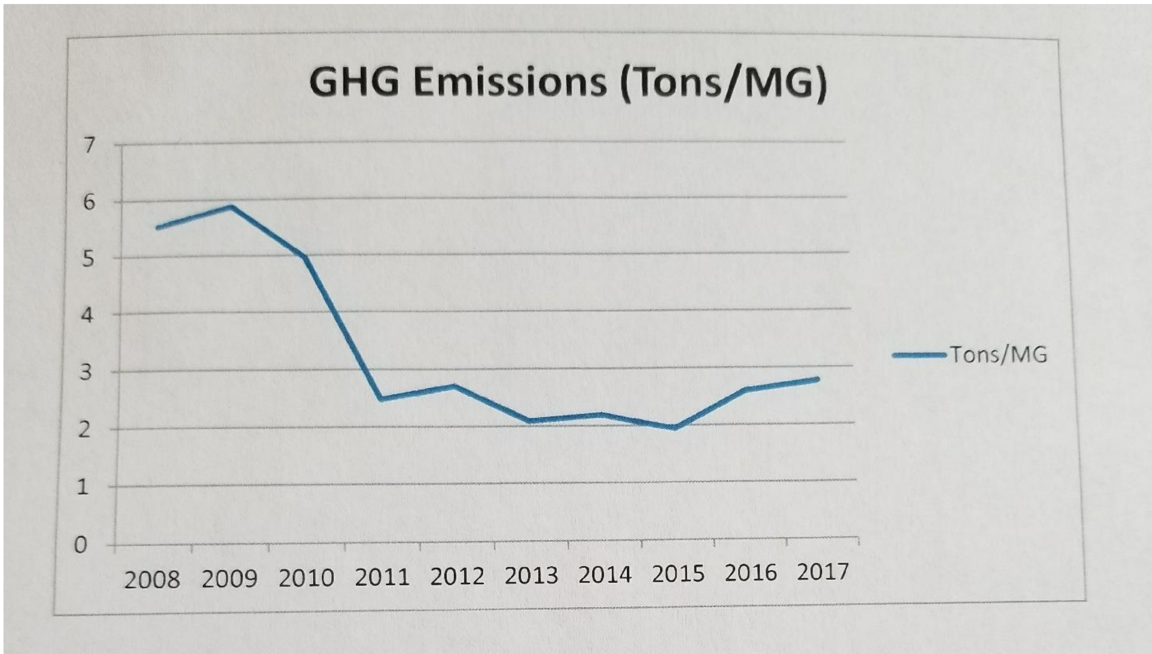


Figure 2. GHG Emissions per Million Gallons Treated



Future GHG Emissions

Electricity usage will be reduced because of the turbo aeration blower project which is expected to be implemented in the coming years. Natural gas emissions will be reduced as the current biosolids drying system will be replaced with a more energy efficient system within the next several years.