Technical Appendix

Biosolids generated by wastewater treatment facilities pose significant environmental challenges, specifically those directed towards landfills or land application for final disposal. In response, the Kissimmee, Orlando, Sanford Metropolitan Statistical Area (KOS MSA) proposes a strategic public-private partnership aimed at maximizing resource utilization and minimizing environmental impact. The KOS MSA aims to capture methane gas from biosolids and convert it into Renewable Natural Gas (RNG) through well-established anaerobic digestion technology. This RNG will be seamlessly integrated into the natural gas pipeline and utilized as compressed natural gas (CNG) for government fleet vehicles or for use by the local municipal power provider to offset demand for non-renewable gas for power production. The revenue generated from the sale of RNG and associated Renewable Identification Number (RIN) credits will be shared among the participating jurisdictions within the MSA.

Moreover, an innovative Super Critical Water Oxidation (SCWO) process will be utilized to address contaminants such as per- and polyfluoroalkyl substances (knows as PFAS) in the residual digested solids concurrently generating clean steam power. Through the SCWO process, PFAS chemicals are destroyed and biosolids are rendered an inert solid with less than 30% of their initial volume remaining to be land applied or directed to landfills. The additional energy generated will provide energy to operate the treatment plant.

In addition to biosolids treatment, Seminole County proposes to add a geo-membrane cap at the Seminole County Landfill to improve the collection efficiency of the current methane collection system and reduce fugitive methane emissions from the landfill. The landfill gas system currently extracts landfill gas from the disposal area and delivers it to an on-site gas to power generation plant that is used to produce electricity by a private third-party operator. A flare system operates to mitigate emissions when plant is not operating. Analysis completed by Seminole County's contractor S2L*i*, with subcontractor Sullivan Environmental, indicates that historically approximately 50% of the available landfill gas (primarily methane and CO_2) is captured by the system, with reduced effectiveness to approximately 28% in 2023.

The greenhouse gas (GHG) emissions accounting for the current treatment of biosolids, referred to as the business as usual (BAU) case, includes emissions from the transportation of the biosolids to the landfills and the long-term emissions associated with the landfilling of the biosolids as they degrade. Estimated fugitive emissions and emissions from the landfill gas to electricity and flaring system from the Seminole County Landfill were also included as part of the BAU estimate.

Estimates of GHG emissions associated with the proposed biosolids treatment plant include emissions associated with each process at the facility, as well as upstream emissions associated with transportation of biosolids and downstream emissions associated with the final landfilling/land application of treated inert solids. The proposed facility includes an anaerobic digestion (AD) plant, gas upgrading for the biogas (methane) offtake from the digestors, carbon dioxide (CO_2) liquification process, and SCWO process for final remediation of biosolids. Emissions associated with the proposed facility are a result of the initial construction of the plant, limited fugitive methane and CO_2 emissions from the anaerobic digestion and SWCO processes, flared methane during plant downtime, heating for startup and of SWCO process, and scope 2 emissions from plant energy usage from the grid. In addition, biosolids transportation will still be required to the plant and to the final disposal location; however, it is proposed that the CNG trucks be utilized for this rather than current diesel vehicles.

Emissions associated with the operation of the landfill gas to power generation plant at the Seminole County Landfill, based on improved collection of methane associated with the installation of the geo-membrane were also calculated.

Data for each component of the analysis were sourced from relevant project partners. Emissions intensity factors for transportation and landfilling of sludge were calculated using the Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) model and Biosolids Emissions Assessment Model (BEAM), respectively. AFLEET is published by the Argonne National Lab and uses emissions factors from the EPA Motor Vehicles Emission Simulator (MOVES) model as well as other sources through ANL's Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) tool. Landfill gas generation estimates were previously prepared by S2L*i* (and their subcontractor Sullivan Environmental) using USEPAs LandGEM Model. Data sources are tabulated below:

Table 1: Data Sources

Data	Source
Biosolids treatment requirements (initial) in wet tons/day	Seminole County, City of Orlando, Toho, and City of Altamonte Springs
Primary Biosolids Treatment Methods	Seminole County, City of Orlando, Toho, and City of Altamonte Springs
Growth factors for biosolids treatment	*Regional Biosolids Study*, July 2023
Emissions modeling – landfilling	BEAM
Emissions modeling – land application	IPCC Protocol
Emissions modeling – transportation	AFLEET
Seminole County Landfill; landfill gas generation estimates through 2061	LandGEM model
Global Warming Potential	2013 IPCC AR5 Fifth Assessment Report

<u>Business As Usual (BAU) Case</u>

The BAU case assumes that secondary sludge is transported directly by class 8 diesel tractor-trailers from each WWTP (wastewater treatment plant) to its disposal location, either land applied, landfilled, or composted. GHG emission estimates for biosolids disposal are calculated using a combination of approaches. Based on projection data in the latest *Regional Biosolids Study* (Tetra Tech, 2023) for the central Florida region, annual biosolid productions for 11 facilities within 4 jurisdictions were projected to 2050. The projections were further adjusted using the latest 2023 biosolids quantity reported by each jurisdiction (**Table 2**). After the SCWO process, the weight of biosolids is expected to be substantially reduced. Based on field data provided by project partner 374Water, 99.99%, 95%, and 5% destruction efficiency for organic contents, nitrogen, and phosphorus contents, respectively, and 95 weight reduction of biosolids after final biosolids SCWO treatment process, were used for the analysis.

Different stabilization and disposal approaches are utilized by these facilities (**Table 2**). For example, among three Water Reclamation Facility (WRF) facilities operated by the City of Orlando, only biosolids generated by Water Conserv II WRF are stabilized using lime but not the other two. Among all 11 facilities, biosolids are disposed with a combination of landfill, land application and composting.

For landfill disposed and composted biosolids, the BEAM (version 2022v2) (NEBRA, 2022) was applied separately for each facility to estimate temporally varying methane emissions. Numerous life cycle assessments (LCA) studies have been performed in the past to quantify the GHG emissions of various biosolids disposal approaches including but not limited to landfill disposal, land application, composting, incineration and cement manufacturing (Murray et al., 2008; Peters and Rowley, 2009; Brown et al., 2010; Yoshida et al., 2013; Yang et al., 2015; Alvarez-Gaitan et al., 2016). However, estimates of GHG emissions vary drastically among past studies due mostly to differences in study assumptions, many of which are closely related to local conditions where the biosolids were generated and disposed (Yoshida et al., 2013; Alvarez-Gaitan et al., 2016). The BEAM model was designed specifically for GHG emission estimation from biosolids, with built-in representative conditions for the US (Burke-Wells, 2022).

The BEAM estimated annual GHG emissions were subsequently allocated temporarily between 2025 through 2050. Specifically, for landfill disposal, different methane emission rates (grams per day per ton) were assigned based on the duration that the biosolids stayed in the landfill. Methane emission rates differ for years 1-2, 3-4 and 4-15 after disposal. Additional sources such as emissions from on-site biosolid handling vehicles were included based on estimated fuel consumption data. Default parameters were used in BEAM when such data are not readily available.

However, the BEAM model does not provide estimates for CO_2 and Nitrous Oxide (N_2O) emissions from landfilled biosolids. Instead, CO_2 and N_2O emissions were estimated based on the typical composition of landfill gas. Among the GHG portion of landfill gas, we assumed a proportion of 55% methane, 43% of CO_2, and 2% of N_2O. Similarly with methane, the emission rates of CO_2 and N_2O from landfill disposed biosolids will differ for years 1-2, 3-4 and 4-15 after disposal. For land applied biosolids, GHG emissions were calculated using two separate approaches: the BEAM model, and standard IPCC (Intergovernmental Panel on Climate Change) Tier 1 approach (Obi-Njoku, 2021). Initial results estimated using the BEAM model were found to only account for approximately 0.2% of total nitrogen contents of biosolids (without lime stabilization). This value is substantially below the typical range of between 1.6% (wet climate extreme) and 0.5% (dry climate extreme) as recommended by IPCC (Obi-Njoku, 2021). Therefore, the IPCC approach was selected for estimating N_2O and CO_2 emissions from land applied biosolids, assuming a 1% conversion of nitrogen content to N_2O emissions and 1% conversion of carbon content to CO_2 emissions (Hergoualc'h et al., 2019). Given the relatively oxygen-rich environment of land application, methane emissions are assumed to be negligible. We also assume the conversions occur entirely within one year based on past measurement data (Czepiel et al., 1996; Levis & Morton, 2013; Willén et al., 2016; Hunt et al., 2019). Credits including carbon sequestration and calcium carbonate debits were also not included in our estimation.

Table 2: Biosolid Production and Disposal Method by Facility (2023)

Jurisdiction	Name of Facility	Biosolids (wet tons per day)	Stabilization Method	Disposal Method
City of Orlando	Iron Bridge Regional WRF	125.0	None	Land application
	Water Conserv II WRF	95.6	Lime	Land application
	Water Conserv I WRF	25.9	None	Land application
Toho	Sand Hill WRF	20.3	None	Land application
	South Bermuda WRF	84.9	None	Land application
	Cypress West WRF	12.3	None	Land application
	Parkway WRF	6.0	None	Land application
	Southside WRF	26.8	None	Land application
Altamonte Springs	Regional WRF	32.5	None	Land application

Seminole County	Greenwood Lakes WRF	14.6	None	Landfill
	Yankee Lake WRF	13.4	None	Landfill
Total		**457.5**		

The growth projections provided in the *Regional Biosolids Study* (2023, Tetra Tech) indicate biosolids production approaching 800 wet tons/day by 2050. Results from the analyses indicate estimated total GHG emissions (as CO_2 equivalent) associated with the landfilling of biosolids during the evaluation period as follows:

Table 3: GHG Emissions from Biosolids Management (BAU Case)

Jurisdiction	Name of Facility	GHG Emissions (metric tons in CO2e) 2025-2030	GHG Emissions (metric tons in CO2e) 2025-2050
City of Orlando	Iron Bridge Regional WRF	8,169	36,619
	Water Conserv II WRF	4,877	21,863
	Water Conserv I WRF	1,695	7,598
Toho	Sand Hill WRF	1,770	8,669
	South Bermuda WRF	7,434	36,417
	Cypress West WRF	1,076	5,272
	Parkway WRF	471	2,306
	Southside WRF	2,097	10,272
Altamonte Springs	Regional WRF	1,637	7,093
Seminole County	Greenwood Lakes WRF	91,497	654,842
	Yankee Lake WRF	84,278	603,180
Total		**205,000**	**1,394,131**

In addition to GHG emissions associated with the landfilling of the biosolids, GHG emissions also result from the transportation of the biosolids to the landfill for disposal. Baseline data was obtained from each jurisdiction to determine the total number of trips required to transport the biosolids based on an assumed transport volume of 20 wet tons/trip, one-way mileage to the disposal facility, and estimated diesel fuel use (based on estimated fuel economy of 4.5 mpg for a Class 8 tractor trailer hauling a load) required annually to transport the biosolids for final disposal. AFLEET was used to estimate the annual GHG emissions based on fuel quantity and emissions intensity.

The estimated annual mileage required for transportation of biosolids increased year over year with the growth of the biosolids requiring disposal in accordance with the *Regional Biosolids Study* (2023, Tetra Tech). GHG emissions associated with transportation of biosolids to the landfill for the performance period are estimated as follows:

- 2025-2030: 11,621 metric tons of CO_2 equivalent
- 2025-2050: 52,634 metric tons of CO_2 equivalent

Transportation of biosolids also results in the emission of various criteria pollutants, summarized below in **Table 4** for the BAU case. These values were calculated based on the total mileage or fuel quantity used and emissions intensities from AFLEET.

Table 4: Transportation Criteria Pollutants for the BAU case

Criteria Pollutant	2025 – 2030 [kg]	2025 – 2050 [kg]
NOx	20,474	20,745
PM10	325.5	329.8
PM10 (TBW)	677.7	686.6
PM2.5	298.8	302.8
PM2.5 (TBW)	85.4	86.5
VOC	720.4	729.9
VOC (Evap)	277.5	281.1
SOx	376.4	381.3

In addition to the biosolids management, baseline emissions result from inefficient collection of landfill gas from Seminole County Landfill. Landfill gas production was estimated in 2023 by S2L*i* using USEPA's LandGEM Model. Growth factors were applied through 2061 to account for planned continued land disposal and projected closure of the landfill in 2061. The model was calibrated using actual disposal data from 2012 to 2022. The emissions are comprised of 50% methane and 50% other gases (primarily CO_2), as noted in the EESI Landfill Methane Fact Sheet (Pierson & Cross, 2013). Captured landfill gas, calculated using 50% collection efficiency based on observed collection data from 2017 through 2022, is either flared or burned in an onsite power generation plant. Currently the landfill gas collection system is only operating at a 28% collection efficiency. Emissions associated with the methane component of captured gas are calculated using a GWP of 1, assuming complete combustion of captured methane. The impact of fugitive methane emissions, coming from the remaining 50% of the landfill gas, is calculated using a GWP of 28 from the IPCC AR5, and direct carbon dioxide emissions from both the captured and fugitive quantities of gas are also calculated.

Estimated GHG emissions for all components of the BAU case are included in **Table 5**.

Table 5: GHG Emissions Estimates (BAU Case)

Process	GHG Emissions (metric tons CO_2e) 2025-2030	GHG Emissions (metric tons CO_2e) 2025-2050
Biosolids - Landfilling	205,000	1,394,131
Biosolids - Transportation	11,621	52,634
Seminole County Landfill Emissions	2,265,705	13,729,903
Total	**2,482,327**	**15,176,668**

<u>Proposed Case</u>

The Proposed Case assumes that secondary sludge is transported directly by class 8 CNG tractor-trailers from each WWTP to the new centrally located facility for treatment using anaerobic digestion and the SCWO process. GHG emission estimates for biosolids material post-treatment are based on the BEAM model (version 2022v2) (NEBRA, 2022) and IPCC Tier 1 Approach. Additional sources of emissions are also present from the proposed treatment plant including power needs.

Emissions associated with the plant processes are broken into the following categories: plant construction, plant energy use, oxidation of feedstock in the SCWO reactor, diesel-fueled startup and trim heat for the SCWO reactor, fugitive methane, carbon dioxide from flared methane during plant downtime, and carbon dioxide escape from the liquefication process. Calculation assumptions for these processes are shown in the table below.

Table 6: Proposed Plant Assumptions and Factors

Assumption	Value	Units
CO2 eq for methane	28	GWP
CO2 eq for N20	265	GWP
GHG emissions per gallon of diesel burned in SCWO	10.24	kg/gal
GHG emissions from grid	0.370484874	kg/kWh
GHG emissions from cement	0.776	kg/kg
GHG emissions from steel	1.85	kg/kg
Unit Conversions		
days per year	365	days
minutes per hour	60	minutes
hours per day	24	hours/day
hours per year	8760	hours
kg per short ton	907.185	kg/short ton
short tons per metric tonne	1.10231	short tons/tonne
cubic feet per cubic meter	35.3147	ft3/m3
Nm3/hr per scfm	1.61	Nm3/hr
Material Properties		
Molar volume of Methane under normal conditions	44	mol/Nm3
Density of Methane under normal (0C, 1atm) conditions	0.7156	kg/Nm3
Density of CO2 under normal (0C, 1atm) conditions	1.963	kg/Nm3
Anaerobic Digestion (AD) Plant		
AD plant BMP	225	Nm3 methane/metric tonne
AD plant biogas	65%	methane by volume
Gas upgrading electrical consumption	0.29	kWh/Nm3 biogas
Biomass facility electrical consumption	12	kWh/metric tonne biomass
Electricity needed for CO2 liquification	0.22	kwh/Nm3
Thermal energy needed per short ton of biomass	44	kWh/short ton
Fugitive biogas emissions by volume	0.50%	
Uptime	95%	
Biomass facility NG consumption	1312500	Nm3
Site general NG consumption	400000	Nm3
Supercritical Water Oxidation (SCWO)		
Number of SCWO units	2	units
Target calorific value of SCWO digestate	2.5	MJ/kg
SCWO annual operation time	8000	h/yr
SCWO plant initialization	633.68	metric WTPD
Ratio of wet tons to dry tons in dewatered SCWO biosolids	15%	
Ratio of dry tons to wet tons in raw SCWO biosolids	5%	
Higher heating value of digested biosolids	15.2	MJ/kg
Estimated molar mass of digested biosolids	108	g/mol
Molar mass of carbon	12	g/mol
Molar mass of hydrogen	1	g/mol
Molar mass of oxygen	16	g/mol
Molar mass of nitrogen	14	g/mol
Mass percent of carbon in digested biosolids	33%	
Mass percent of hydrogen in digested biosolids	4.8%	
Mass percent of oxygen in digested biosolids	21.8%	

Mass percent of nitrogen in digested biosolids	5.6%	
Heat and trim fuel used (diesel)	20000	gal/year
Nominal electricity consumption with expander online	-333.32	kW
Wet tons per day dewatered	211	tons/day
Dry tons per day raw	31.68	tons/day
SCWO wet treatment capacity needed	211226.49	kg/day
SCWO wet treatment capacity needed	8801.10	kg/h
SCWO units	2.00	units needed
SCWO wet treatment capacity needed per unit	4400.55	kg/h
SCWO max wet flow rate per unit	8333.33	kg/h
SCWO nominal wet flow rate	8801.10	total kg/h
Estimated molar ratio of carbon in digestate	3.00	
Estimated molar ratio of hydrogen in digestate	5.19	
Estimated molar ratio of oxygen in digestate	1.48	
Estimated molar ratio of nitrogen in digestate	0.44	
N_2 generation	0.056	kg/kg digestate
H_2O generation	0.430	kg/kg digestate
CO_2 generation	1.217	kg/kg digestate
CO_2 generation	0.0801	kg/MJ
Construction		
Days of construction	520	days
Hours of work per day	8	hours
Construction vehicles onsite	20	vehicles
Construction vehicle diesel consumption	2.500	gal/hour
Thickness of concrete	2	ft
Proportion of rebar by volume in concrete	7%	
Proportion of cement by volume in concrete	12%	
Density of steel	222.3	kg/ft3
Density of cement	42.6	kg/ft3
Years of construction	2	years

Unlike the baseline scenario, transportation emissions calculations assume that class 8 **CNG** tractor-trailers transport sludge from each WWTP to the new plant – in most cases, a shorter distance – and then transport the post-SCWO sludge from the new plant to a disposal location: the Seminole County landfill.

Table 7: Proposed Transportation Assumptions and Factors

Data	Value	Units
Hauling distance from new plant to land disposal	36.6	miles/trip
Biosolids weight per truckload	20	short tons
Diesel truck fuel economy	4.5	miles/DGE
CNG truck fuel economy	3.5	miles/GGE
CO2 emissions per DGE Diesel	0.011393519	short tons/DGE
CO2 emissions per GGE for CNG	0.007485433	short tons/GGE

GHG emission impacts associated with plant construction were estimated based on the primary contributors to the emission footprint: materials production (e.g. cement/concrete and steel reinforcement) and the site work associated with the construction. An estimated 161,520 cubic feet of concrete and 4,755 tons of steel reinforcement are expected to be required for the construction of the facility with an estimated GHG impact of approximately 8,622 mtCO2e. Estimates were based on the quantities of cement and steel needed for each element of the facility, calculated using the assumptions noted in **Table 7**. Emissions factors for cement and steel were sourced from a 2021 EPA fact sheet and a 2020 McKinsey publication (Hoffman et al, 2021), respectively. Construction is expected to take up to 2 years to complete from clearing and grading to final commissioning. Approximately 400 gallons of diesel fuel per day was estimated to fuel the construction vehicles (dozers, loaders, compaction equipment, cranes, dump trucks, etc.) for the construction duration (estimated at 520 days) for a total fuel use of approximately 208,000 gallons of diesel fuel used during the construction phase. An estimated 10,772 mtCO2e of GHGs is expected to be generated during the construction of the plant.

Total AD plant emissions are calculated as the sum of all emissions sources within the facility, noted previously. Anaerobic digestion results in the production of biogas, a mixture of methane and carbon dioxide in the ratio noted in the assumptions. This biogas is then upgraded with the methane component contributed to the local natural gas stream and the carbon dioxide is captured and sold. A small fraction of the methane, noted in the assumptions, escapes the upgrading process as fugitive emissions. This quantity is adjusted for the global warming potential (GWP) according to IPCC AR5 values. Since gas upgrading equipment may experience short periods of downtime, biogas produced from anaerobic digestion will at times be flared. Emissions from the flaring of biogas are calculated as the quantity of carbon dioxide that results from an equal molar quantity of methane fully combusting plus the residual carbon dioxide share of the biogas that escapes through the flare. Biogas calculations are done using volumetric quantities under Normal conditions and are converted to molar and mass quantities using stoichiometric ratios specified in the assumptions.

All biosolids, biogas, and carbon dioxide quantities were calculated on an annual basis, derived from daily quantities provided by participating agencies that were then scaled by growth factors. These growth factors are interpolated sludge projections from the *Regional Biosolids Study* normalized to the first year of this proposal. Biogas, methane, and carbon dioxide quantities were derived using a biochemical methane potential (BMP) and stoichiometric ratios provided by technology partner Bigadan and noted in the assumptions.

Energy used by the AD plant includes quantities associated with biosolids processing, gas upgrading, carbon dioxide liquefication, and digestor heating. Biosolids processing energy was provided by Bigadan on a kWh per wet ton of biosolids, and total energy use for the plant is the product of the processed quantity of biosolids and this factor. Gas upgrading energy was provided as a similar factor: kWh per volume of biogas, and total energy was calculated similarly as the product of the total quantity of biogas produced and this factor. Energy for carbon dioxide liquefication was also provided as a kWh per volume of CO_2 figure and was calculated similarly, adjusting for the carbon dioxide share of biogas noted in the assumptions. Heat required for the digestors was provided on a kWh per wet ton basis, and total heat required was again calculated as the product of this factor and the quantity of biosolids processed.

AD plant heating energy is fully supplied by waste heat from the exothermic SCWO process, and some electrical energy for the AD plant is provided by a turbine downstream of the SCWO process, so emissions from plant energy use are calculated based on the net energy used by both the AD and SCWO portions of the plant. Since the total plant electricity use exceeds what is provided by the SCWO turbine, grid emissions are calculated using an emissions intensity of 0.37 kg per kWh, from the EPA Emissions & Generation Resource Integrated Database (eGRID) 2024 values for subregion FRCC.

SCWO plant emissions are calculated as the sum of emissions from feedstock oxidation, diesel startup and trim heat, and net energy use. Feedstock oxidation, the process by which harmful organic species in sludge are destroyed, occurs at high temperatures and pressures and directly results in the production of carbon dioxide. The quantity of carbon dioxide produced is calculated using the hourly flow rate of dry sludge, calculated using the quantity of wet sludge accepted by the plant, related assumptions about the dry matter content, and the SCWO plant uptime assumption. The carbon content of this dry matter is then obtained using stoichiometric ratios provided by technology partner 374Water.

The SCWO process is highly exothermic, providing heat to the AD process in excess of what is needed, and depressurization of the reaction products through a turbine provides an estimated 333 kW (net) to be used elsewhere in the plant. The heat provided by the SCWO process is only quantified insofar as it offsets the heat needed by the digestors. Some auxiliary diesel heat is needed to start and maintain reactor conditions, and emissions associated with this diesel combustion are calculated using an emissions factor of 10.24 kg per gal, from 2024 EPA estimates for No. 2 fuel oil reported in accordance with 40 CFR Part 1.C.98.

The BEAM model and IPCC protocol were again utilized to estimate the GHG emissions associated with the inert biosolids post-treatment for the materials to be landfilled at the Seminole County Landfill. As previously discussed, the SCWO process reduces the biosolids to less than 30% of their original volume.

Transportation GHG emissions for the proposed case are calculated using the same method as in the baseline scenario: the number of trips from each WWTP to the new facility is the total transported biosolids quantity divided by the quantity of biosolids that a single vehicle can transport, the total mileage is the number of trips times the trip distance, the fuel quantity is the total distance divided by the fuel economy, and the total emissions are the product of the fuel quantity and the emissions intensity from AFLEET. Criteria pollutants associated with the transportation of biosolids were also calculated for the proposed case, shown below in the table below along with the percent reduction from the BAU case.

Table 8: Transportation Criteria Pollutants for the Proposed Case

Criteria Pollutant	2025 – 2030 [kg]	% Reduction from BAU; 2025-2030	2025 – 2050 [kg]	% Reduction from BAU; 2025-2050
NOx	596.0	97%	600.8	97%
PM10	123.6	62%	124.6	62%
PM10 (TBW)	657.7	3%	663.0	3%
PM2.5	113.4	62%	114.3	62%
PM2.5 (TBW)	86.0	0%	86.7	0%
VOC	270.1	63%	272.3	63%
VOC (Evap)	0.0	100%	0.0	100%
SOx	152.4	59%	153.7	60%

As part of this proposal, a new cap will be added to the Seminole County Landfill, increasing the collection efficiency, and thereby reducing the impact of fugitive emissions. As with the BAU case, these emissions are comprised of 50% methane and 50% carbon dioxide (Pierson & Cross, 2013). The collection efficiency with the new cap is expected to be in excess of 75%, and methane captured from the landfill is either flared or burned in an onsite power generation facility. Emissions associated with the methane component of captured gas are calculated using a GWP of 1, assuming complete combustion of captured methane. The impact of fugitive methane emissions, coming from the now 25% of released landfill gas, is calculated using a GWP of 28 from the IPCC AR5. Direct carbon dioxide emissions from both the captured and fugitive quantities of gas are also calculated.

Estimated GHG emissions from the proposed project are as follows:

Table 9: GHG Emissions Estimates (Proposed Case)

Process	GHG Emissions (mt CO2e) 2025-2030	GHG Emissions (mt CO2e) 2025-2050
Transportation of Sludge	9,816	44,460
Plant Construction	10,772	10,772
Plant Electrical Consumption	30,750	204,481
Plant Diesel Consumption	819	4,915
Plant Fugitive Emissions	15,666	107,431
Plant Flared Emissions	7,857	53,844
Plant Feedstock Oxidation	43,201	284,081
Inert Biosolids Disposal	50,322	55,294
Seminole County Landfill Methane Collection Upgrades	1,378,773	8,355,199
Total	**1,547,975**	**9,120,517**

Detailed calculations for each of the above metrics and the associated bibliography are included in the attached Excel workbook. The net GHG savings associated with developing the proposed project is show in **Table 10** and cost effectiveness are provided in **Table 11**.

Table 10: Emissions Savings

Case	GHG Emissions (mt CO2e) 2025-2030	GHG Emissions (mt CO2e) 2025-2050
Business As Usual	2,482,327	15,176,668
Proposed Project	1,547,975	9,120,517
Net Savings	**934,351**	**6,056,151**

Table 11: Cost Effectiveness

Period	Project Cost ($)	GHG Emissions Reduction (mtCO2e)	Cost Effectiveness ($/mtCO2e)
2025-2030	$174,837,252	934,351	$187.12
2025-2050		6,056,151	$28.87