Appendix L
Greenhouse Gas Emissions

APPENDIX L: GREENHOUSE GAS EMISSIONS

L1.1 GREENHOUSE GAS EMISSIONS

To determine the potential change in greenhouse gas emissions related to the proposed project, a facility level estimate of direct greenhouse gas emissions associated with the existing IWWTF and the proposed IWWTF was completed.

As outlined in the document "Greenhouse Gas Emissions Reporting: Technical Guidance on Reporting Greenhouse Gas Emissions", greenhouse gas emissions should be estimated using methods consistent with the guidelines adopted by the United Nations Framework Convention on Climate Change (UNFCC) (Government of Canada, 2006). The UNFCC accepts the Intergovernmental Panel on Climate Change (IPCC) technical documents for estimating greenhouse gas emissions. For the purposes of this assessment, the IPCC technical document titled "2006 IPCC Guidelines for National Greenhouse Gas Inventories" was used to estimate the greenhouse gas emissions (Intergovernmental Panel on Climate Change, 2006). Further guidance on emission factors and methodology was obtained from Canada's National Inventory Report 1990-2006: Greenhouse Gas Sources and Sinks in Canada (Environment Canada, 2008).

Reporting of greenhouse emissions is mandatory in Canada for facilities that emit 100 kilotonnes or more of carbon dioxide (CO_2) equivalent annually.

Under the facility level reporting guidelines (Government of Canada, 2006), when reporting greenhouse gas emissions, the reporter is required to disaggregate the emissions by the following source categories:

- Stationary Fuel Combustion
- Industrial Process
- Venting and Flaring
- Other Fugitive Emissions
- Waste and Wastewater
- On-site Transportation

The existing IWWTF generates direct greenhouse gas emissions under the Waste and Wastewater source category whereas the proposed IWWTF generates direct greenhouse gas emissions under both the Waste and Wastewater and Stationary Fuel Combustion source categories.

L1.1.1 Waste and Wastewater Greenhouse Gas Emissions

According to the IPCC, reported and counted emissions from wastewater treatment are to include methane (CH_4) and nitrous oxide (N_2O). Aerobic treatment of wastewater can emit substantial quantities of carbon dioxide (CO_2); however, these emissions are of biogenic

origin. In accordance with IPCC reporting guidelines, special consideration is necessary when reporting carbon dioxide emissions from biomass to ensure that there is no double counting. Carbon dioxide emissions from the aerobic treatment of wastewater are not to be included in inventories as it is assumed that the biomass is produced in a sustainable manner meaning that the carbon dioxide released by the degraded biomass is replaced by growing biomass which in turn reabsorbs the same amount of atmospheric carbon as was given during the aerobic wastewater treatment process. Methane and nitrous oxide emissions must be reported for wastewater treatment as there is no reverse biogenic mechanism by which replacement biomass removes these emissions from the atmosphere. As a result, the IPCC have not developed guidelines to quantify the amount of carbon dioxide generated during aerobic wastewater treatment. (Intergovernmental Panel on Climate Change, 2006)

According to the IPCC, wastewater and its sludge can produce methane if degraded anaerobically. During aerobic wastewater treatment, methane production is assumed negligible. Methane production is dependant on the quantity of degradable organic material in the wastewater.

Direct emissions of nitrous oxide are generated during both the nitrification and denitrification process in wastewater treatment

The IPCC has developed a method to estimate the nitrous oxide emissions at municipal treatment plants based on the human population discharging to the plant. No method has been developed to determine the nitrous oxide emissions from industrial wastewater treatment facilities (Intergovernmental Panel on Climate Change, 2006).

L1.1.2 Stationary Fuel Combustion Greenhouse Gas Emissions

Carbon dioxide, methane and nitrous oxide are emitted during the combustion process. For the purposes of this assessment, the amount of carbon dioxide, methane and nitrous oxide emitted during the combustion of natural gas, diesel fuel and fat from the first stage dissolved air flotation unit was estimated.

L1.2 CURRENT CONDITION

Detailed calculation sheets for the greenhouse gas quantification are attached.

As indicated previously, the emission source category applicable to the existing IWWTF is Waste and Wastewater. Methane is generated during anaerobic wastewater treatment. According to the IPCC guidelines, lagoons are considered anaerobic when their depth is greater than 2 meters. Shallow lagoon cells are considered aerobic and are generally not significant sources of methane or nitrous oxide. Anaerobic conditions are likely occurring in the IWWTF anaerobic cell and the Town of Neepawa municipal cell #3 which is used for further treatment of the IWWTF effluent as their maximum liquid depths are greater than 2 meters and these cells are not aerated. Anaerobic conditions are not likely occurring within

the IWWTF anoxic cell as the rate of recycle from the aeration cells to this cell is approximately 10 times greater than the flow into this cell from the anaerobic cell.

For methane generation calculations due to anaerobic conditions, the IPCC default value for maximum methane producing capacity of 0.25 kgCH_4/kg COD removed was used. Chemical oxygen demand (COD) loadings into the IWWTF anaerobic cell and the municipal cell #3 were obtained from historical sample data.

No sludge is removed from the IWWTF anaerobic cell or the municipal cell #3 on a consistent basis. Further, these cells are not covered and are not equipped with a methane recovery system.

The Stationary Fuel Combustion category is not considered an applicable source category for the exiting IWWTF as this facility utilizes electricity for heat. Further there is no on-site backup diesel generator which would be included in the Stationary Fuel Combustion category.

L1.2.1 Anaerobic Cell

The anaerobic cell is an uncovered cell and is not equipped with methane recovery. The COD inputs to the cell are from the Springhill Farms pork processing facility and include processing wastewater, truck wash wastewater, sanitary wastewater and supernatant from the hog receiving facility. The influent COD load to the anaerobic cell is estimated to be approximately 1,718 kg COD/day based on historical sample data. No sludge is removed from the anaerobic cell.

Using the IPCC estimation methods, it is estimated that 344 kg/day of methane is generated in the anaerobic cell

The IPCC methane correction factor of 0.8 for anaerobic reactor/digesters was used to determine the emissions.

L1.2.2 Municipal Cell # 3

As the Town of Neepawa municipal cell #3 is currently used to provide additional treatment for IWWTF effluent, the greenhouse gas emissions associated with the use of this cell were estimated. The municipal cell #3 is an uncovered cell and is not equipped with methane recovery. The influent COD load to the municipal cell from the existing IWWTF was estimated based on historical sample data. It was estimated that the influent COD load from the existing IWWTF was approximately 82 kg/day.

No sludge is removed from the municipal cell.

Using the IPCC estimation methods, it is estimated that approximately 16 kg/day of methane is generated in the municipal #3.

The IPCC methane correction factor of 0.8 for anaerobic reactor/digesters was used to determine the emissions.

L1.2.3 Current Condition Total Carbon Dioxide Equivalent Emissions

Using the IPCC global warming potential (GWP) values of 21 for methane and 310 for nitrous oxide, the total equivalent carbon dioxide emissions were determined as shown in the following table.

Table L.1: Total Equivalent Carbon Dioxide Emissions – Current Condition

Total CO_2	0	$kgCO_2$/day
Total CH_4	360	kg CH_4/day
Total N_2O	0	kg N_2O/day
GWP CH_4	21	
GWP N_2O	310	
Total CO_2e	**7,561**	**kg CO_2e/day**

*Note: totals may not add due to rounding

L1.3 PROPOSED CONDITION

Detailed calculation sheets for the greenhouse gas quantification are attached.

As indicated previously, the emission source categories applicable to the proposed IWWTF are both Stationary Fuel Combustion and Waste and Wastewater.

Carbon dioxide, methane and nitrous oxide are generated during the combustion process. The use of natural gas for building and process heat, the combustion of diesel fuel in the on-site back-up generator and the combustion of fat separated from the sludge from the first stage dissolved air flotation unit will produce carbon dioxide, methane and nitrous oxide emissions.

Methane is generated during anaerobic wastewater treatment. The proposed IWWTF will treat wastewater using aerobic processes, and will likely not generate methane. The proposed IWWTF will no longer require the use of the Town of Neepawa municipal cell #3 and therefore the emissions generated by this cell are no longer considered direct emissions related to the proposed facility. Biosolids generated during wastewater treatment will be both stabilized and stored in cells with the cells being aerated during their fill cycle. During the isolation cycle, the sludge cells will not be aerated, which will likely create anaerobic conditions as the maximum liquid depth of the lagoon is 5 m. Sludge will be removed from the sludge cell after approximately the year of full isolation. These cells are not covered or equipped with a methane recovery system.

For methane generation under anaerobic conditions, the IPCC calculation default value for maximum methane producing capacity of 0.25 kgCH_4/kg COD removed was used.

The COD loadings in the sludge cells were estimated by Pharmer Engineering.

L1.3.1 Natural Gas Use

The proposed IWWTF is estimated to use approximately 77,000 m^3 of natural gas per year for process and building heat. To determine the carbon dioxide, methane and nitrous oxide emissions generated due to the combustion of natural gas, emission factors for natural gas use – industrial from Canada's National Inventory Report 1990-2006 were used. For carbon dioxide an emission factor of 1,891 g CO_2/m^3 natural gas was applied. For methane an emission factor of 0.037 g CH_4/m^3 natural gas was applied. For nitrous oxide, an emission factor of 0.033 g N_2O/m^3 natural gas was applied

The combustion of natural gas was estimated to generate approximately 399 kg CO_2/day, 0.01 kg CH_4/day and 0.01 kg N_2O/ day.

L1.3.2 Diesel Fuel Use

The proposed IWWTF is estimated to use approximately 38 liters of diesel fuel per month in the backup generator. To determine the carbon dioxide, methane and nitrous oxide emissions generated due to the combustion of diesel fuel, emission factors for refined petroleum products from Canada's National Inventory Report 1990-2006 were used. For carbon dioxide an emission factor of 2,663 g CO_2/L diesel fuel was applied. For methane an emission factor of 0.133 g CH_4/ L diesel fuel was applied. For nitrous oxide, an emission factor of 0.4 g N_2O/ L diesel fuel was applied

The combustion of diesel fuel was estimated to generate approximately 3 kg CO_2/ day, 0.0002 kg CH_4/day and 0.0005 kg N_2O/ day.

L1.3.3 Fat Use

Fat removed from the first stage dissolved air flotation unit sludge will be combusted in an on-site boiler. It is estimated that approximately 136 kg/day of fat will be generated for use in an on-site boiler.

To determine the fuel consumption, a net calorific value for the fat of 27.4 TJ/Gg was assumed using IPCC default values for liquid biofuels – other liquid biofuels. Default carbon dioxide, methane and nitrous oxide emission factors of 79,600 kg CO_2/TJ, 3 kg CH_4/TJ and 0.6 kg N_2O/TJ were used respectively. (Intergovernmental Panel on Climate Change, 2006).

The combustion of fat was estimated to generate approximately 296.6 kg CO_2/ day, 0.01 kg CH_4/day and 0.002 kg N_2O/ day.

L1.3.4 Sludge Cells

Anaerobic conditions are likely to exist during the one year isolation period, when no aeration of the sludge cells will occur. Pharmer Engineering has estimated that after the one year fill period when the cell will go into the isolation period (under anaerobic conditions), the COD in the cell will be approximately 240 kg/day. After the one year isolation period, the COD of the sludge will be 168 kg/day.

Using the IPCC estimation methods, it is estimated that approximately 14.4 kg/day of methane is generated in the isolated sludge cell.

The IPCC methane correction factor of 0.8 for anaerobic reactor/digesters was used to determine the emissions.

L1.3.5 Proposed Condition Total Carbon Dioxide Equivalent Emissions

Using the IPCC global warming potential (GWP) values of 21 for methane and 310 for nitrous oxide, the total equivalent carbon dioxide emissions were determined as shown in the following Table.

Table L.2: Total Equivalent Carbon Dioxide Emissions – Proposed Condition

Total CO_2	699	$kgCO_2$/day
Total CH_4	14.4	kg CH_4/day
Total N_2O	0.01	kg N_2O/day
GWP CH_4	21	
GWP N_2O	310	
Total CO_2e	**1,005**	**kg CO_2e/day**

*Note: totals may not add due to rounding

L1.4 CHANGE IN GREENHOUSE GAS EMISSIONS

The following Table presents the current and proposed emissions in carbon dioxide equivalent.

Table L.3: Current and Proposed Carbon Dioxide Emissions

Current Condition		
Total CO_2e	7,561	kg CO_2e/day
Total CO_2e	2,760	tonne CO_2e/year
Proposed Condition		
Total CO_2e	1,005	kg CO_2e/day
Total CO_2e	367	tonne CO_2e/year

The proposed changes related to the sludge management program represent an 87% decrease in the amount of direct carbon dioxide equivalent emissions released to the atmosphere by the project.

REFERENCES

Government of Canada. 2006. Greenhouse Gas Emissions Reporting: Technical Guidance on Reporting Greenhouse Gas Emissions. Greenhouse Gas Division, Environment Canada.

Intergovernmental Panel on Climate Change. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: Institute for Global Environmental Strategies, Hayama, Japan.

Environment Canada. 2008. National Inventory Report 1990-2006: Greenhouse Gas Sources and Sinks in Canada. Environment Canada.

Calculations based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories

Current Condition			
Anaerobic Cell			***Notes***
Average Influent COD from Springhill Farms pork processing facility	3135	mg COD/L	Sample data
Flow from Springhill Farms pork processing facility	548	m^3/day	Current average flow
Influent COD load	1718.0	kg COD/day	
EF=Bo x MCF		kg CH_4/kg COD	
Bo	0.25	kg CH_4/kgCOD	IPCC Default
MCF	0.8		IPCC factor for anaerobic lagoon
EF	0.2	kg CH_4/kgCOD	
CH_4 Emissions = (TOW - S)EF-R		kg CH_4/day	
TOW	1718.0	kg COD/day	Total influent COD to anaerobic cell
S	0	kg COD/day	Total COD removed as sludge
TOW - S	1718.0	kg COD/day	
EF	0.2	kg CH_4/kgCOD	
R	0	%	No cover on anaerobic (no recovery)
CH_4 Emissions (no recovery)	343.6	kg CH_4/day	
R	0	kg CH_4/day	
CH_4 Emissions	***343.6***	***kg CH_4/day***	

Municipal Cell			***Notes***
Average Influent COD to municipal cell (effluent from IWWTF)	150	mg COD/L	Sample data
Flow from IWWTF to municipal cell #3	548	m^3/day	Current average flow
Influent COD load	82.2	kg COD/day	
EF=Bo x MCF		kg CH_4/kg COD	
Bo	0.25	kg CH_4/kgCOD	IPCC Default
MCF	0.8		IPCC factor for anaerobic lagoon
EF	0.2	kg CH_4/kgCOD	
CH_4 Emissions = (TOW - S)EF-R		kg CH_4/day	
TOW	82.2	kg COD/day	Total influent COD to municipal cell
S	0	kg COD/day	Total COD removed as sludge
TOW - S	82.2	kg COD/day	
EF	0.2	kg CH_4/kgCOD	
R	0	%	No cover on municipal cell (no recovery)
CH_4 Emissions (no recovery)	16.4	kg CH_4/day	
R	0	kg CH_4/day	
CH_4 Emissions	***16.4***	***kg CH_4/day***	
CURRENT CONDITION TOTAL EMISSIONS AS CO_2 EQUIVALENT			
Total CO_2	0.0	kg CO_2/day	
Total CH_4	360.0	kg CH_4/day	
Total N_2O	0.0	kg N_2O/day	
GWP CH_4	21		IPCC values
GWP N_2O	310		IPCC values
Total CO_2e	***7,561***	***kg CO_2/day***	

Proposed Condition			
Natural Gas Use			***Notes***
Natural Gas Usage	77,000	m^3/year	Supplied by Pharmer Engineering
Emissions GHG = Fuel Consumption x Emission Factor			
CO_2 Emission Factor	1,891	g CO_2/m^3	Canada - National Inventory Report 1990-2006 Table A12-1 Emission Factors for Natural Gas and NGLs - Industrial
CH_4 Emission Factor	0.037	g CH_4/m^3	Canada - National Inventory Report 1990-2006 Table A12-1 Emission Factors for Natural Gas and NGLs - Industrial
N_2O Emission Factor	0.033	g N_2O/m^3	Canada - National Inventory Report 1990-2006 Table A12-1 Emission Factors for Natural Gas and NGLs - Industrial
CO_2 emissions	145,607,000	g CO_2/year	
CO_2 emissions	***399***	***kg CO_2/day***	
CH_4 emissions	2,849	g CH_4/year	
CH_4 emissions	***0.01***	***kg CH_4/day***	
N_2O emissions	2,541	g N_2O/year	
N_2O emissions	***0.01***	***kg N_2O/day***	
Diesel Use			
Diesel Use	10	gallons/month	Back up generator estimated by Pharmer Engineering
Diesel Use	38	litres/month	Convert to metric
Emissions GHG = Fuel Consumption x Emission Factor			
CO_2 Emission Factor	2,663	g CO_2/L	Canada - National Inventory Report 1990-2006 Table A12-2 Emission Factors for Refined Petroleum Products - Diesel fuel
CH_4 Emission Factor	0.133	g CH_4/L	Canada - National Inventory Report 1990-2006 Table A12-2 Emission Factors for Refined Petroleum Products - Diesel fuel
N_2O Emission Factor	0.400	g N_2O/L	Canada - National Inventory Report 1990-2006 Table A12-2 Emission Factors for Refined Petroleum Products - Diesel fuel
CO_2 emissions	100,806	g CO_2/month	
CO_2 emissions	***3***	***kg CO_2/day***	
CH_4 emissions	5	g CH_4/month	
CH_4 emissions	***0.0002***	***kg CH_4/day***	
N_2O emissions	15	g N_2O/month	
N_2O emissions	***0.0005***	***kg N_2O/day***	

Fat Used in Boiler			
Emissions GHG = Fuel Consumption x Emission Factor		kg GHG	Assumed fat is liquid biofuel - other liquid biofuel under IPCC 2006 Volume 2 Energy Table 1.1 - Definitions of Fuel Types Used in the 2006 IPCC Guidelines
Fuel Consumption		TJ	
Emission Factor		kg gas/TJ	
Fat used in boiler	136	kg/day	Estimated by Pharmer Engineering
Convert to energy units			
Net Calorific Value	27.4	TJ/Gg	IPCC Default - Liquid Biofuels - other liquid biofuels - IPCC 2006 Volume 2 Energy Table 1.2 - Default Net Calorific Values (NCVS) and Lower and Upper Limits of the 95% Confidence Intervals
Net Calorific Value	0.0000274	TJ/kg	convert to kg
Fuel Consumption	0.0037264	TJ/day	
Default CO_2 emission factor for combustion	79600	$kgCO_2/TJ$	IPCC Default - Liquid Biofuels - other liquid biofuels - IPCC 2006 Volume 2 Energy Table 2.3 - Default Emission Factors for Stationary Combustion in Manufacturing Industries and Construction
Default CH_4 emission factor for combustion	3	$kgCH_4/TJ$	IPCC Default - Liquid Biofuels - other liquid biofuels - IPCC 2006 Volume 2 Energy Table 2.3 - Default Emission Factors for Stationary Combustion in Manufacturing Industries and Construction
Default N_2O emission factor for combustion	0.6	kgN_2O/TJ	IPCC Default - Liquid Biofuels - other liquid biofuels - IPCC 2006 Volume 2 Energy Table 2.3 - Default Emission Factors for Stationary Combustion in Manufacturing Industries and Construction
CO_2 Emissions	***296.62***	***kg CO_2/day***	
CH_4 Emissions	***0.01***	***kg CH_4/day***	
N_2O Emissions	***0.002***	***kg N_2O/day***	

Anaerobic Sludge Storage during Stabilization Period			
COD of sludge when first goes into "isolation" phase	530	lb COD/day	Estimated by Pharmer Engineering
COD of sludge when first goes into "isolation" phase	240	kg COD/day	Converted to metric
COD of sludge after one year of full isolation	371	lb COD/day	Estimated by Pharmer Engineering
COD of sludge after one year of full isolation	168	kg COD/day	Converted to metric
Influent COD load	240	kg COD/day	
EF=Bo x MCF		kg CH_4/kg COD	
Bo	0.25	kg CH_4/kgCOD	IPCC Default
MCF	0.8		IPCC anaerobic lagoon
EF	0.2	kg CH_4/kgCOD	
CH_4 Emissions = (TOW - S)EF-R		kg CH_4/day	
TOW	240	kg COD/day	total influent COD to sludge cell
S	168	kg COD/day	total COD removed as sludge
TOW - S	72	kg COD/day	
EF	0.2	kg CH_4/kgCOD	
R	0	%	No cover on cell (no recovery)
CH_4 Emissions (no recovery)	14.4	kg CH_4/day	
R	0	kg CH_4/day	
CH_4 Emissions	***14.4***	***kg CH_4/day***	
PROPOSED CONDITION TOTAL EMISSIONS AS CO_2 EQUIVALENT			
Total CO_2	698.9	kg CO_2/day	
Total CH_4	14.4	kg CH_4/day	
Total N_2O	0.01	kg N_2O/day	
GWP CH_4	21		IPCC values
GWP N_2O	310		IPCC values
Total CO_2e	***1,005***	***kg CO_2/day***	