DILLON CONSULTING

CITY OF IQALUIT

Greenhouse Gas Mitigation Assessment

Solid Waste Landfill and Transfer Station

Investing in Canada Infrastructure Program (ICIP)

October 2019 – 19-9543

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Attestation of Completeness

I/we the undersigned attest that this GHG Mitigation Assessment was undertaken using recognized assessment tools and approaches (i.e., *ISO 14064-2: Specification with guidance at the project level for quantification, monitoring, and reporting of greenhouse gas emissions reductions or removal enhancements* and, if chosen, the *GHG Protocol for Project Accounting*) and complies with the General Guidance and any relevant sector-specific technical guidance issued by Infrastructure Canada for use under the Climate Lens.

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*GHG Mitigation Assessments must be prepared, or at a minimum validated by, a qualified party (e.g., a licenced professional engineer **or** a professional GHG accounting specialist certified under the ISO 14064-3 or 14065 standard).

Executive Summary

The City of Iqaluit is proposing to construct a new bale-fill landfill and transfer station (the Project), as the present landfill is nearing full capacity. The Project will also include the construction of new access to the location, waste-transfer facility, and leachate collection and treatment systems. The Project is being designed with a 75 year service life. This report demonstrates and documents that a greenhouse gas (GHG) emissions mitigation assessment following Infrastructure Canada's Climate Lens General Guidance has been completed for the City of Iqaluit's proposed new landfill and waste transfer facility. Currently, the City operates a landfill with mobile compacting equipment and a cardboard incinerator.

GHG emissions from the Project are anticipated to consist of both Scope 1 and 2 sources. Scope 1 Sources are anticipated to include mobile combustion emissions from construction and operation and maintenance activities, as well as emissions from the operation and maintenance of the constructed wetland, landfill gas, biomass boiler, hydronic boiler, and stationary equipment. Scope 2 emissions are anticipated to include electricity usage at the new transfer station. Scope 3 sources were not included in this assessment. The Scope 1 sources included in the Baseline assessment include emissions from the landfill gas, mobile equipment, landfill fires (which occur from time to time), and cardboard incinerator. It is our understanding that the facility currently uses nominal electricity, and that there are no significant emissions from Scope 2 sources. Scope 3 sources were not included in the assessment.

The Project has demonstrated significant reductions in overall GHG emissions in comparison to the Business-as-usual (Baseline) scenario. The reductions stem from Scope 1 emissions, which is largely driven by the removal of the cardboard incinerator activities. The Net reduction in GHG emission in 2030 and cumulative over asset lifespan are presented in **Table 1** below.

Table 1 - Net Increase/reduction in GHG emissions in 2030 and cumulative over asset lifespan

2030 GHG Results		Lifetime GHG Results	
Baseline scenario emissions (in 2030)	8,624 tonnes CO_2e	Baseline scenario emissions (cumulative)	1,263,670 tonnes CO_2e
Estimated project emissions (in 2030)	2,794 tonnes CO_2e	Estimated project emissions (cumulative)	412,069 tonnes CO_2e
Net emissions	-5,830 tonnes CO_2e	Net emissions	-851,601 tonnes CO_2e

The total Federal cost per tonne$_{CO2e}$ of GHG reductions in the year 2030 (non-cumulative) associated with construction costs (only including Federal-share of funding) of this Project is $4,497.87 per tonne$_{CO2e}$. The total cost per tonne$_{CO2e}$ of GHG reductions for the Project (total construction costs and O&M costs over lifetime) over its anticipated lifespan is calculated to be $591.33 per tonne$_{CO2e}$.

1.0 Introduction/Project Overview

The City of Iqaluit recently underwent a procurement process for the design of a new landfill and transfer station, as the existing landfill is nearing full capacity. The Project will include the construction of a new landfill, including new access to the location, a new recycling and eco-centre, composting facility, new methods of waste collection and leachate treatment. The Project is being designed with a 75 year service life.

Key elements of the project include a solid waste transfer station (WTS) within the immediate urban area of the City where residential and commercial waste will be hauled to, processed, and compacted in bales or in the case of waste wood and cardboard, shredded and pelletized for use as a fuel source for an on-site biomass boiler. Tires, metal and some construction and demolition (C&D) wastes will also be shredded and or baled for landfilling or transported south for recycling. The resulting solid waste bales and possibly a smaller amount of unbaled construction and demolition waste will be trucked to an engineered balefill landfill site located approximately six kilometres from the WTS. The vehicles transferring the waste bales will access the road leading to the landfill site from the waste transfer station to avoid having the transfer vehicle travel through the City.

The landfill site is located approximately 8 km northwest of the City of Iqaluit and occupies an approximate area of 19 hectares. Access to the landfill will be via a new road to the location. A constructed lagoon made up of a two holding ponds in series will receive pumped leachate from the landfill collection system. The lagoon will serve to store leachate that is pumped out from the landfill to provide biological treatment before discharging to an engineered wetland area downstream. In the wetland, native plants will provide a surface for biofilm to grow, which filters the water naturally as semi-treated leachate passes through it. An area of approximately 2.5 ha for the lagoon holding ponds and wetland is anticipated to be used.

A Business-as-usual, or Baseline, Scenario has to be established as well. The Baseline scenario established assumes that landfill operations and associated activities remain the same as they currently are with no substantive technological changes or improvements over time and with operations adjusted for inflation over the 75 year timespan.

2.0 Methodology

2.1 Boundary of the Assessment

The Assessment Boundary defines the scope of the mitigation assessment in terms of all direct and all significant indirect emissions and emission reductions associated with the project. Direct emissions (commonly referred to as Scope 1 emissions) are emissions or removals from GHG sources or sinks that are owned or controlled by the proponent. Indirect emissions (Scope 2 and some Scope 3 emissions) are emissions or removals that are of consequence to the project, but occur at the GHG sources or sinks not owned or controlled by the proponent. Only Scope 1 and Scope 2 emissions are included in this assessment.

The Project and Business-as-usual (Baseline) scenario emissions sources comprising the Assessment Boundary are summarized below in **Table 2**.

Table 2 - Project and Baseline Assessment Boundary

Scenario	Direct Effects (Scope 1)	Indirect Effects (Scope 2)	Indirect Effects (Scope 3)
Project	Leachate treatment	Purchased Electricity	-
	Landfill Gas Generation	Purchased Heating	-
	Emergency Diesel Generator	-	-
	Mobile Equipment	-	-
	Stationary Equipment	-	-
	Pellets- Biomass Boiler	-	-
	Fuel Oil - Hydronic Boiler	-	-
	Construction Emissions	-	-
Baseline	Landfill Gas Generation	Purchased Electricity	-
	Mobile Equipment	Purchased Heating	-
	Stationary Equipment	-	-
	Landfill Fires	-	-
	Incinerator	-	-

2.2 Greenhouse Gases Considered

In accordance with Section 2.2 of the *Climate Lens General guidance Version 1.1 – June 1, 2018*, the GHG mitigation assessment was conducted considering the following greenhouse gases tracked in Canada's *National Inventory Report 1990 – 2017* (Section 1.1.2):

- Carbon dioxide (CO_2);
- Methane (CH_4);

- Nitrous oxide (N_2O);
- Perfluorocarbons (PFCs; various chemical compounds);
- Hydrofluorocarbons (HFCs; various chemical compounds);
- Sulphur hexafluoride (SF_6); and
- Nitrogen trifluoride (NF_3).

Emissions are reported in CO_2 equivalents (CO_2e) using Global Warming Potentials in Table 1-1 of the *National Inventory Report 1990–2017—Part 1*.

2.3 Emission Scopes

Both Scope 1 and 2 emissions have been included in this assessment. Emissions for both Baseline and Project scenarios have been grouped by general sources. Under the Baseline scenario, the direct emissions include landfill gas generation, mobile equipment, landfill fires, and the site's incinerator.

The Project scenario Scope 1 emissions have been grouped by leachate treatment, landfill gas generation, biomass boiler, fuel-fired boiler, mobile equipment, construction, and stationary equipment. The direct emissions associated with the stationary equipment operations at the transfer station involves the operation of shredding/baling and compacting equipment.

Baseline mobile equipment includes:

- 1 landfill compactor;
- 1 front end loader;
- 1 skid steer; and
- 2 general duty trucks.

Project mobile equipment includes:

- 2 wheel loaders;
- 1 skid steer; and
- 2 general duty and transfer vehicles (flatbed trucks).

Scope 2 emissions for the Project scenario include those associated with electricity that will be supplied from the grid to power the facility operation including the scale house, transfer station, trailers at the landfill, and lighting at the site.

2.4 Data Collection and Calculation Procedures

2.4.1 List of data sources

- Nunavut Bureau of Statistics, for population projection data;
- US EPA, for emission factors for nonroad mobile equipment;

- National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada—Part 2—Table A6-13. Environment and Climate Change Canada, 2019;
- Memo from L. Marko (AECOM) dated May 10th, 2019, titled *Dillon Question Response*;
- Dillon Consulting Limited *CITY OF IQALUIT Phase I Design Report (30% Submission) Landfill and Waste Transfer Station*, dated July 2019;
- United States Environmental Protection Agency (US EPA), for weight-to-volume (density) conversions; and
- Other communications regarding existing operations details from Client.

2.4.2 Emission factor references

In accordance with the Section 2.3 (i) of the *Climate Lens General guidance Version 1.1 – June 1, 2018*, emission factors and recommended default values were referenced from "Canada's most recent National Inventory Report". For this assessment, , the most recent NIR document is the 2019 publication by Environment and Climate Change Canada (ECCC), *National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada* (NIR)[1].

In addition to the NIR, emission factors for electricity generation from diesel combustion have been taken from the ECCC *Canada's Greenhouse Gas Quantification requirements, Greenhouse Gas Reporting Program, December 2018* (GHGRP)[2].

In the absence of emission factors for nonroad mobile combustion, US EPA emission factors were taken to support the calculation methodologies. Alternative emission factors, where required, are noted in the respective emissions calculations descriptions in this section.

2.4.3 Methodologies

Construction is expected to conclude, and operations are expected to begin, in October 2022 (Project Year 1). Annual estimates of fuel use, operating hours, biomass pellet requirements, etc., are adjusted to account for two months of operation during Project Year 1. The assumed operating schedule of the WTS is 260 days per year, 8 hours per day. Example calculations are presented for the Project for both construction (Year 1 - 2020) and operations (Year 10 - 2030), calculating CO_2 emissions in tonnes of CO_2e.

2.4.3.1 Construction Emissions

The construction phase of the project is expected to begin on in 2020 and be finished by October 2022. The construction has been broken down into four main activities with expected duration for each as provided in **Table 3** and **Table 4**.

[1] ECCC. 2019. National Inventory Report 1990-2017: Greenhouse Gas Sources and Sinks in Canada. Parts 1, 2, and 3.
[2] ECCC. 2018. Canada's Greenhouse Gas Quantification Requirements. Greenhouse Gas Reporting Program.

Table 3 - 2020 Construction Activity and Equipment

Construction Activity		Duration	Expected Equipment
Waste Transfer Station	Site Development	28 days	Dozers, rock truck, exc., grader + roller
	Building slab	28 days	Cement truck (x2), for duration
	Pre-engineered building erected	56 days	Equip. trucks (x2), crane (x1), for duration
Landfill	Site development/environmental protection	28 days	Dozers, rock truck, exc., grader + roller
	Access roads/ditching	49 days	Dozers, rock truck, exc., grader + roller
	Cut and fill - landfill & lagoons	70 days	Rock truck, excavator
	Perimeter & temporary berms - landfill & lagoons	21 days	Dozers, rock truck, exc., grader + rollers
	Grading pad	14 days	Rock truck, excavator

Table 4 - 2021 Construction Activity and Equipment

Construction Activity		Duration	Expected Equipment
North West Aggregate Deposit Road	Construction	130 days	Dozers, rock truck, exc., grader + rollers
Waste Transfer Station	Installation of pre-purchased equipment	70 days	Equip. trucks (x1) for duration
	Installation of exterior elements	49 days	Equip. trucks (x1) for duration
Landfill	Installation of geotextiles and geomembranes	49 days	Dozer (backhoe), truck
	Installation of leachate collection granular and piping	35 days	Dozer, rock truck, excavator
	Pump station and forcemain	21 days	Excavator (x2)
	Wetlands	35 days	Dozer, rock truck, excavator
	Miscellaneous site works	28 days	Trucks (x4), for duration

For each construction activity, the expected equipment was identified and evaluated for emissions. Only carbon dioxide was quantified, as methane and nitrous oxide emissions are expected to be negligible. The emissions from the equipment used in the construction phase are calculated using emission factors for Nonroad Compression Ignition Engines from the *Enhanced estimation of air emissions from construction operations based on discrete-event simulation* (Anh, C., et al., n.d.), and the operating hours required to complete each activity. This methodology is specific for generating emissions rates for construction related activities for non-road mobile equipment. The operating hours to complete each activity were estimated based on the design specifications of those parts of the Project. The engine type

for each piece of equipment was identified and its corresponding emission factor was applied to the estimated total activity hours. The emission factors are provided in **Table 5**.

Table 5 - Nonroad Construction Equipment Emission Factors

Equipment	Duty Cycle	CO_2 Emission Factor (kg/hr)
Bulldozer	Rough Grade	55.13
Bulldozer	Stock Pile	83.44
Off-Road Truck	Hauling	28.84
Excavator	Excavating Soil	98.05
Grader	Resurfacing	56.48
All Equipment	Idling	6.72

Mobile Combustion of Bulldozer – Rough Grade

$$CO_{2(\,bulldozer\ rough\ grade)} = 55\frac{kg}{hr} \times m^2 \times 628hrs \times \frac{1tonne}{1x10^3 g} = 34.54\ tonnes_{CO2}$$

2.4.3.2 Landfill Gas [Baseline and Project]

Landfill gas emissions were calculated using the US EPA's Landfill Gas Emissions Model LandGEM software; calculation parameters are presented in **Table 6**.

Table 6 - Landfill Gas Calculation Parameters

Parameter	Value	Units
Methane content	50	% by volume
Methane Generation Rate, k	0.010	$year^{-1}$
Potential Methane Generation Capacity, L_o	18	m^3/Mg
NMOC Concentration	4,000	ppmv as hexane
Methane Content	50	% by volume

2.4.3.3 Leachate Treatment [Project]

Leachate from the proposed landfill is anticipated to be collected and treated in a vertical engineered wetland. This activity is assumed to include the treatment of leachate from the landfill, and excludes any pumping, construction, repair and maintenance activities. The leachate is collected from the landfill and flows via gravity to the engineered wetland, where it is applied at the top of the wetland, and allowed to percolate through the wetland and substrate, being treated, and flow passively out of the wetland. This process has been assessed for potential GHG emissions.

Emissions from the leachate treatment process were calculated using methodology in Mander et Al. (2014), *Greenhouse gas emission in constructed wetlands for wastewater treatment: A review* (Accessed:

August 28 2019). This paper surveyed the literature for research and values recorded for GHG emissions from leachate treatment systems. Average emission factors for leachate treatment systems most similar to that proposed for Iqaluit landfill were used. These emissions factors were then applied to the leachate influent quality and estimated annual volume of leachate generated. It is assumed that the volume of leachate generated will increase annually proportionally to the increases in waste tonnages.

Influent quality data was obtained from Phase I Design Report (30% Submission), Landfill and Waste Transfer Station - City of Iqaluit (June 2019), and is summarized in **Table 7**.

Table 7 - Influent Quality Parameters

Parameter	Value
$BOD_{5\ day}$	100 mg/l
TOC[1]	50 mg/l
NH3 - N	40 mg/l

The two main emissions from leachate treatment are CH_4 and N_2O. Both of these emissions are calculated based on the leachate system influent TOC, and associated emission factor calculations in Mander et al (2014). The median CH4-C/TOC and N2O-N/TOC ratios provided in Mander et al (2014) are 1.28% and 0.018% respectfully. Using these ratios, the average annual emissions of CH4 and N2O were calculated to be 3.76kg of CH_4 per year, and 0.05kg of N_2O per year

The following assumptions specific to this source were applied:

1. Assumed wetland operating at all times, and emissions are commensurate with increases in leachate flow.
2. Assumed CO2 emissions are negligible, based on sequestration potential of CWs and research studies referenced below.
3. Assumed only significant emissions are from N2O and CH4. Due to the lack of significant and verifiable data, and literature remarking the difficulty in estimating GHG emissions from constructed wetlands, only the total average N2O and CH4 emission factors for Vertical Sub Surface Flow (VSSF) wetland were considered.
4. Assumed constant leachate quality.
5. Assumed TOC roughly equal to 0.5 BOD (Garcia et al., 2007).
6. Assumed leachate generation will increase annually proportionally to increases in waste tonnages.
7. N_2O data was not available, therefore NH3-N was assumed to be fully consumed and converted to N_2O.

2.4.3.4 Landfill Fires [Baseline]

The average annual emissions resulting from landfill fires was calculated based on historic records of landfill fire frequency, size, depth, and length of burn at the Iqaluit landfill. Methodology was consistent

with 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 5 Incineration and Open Burning, with the exception of the recommendation to exclude biomass materials (food, paper, wood waste). Three distinct fire events were used as a basis for average landfill fire parameters, which is summarized in **Table 8** below.

Table 8 - Average Landfill Fire Parameters

Landfill Fire Event	Estimate Size	Estimated Duration
2010/2011	*3165 m3*	27 days
2014	15852 m3	122 days
2018	15 m3	0.15 days

Waste density was selected from the US EPA's *Volume to Weight Conversion Factors Memorandum* (dated April 19th 2016)[3]. The waste density was estimated to be most similar to mixed *MSW – Residential, institutional, and commercial (compacted)* waste with an average density ranging from 400 to 700lbs per cubic yard, which is equivalent to 330kg/m^3. Taking an average of the estimated landfill fire size over the sampling period results in an average of 697,017 kg of waste being combusted per year. A sample calculation for this quantity is provided below:

$$Annual\ Average\ mass\ of\ MSW\ Combusted = \left(\left(\frac{3165m3 + 15852m3 + 15m3}{9years}\right) \times \frac{330kg\ MSW}{m3}\right)$$

$$= 697{,}017\ kg\ of\ MSW\ combusted\ per\ year$$

Waste physical parameters and GHG emission factors were selected from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 2 Waste Generation, Composition and Management Data. These parameters are used to calculate the total annual average CO_2e emissions and are summarized in **Table 9**.

Table 9 - Landfill Parameters

Parameter	Value
Dry matter content (*dm*)	72%
Total carbon content (*CF*)	40%
Fraction of fossil carbon in the total carbon (fraction) (*FCF*)	20%
Oxidation factor (*OF*)	58%

[3] *Volume to Weight Conversion Factors Memorandum* (dated April 19th 2016) Accessed from https://www.epa.gov/sites/production/files/2016-04/documents/volume_to_weight_conversion_factors_memorandum_04192016_508fnl.pdf

The sample calculations below illustrate the calculation of the average annual CO_2e emissions using the calculated average quantity of waste combusted per year (697,017 kg).

$$CO_2e_{landfill\ fires} = \sum_i (SW_i \times dm_i \times CF_i \times FCF_i \times OF_i) \times \left(\frac{44}{12}\right)$$

$$CO_2e_{landfill\ fires} = \left(697\ tonnes \times 72\% \times 40\% \times 20\% \times 58\% \times \frac{44}{12}\right) \times \frac{1\ tonne\ CO_2e}{1\ tonne\ CO_2}$$

$$Annual\ CO_2e_{landfill\ fires} = 84.95\ tonnes$$

2.4.3.5 Incinerator [Baseline]

Cardboard waste received at the Landfill is currently segregated and subsequently incinerated in an Airburners S-220 Refractory Walled Air Curtain Burner, with a Kubota V2403-TE Diesel Engine. It is assumed that this equipment equates a batch-stoker style burner; emission factors are provided in **Table 10** from the NIR (2019). Diesel fuel is used as an accelerant and for operation to the Kubota V2403 Diesel Engine for the incinerator, however it is note by the site operator that these fuel usages would be included in the site diesel fuel usages, which is included in the mobile equipment emissions calculations. IT was assumed that the quantity of cardboard received at the landfill would increase annually proportionally to the City of Iqaluit's projected population increases.

Table 10 - Cardboard Incinerator Emissions Parameters

Emission Factor (g/kg fuel)		
CO_2	CH_4	N_2O
1,652	4.12	0.059

$$CO_2e_{incinerator} = EF_{incinerator} \times mass\ fuel_{cardboard}$$

$$CO_2e_{incinerator} = \left(1{,}652\ \frac{g\ CO_2}{tonne\ fuel} \times\ 3{,}438\ tonnes_{cardboard}\right) \times \frac{1\ tonne\ CO_2e}{1\ tonne\ CO_2}$$

$$CO_2e_{incinerator} = 5{,}679\ tonnes$$

2.4.3.6 Biomass Boiler [Project]

Waste wood and cardboard will be segregated, shredded, and pelletized on-site for use as the fuel source for an on-site biomass boiler. An estimated 75% of the total heating load of the WTS will be met by the operation of the biomass boiler, requiring an estimated 200 tonnes of biomass pellets per year to meet these heating load requirements, as outlined in Internal Memo dated May 30 2019, *Subject: Design and Construction Options Technical Brief*, File number 19-9543. The biomass boiler is assumed to equate the operations of a pellet stove as per NIR 1990-2017, Part 2, Table A6-56, with emission factors presented in **Table 11**:

Table 11 - Biomass Boiler Emission Factors

Emission Factor (g/kg fuel)		
CO_2	CH_4	N_2O
1,652	4.12	0.059

$$CO_2e_{biomass\ boiler} = kg_{fuel} \times EF_{biomass}$$

$$CO_2e_{biomass\ boiler} = 200{,}000\ kg_{fuel} \times 1{,}652\ \frac{g_{CO_2}}{kg_{fuel}} \times \frac{1\ tonne\ CO_2e}{1\ tonne\ CO_2}$$

$$CO_2e_{biomass\ boiler} = 330.40\ tonnes$$

2.4.3.7 Hydronic Boiler [Project]

The remaining 25% of the total heating load of the WTS will be met by the operation of the hydronic (oil-based) boiler, designed for on-peak heating (as outlined in Internal Memo dated May 30 2019, *Subject: Design and Construction Options Technical Brief*, File number 19-9543). On-peak heating demands will require an estimated 2,500 US gallons (approx. 9,500 L) of fuel oil. Emission factors for fuel combustion are from NIR 1990-2017, Table A6-4 for Light Fuel Oil (industrial), presented in **Table 12**:

Table 12 - Hydronic Boiler Emission Factors

Emission Factor (g/L fuel)		
CO_2	CH_4	N_2O
2,753	0.006	0.031

$$CO_2e_{hydronic\ boiler} = fuel\ usage \times EF_{fuel}$$

$$CO_2e_{hydronic\ boiler} = 2{,}500\ US\ Gal \times \left(\frac{3.79\ L}{US\ Gal}\right) \times 2{,}753\ \frac{g_{CO_2}}{L_{fuel}} \times \frac{1\ tonne\ CO_2e}{1\ tonne\ CO_2}$$

$$CO_2e_{hydronic\ boiler} = 26.05\ tonnes$$

2.4.3.8 Mobile Combustion [Project and Baseline]

Mobile combustion sources include non-road and on-road activities for waste transfer within the WTS and from the WTS to the landfill. Sources for both the Baseline and Project scenarios are listed below. It was assumed that both on-road and non-road activities would increase annually proportionally to the projected increases in the City of Iqaluit's waste generation.

Baseline Scenario Source:

- Bucket Loader (Cat 950G Loader (Tier 2))
- Skid Steer (John Deere Skid Steer (Tier 4))
- Landfill Compactor (Cat 816F Landfill Compactor (Tier 2))
- Ford F-250 Truck (general)

Project Scenario Sources:

- Wheel loader (with bucket thumb (110-120hp))
- Skid Steer (John Deere Skid Steer (Tier 4))
- Wheel loader (with forklifts (110-120hp))
- Ford F-250 Truck (flatbed)

Emissions from mobile combustion were calculated as the sum of on-road and non-road activities, as described in the equation below:

Mobile Combustion Emissions[4] Year 2022 –Project scenario

$$CO_2e_{Mobile\ Combusion,\ \ Year\ n} = \sum(NonRoad\ emissions) + \sum(OnRoad\ emissions)$$

On-Road Activities Emissions

Emissions from the Baseline scenario were calculated using reported fuel usages and emissions factors from the NIR. Emissions from the Project scenario were estimated using estimated daily travel distances, average fuel efficiencies, and emissions factors from the NIR. For the Project scenario, the connecting road from the proposed WTS to the proposed landfill is approximately 5 km (roundtrip 10 kM). It is assumed that one of the flatbed Ford F-250 trucks will travel 4 roundtrips per working day, or 10,400 km/year (Project Year 2). It is assumed that operating effort in both the Project and Baseline Scenarios (hours per day and vehicle-kilometers travelled) for mobile vehicles and equipment increases annually proportionally with the increasing waste generation.

Emission factors for on-road vehicles are from NIR 1990-2017, Table A6-13 for light duty gasoline trucks (Tier 2), presented in **Table 13**.

Table 13 - On-Road Mobile Combustion Emission Factors

Emission Factor (g/L fuel)		
CO_2	CH_4	N_2O
2,307	0.14	0.022

Non-Road Activities Emissions

Emissions for non-road activities are calculated using the same methodology for Project and Baseline scenarios. For both scenarios the emissions are calculated by first generating a CO_2 emission factor from the non-road equipment's engine's specific combustion parameters. These are obtained from Equation 6 and Table A4 of *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression-Ignition* (EPA, 2010) (see **Table 14**). Emissions of CH_4 and N_2O for non-road vehicles are considered

[4] Constants used as per Equation 6 for non-road emissions
453.6 = conversion factor, pounds to grams
0.87 = carbon mass fraction of diesel
44/12 = ratio of CO_2 mass to carbon mass

negligible in this calculation methodology. Once a CO_2 emission factor is generated it is then applied to the equipment's estimated annual operating hours.

Table 14 - Non-Road Equipment Operating Conditions, Estimation Parameters

Source	Number Operating	Engine HP	Operating Hours per Day (each)[1]	Operating Hours per Year (each)[1]	BSFC[2]	HC[3]
Wheel Loader	2	120	4	1,040	0.367	0.1314
Skid Steer	1	100	1	260	0.408	0.1314

[1] Operating Hours are presented for Project Year 2 (2022), the first full-year of landfill and WTS operation.

[2] BFSC is the in-use adjusted fuel consumption in lb/hp-hr (constant for Tier 4 non-road engines, based on engine horsepower).

[3] HC is the in-use adjusted hydrocarbon emissions in g/hp-hr (constant for Tier 4 non-road engines, based on engine horsepower).

A sample calculation for the CO_2 emission factor following the methodology prescribed in Equation 6 of *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression-Ignition* (EPA, 2010) for the Skid Steer is provided below:

$$Skid\ Steer\ CO2\ Emission\ Factor = \left[(BSFC \times 453.6 - HC) \times 0.87 \times \left(\frac{44}{12}\right)\right]$$

$$= \left[(0.408 \times 453.6 - 0.1314) \times 0.87 \times \left(\frac{44}{12}\right)\right]$$

$$= \left[(184.937) \times 0.87 \times \left(\frac{44}{12}\right)\right] = \frac{589.95g}{hp - hr}$$

The resultant emission factors for non-road equipment based on parameters presented in **Table 14** and emission factors for on-road vehicles are presented in **Table 15**. Emission factors for on-road vehicles are based on **Table 13** values from NIR (2019), and the average fuel efficiency for light-duty trucks[5].

Table 15 - On-Road and Non-Road Emission Factors Summary – Project Scenario

Type	Source	Emission Factors		
		CO_2	CH_4	N_2O
Non-Road	Wheel loaders	530.62 g/hp-hr	n/a[1]	n/a[1]
	Skid Steer	589.95 g/hp-hr	n/a[1]	n/a[1]
On-Road	Ford F-250 Truck	284 g/km-travelled	0.017 g/km-travelled	0.003 g/km-travelled

[1] n/a defined as not available.

[5] Obtained from Natural Resource Canada's energy use database. Value of 12.3 L/100km.

Sample calculations for the year 2022 for the Project scenario are provided below to illustrate the methodology used for both the Project and Baseline scenarios.

Mobile Combustion Emissions[6] 2022 – Project scenario

$$CO_2e_{Mobile\ Combusion,\ \ Year\ n} = \sum(NonRoad\ emissions) + \sum(OnRoad\ emissions)$$

$$CO_2e_{Mobile\ Combusion,\ \ Year\ n} = \sum\left(\left[(BSFC \times 453.6 - HC) \times 0.87 \times \left(\frac{44}{12}\right)\right] \times Engine\ HP \times Operating\ Hours\right)_i + \sum(Annual\ usage \times EF)$$

$$CO_2e_{Mobile\ Combusion,\ \ Year\ n} = \left[\left(530.62\frac{g}{hp \cdot hr} \times 120\ HP \times 1{,}040\frac{hrs}{yr}\right) + \left(530.62\frac{g}{hp \cdot hr} \times 120\ HP \times 1{,}040\frac{hrs}{yr}\right) + \left(589.95\frac{g}{hp \cdot hr} \times 100\ HP \times 260\frac{hrs}{yr}\right) + \left(10{,}400\frac{km}{yr} \times 284\frac{g_{CO_2}}{km\ travelled}\right)\right] \times \frac{1\ tonne\ CO_2e}{1\ tonne\ CO_2}$$

$$CO_2e_{Mobile\ Combusion,\ \ Year\ n} = 151\ tonnes$$

2.4.3.9 Stationary Combustion [Project]

Stationary combustion equipment in the Project scenario include diesel powered equipment operating in the WTS. Stationary equipment included in the Project scenario are listed in **Table 16**. Equipment specifications and operating hours are also provided in **Table 16**. It was assumed that both on-road and non-road activities would increase annually proportionally to the projected increases in the City of Iqaluit's waste generation.

Table 16 - Stationary Equipment Operating Conditions, Estimation Parameters, and Emission Factors

Source	Number Operating	Engine HP	Operating Hours per Day (each)[1]	Operating Hours per Year (each)[1]	BSFC[2]	HC[3]
Cardboard/wood Shredder	1	330	n/a	1,709	0.367	0.1314
Car Crusher	1	215	8	8	0.367	0.1314

[1] *Operating Hours are presented for Project Year 2 (2022), the first full-year of landfill and WTS operation.*

[2] *BFSC is the in-use adjusted fuel consumption in lb/hp-hr (constant for Tier 4 non-road engines, based on engine horsepower).*

[3] *HC is the in-use adjusted hydrocarbon emissions in g/hp-hr (constant for Tier 4 non-road engines, based on engine horsepower).*

[6] Constants used as per Equation 6 for non-road emissions
453.6 = conversion factor, pounds to grams
0.87 = carbon mass fraction of diesel
44/12 = ratio of CO_2 mass to carbon mass

Emissions from the cardboard/wood shredder and car crusher are calculated based on the equipment's estimated annual operating hours and engine specifications. The emissions from these two pieces of equipment are calculated following Equation 6 and Table A4 of *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression-Ignition* (EPA, 2010) (see **Table 16**). As such, an emission factor for CO_2 was calculated based on parameters provided in Equation 6 and Table A4 of *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression-Ignition* (EPA, 2010). A sample calculation for this methodology is provided in section 2.4.3.7. Emissions of CH_4 and N_2O for non-road vehicles are considered negligible in this calculation methodology.

From Equation 6, emission factors for stationary equipment are presented in **Table 17**.

Table 17 - Stationary Equipment Emission Factors Summary

Source	Emission Factor – CO_2
Cardboard/Wood Shredder	530.62 g/hp-hr
Car Logger/Crusher	530.62 g/hp-hr

Sample calculations for the year 2022 for the Project scenario are provided below to illustrate the methodology used.

Stationary Combustion Emissions Year 2022 – Project scenario

$$CO_2e_{Stationary\ Combusion,\ \ Year\ n} = \sum(Stationary\ Equipment\ Emissions)$$

$$CO_2e_{Stationary\ Combusion,\ \ Year\ n} = \sum\left(\left[(BSFC \times 453.6 - HC) \times 0.87 \times \left(\frac{44}{12}\right)\right] \times Engine\ HP \times Operating\ Hours\right)_i + \sum(Annual\ usage \times EF)$$

$$CO_2e_{Stationary\ Combusion,\ \ Year\ n} = \left[\left(530.62\frac{g}{hp \cdot hr} \times 330\ HP \times 1{,}750\frac{hrs}{yr}\right)_{Shredder,2022} + \left(530.62\frac{g}{hp \cdot hr} \times 215\ HP \times 8\frac{hrs}{yr}\right)_{Crusher,2022}\right] \times \frac{1\ tonne\ CO_2e}{1\ tonne\ CO_2}$$

$$CO_2e_{Mobile\ Combusion,\ \ Year\ 2022} = 307\ tonnes$$

2030

$$CO_2e_{Stationary\ Combusion,\ \ Year\ n} = CO_2e_{Stationary\ Combusion,\ \ Year\ n-1} \times (1 + Population\ Growth\ Rate) \times (1 + MSW\ Growth\ Rate)$$

$$CO_2e_{Stationary\ Combusion,\ \ Year\ 2030} = 364\ tonnes\ CO_2e_{2029} \times (1.01416) \times (1.01)$$

$$CO_2e_{Stationary\ Combusion,\ \ Year\ 2030} = 372\ tonnes$$

2.4.3.10 Electricity Usage

Scope 2 emissions resulting from the WTS's electricity usages are calculated based on NIR 1990-2017, Part 3, Table A13–14 (value of 790 g CO_2e/kWh for Nunavut), and estimated electrical loading for the proposed WTS. The proposed WTS is anticipated to have capacity to supply up to 1.20 MW of power. It is assumed that there is no increase in electrical requirements at the WTS throughout the project lifespan as the maximum power capacity is used and is reasonably conservative in consideration of potential Project-Baseline emissions reduction. It is estimated that the WTS will operate on average 8 hours per day, 260 days of the year, resulting in an average annual of 2080 hours of operation.

$$CO_2e_{Electricity} = Electrical\ Loading \times Operating\ Hours \times EF_{electricity}$$

$$CO_2e_{Electricity} = 1{,}200\ kW \times 2{,}080\ hours \times \frac{790\ g\ CO_{2e}}{kWh}$$

$$CO_2e_{Electricity} = 1{,}972\ tonnes$$

2.5 Exclusions from the Assessment

The following exclusions are noted:

- Operation of the emergency diesel generator at the WTS is considered negligible (infrequent historic power outages).
- For landfill fires, additional equipment (e.g. fire and emergency services) used to support fire extinguishing activities are excluded, as there is not enough data to quantify impacts at this time and would be considered a Scope 3 source.
- Scope 3 emissions are excluded from this assessment.

2.6 Assumptions

- Annual growth projection rates: 1.416% population growth; 1% growth of waste generation;
- Assumed energy efficiency remains relatively unchanged;
- No alternative energy displacement over time;
- Assumed that all diesel fuel used during the cardboard incineration processes as accelerant (baseline conditions) is already captured under the site-wide diesel fuel usage (therefore excluded from the emissions calculations in incineration);
- Operation of the Airburners S-220 Refractory Walled Air Curtain Burner with a Kubota V2403-TE Diesel Engine for cardboard combustion equates the operation of a batch-type stoker incinerator; and
- Operation of the Airburners S-220 Refractory Walled Air Curtain Burner with a Kubota V2403-TE Diesel Engine will be replaced by the biomass boiler in the project scenario.

3.0 Business-As-Usual (Baseline) Emissions

The assessment of the Baseline Scenario included emissions from the regular operation and maintenance activities associated with the current conditions of the site. No construction emissions were included in the assessment, as it was assumed that operations would continue as normal for comparison to the Project Scenario.

Results from the estimation of GHG emissions from the operations and maintenance during the Baseline scenario are presented below in **Table 18**, **Table 19** and **Table 20**.

Table 18 - Greenhouse Gas Emissions – Baseline (Year 2030)

		Source Description	Greenhouse Gas Emissions			Total (tonnes CO2e)	Percent of Total Emission
			CO2	CH4	N2O		
			tonnes/year	tonnes/year	tonnes/year		
Operation	Scope 1	Landfill Gas Generation	728	-	-	728	8.4%
		Mobile Equipment	355	0	0	362	4.2%
		Landfill Fires	85	5	0	1,501	17.4%
		Incinerator	5,679	14	0	6,033	70.0%
		Total	6,847	19	0	8,624	100%
	Scope 2	Purchased Electricity	-	-	-	0	0%
		Purchased Heating	-	-	-	0	0%
		Total	0	0	0	0	0
TOTAL			**6,847**	**19**	**0**	**8,624**	**100%**

Table 19 - Greenhouse Gas Emissions – Baseline (Cumulative 2030)

		Source Description	Greenhouse Gas Emissions			Total (tonnes CO2e)	Percent of Total Emission
			CO2	CH4	N2O		
			tonnes/year	tonnes/year	tonnes/year		
Operation	Scope 1	Landfill Gas Generation	6,979	-	-	6,979	10.1%
		Mobile Equipment	3,745	0	0	3,747	5.4%
		Landfill Fires	849	45	1	2,762	4.0%
		Incinerator	51,098	127	2	55,733	80.5%
		Total	62,671	173	3	69,221	100.0%
	Scope 2	Purchased Electricity	-	-	-	0	0.0%
		Purchased Heating	-	-	-	0	0.0%
		Total	0	0	0	0	0.0%
TOTAL			**62,671**	**173**	**3**	**69,221**	100.0%

Table 20 - Greenhouse Gas Emissions – Baseline (Cumulative Total Lifespan to 2096)

		Source Description	Greenhouse Gas Emissions			Total (tonnes CO2e)	Percent of Total Emission
			CO2	CH4	N2O		
			tonnes/year	tonnes/year	tonnes/year		
Operation	Scope 1	Landfill Gas Generation	136,487	-	-	136,487	10.8%
		Mobile Equipment	61,754	0	0	61,763	4.9%
		Landfill Fires	6,626	353	6	15,461	1.2%
		Incinerator	988,338	2,465	35	1,049,959	83.1%
		Total	1,193,205	2,819	41	1,263,670	100.0%
	Scope 2	Purchased Electricity	-	-	-	0	0.0%
		Purchased Heating	-	-	-	0	0.0%
		Total	0	0	0	0	0.0%
TOTAL			**1,193,205**	**2,819**	**41**	**1,263,670**	**100.0%**

4.0 Project Emissions

Construction is expected to conclude and operations are expected to begin in November 2021 (Project Year 1). The project is being designed with a 75 year life service. Annual estimates of fuel use, operating hours, and source emissions are adjusted to account for two months of operation during project year 1. The assumed operating schedule of the Waste Transfer Station is 260 days per year, 8 hours per day.

The summary of greenhouse gas emissions from the project year 2030, cumulative emissions up to 2030, and cumulative total emissions for the lifespan of the project are provided in **Table 21**, **Table 22**, and **Table 23** respectively.

Table 21 - Greenhouse Gas Emissions Project (Year 2030)

Source Description			CO2 Equivalents			Total (metric tonnes of CO2e/year)	Percent of Total Emissions in 2030
			CO2	CH4	N2O		
			tonnes/year	tonnes/year	tonnes/year		
Operation	Scope 1	Leachate Treatment	-	0	0	0	0.0%
		Landfill Gas Generation	258	-	-	258	9.2%
		WTS Biomass Boiler (75% of Load)	330	21	4	355	12.7%
		WTS Fuel Oil Boiler (25% of Load)	26	0	0	26	0.9%
		Mobile Equipment	183	0	0	183	6.5%
		Stationary Equipment	372	-	-	-	0.0%
	Scope 2	Purchased Electricity	1,972	-	-	1,972	70.6%
		Purchased Heating	-	-	-	0	0.0%
		Total	**3,142**	**21**	**4**	2,794	100%
TOTAL			**3,142**	**-**	**-**	**2,794**	**100%**

Table 22 - Greenhouse Gas Emissions Project (Cumulative 2030)

Source Description			CO2 Equivalents			Total (metric tonnes of CO2e/year)	Percent of Total Emissions in 2030
			CO2 tonnes/year	CH4 tonnes/year	N2O tonnes/year		
Construction	Scope 1	Mobilization/Staging/ Demobilization	574	-	-	574	1.8%
		Waste Transfer Station	204	-	-	204	0.6%
		Engineered Landfill	3,602	-	-	3,602	11.3%
		North-West Aggregate Road	18	-	-	18	0.1%
		Total	**4,397**	**0**	**0**	**4,397**	**13.8%**
Operation	Scope 1	Leachate Treatment	0	0	0	0	0.0%
		Landfill Gas Generation	1,176	-	-	1,176	3.7%
		WTS Biomass Boiler (75% of Load)	3,029	189	32	3,250	10.2%
		WTS Fuel Oil Boiler (25% of Load)	239	0	1	240	0.8%
		Mobile Equipment	1,521	0	0	1,521	4.8%
		Stationary Equipment	3,102	-	-	3,102	9.8%
	Scope 2	Purchased Electricity	18,075	-	-	18,075	56.9%
		Purchased Heating	-	-	-	0	0.0%
		Total	**27,142**	**189**	**33**	**27,364**	**86.2%**
TOTAL			**31,539**	**189**	**33**	**31,761**	**100.0%**

Table 23 - Greenhouse Gas Emissions Project (Cumulative Total Lifespan 2096)

Source Description			CO2 Equivalents			Total (metric tonnes of CO2e/year)	Percent of Total Emissions in 2030
			CO2 tonnes/year	CH4 tonnes/year	N2O tonnes/year		
Construction	Scope 1	Mobilization/Staging/ Demobilization	574	-	-	574	0.1%
		Waste Transfer Station	204	-	-	204	0.0%
		Engineered Landfill	3,602	-	-	3,602	0.9%
		North-West Aggregate Road	18	-	-	18	0.0%
		Total	**4,397**	**0**	**0**	**4,397**	**1.1%**
Operation	Scope 1	Leachate Treatment	0	3	0	3	0.0%
		Landfill Gas Generation	135,473	-	-	135,473	32.9%
		WTS Biomass Boiler (75% of Load)	24,835	1,548	264	26,648	6.5%
		WTS Fuel Oil Boiler (25% of Load)	1,958	0	7	1,965	0.5%
		Mobile Equipment	31,377	1	2	31,380	7.6%
		Stationary Equipment	63,987	0	0	63,987	15.5%
	Scope 2	Purchased Electricity	148,217	-	-	148,217	36.0%
		Purchased Heating	-	-	-	0	0.0%
		Total	**405,847**	**1,552**	**273**	**407,672**	**98.9%**
TOTAL			**410,244**	**1,552**	**273**	**412,069**	**100.0%**

5.0 Project-Baseline Emissions Comparison

This Section presents the comparison of the Baseline scenario emissions to the Project emissions to demonstrate the net reduction in emissions as a result of the Project. These total GHG emissions are summarized for both Baseline and Project scenarios for the year 2030, cumulative emissions up to 2030, and for the cumulative total for the lifespan of the Project in **Table 24**, **Table 25** and **Table 26** respectively.

Table 24 - Project and Baseline Greenhouse Gas Comparison (Year 2030)

Source	Baseline (tonnes CO_2e)	Project (tonnes CO_2e)	Net Increase or Reduction (tonnes CO_2e)
Scope 1	8,624	822	-7,802
Scope 2	0	1,972	1,972
Scope 3	-	-	-
Total	**8,624**	**2,794**	**-5,830**

Table 25 - Project and Baseline Greenhouse Gas Comparison (Cumulative 2030)

Source	Baseline (tonnes CO_2e)	Project (tonnes CO_2e)	Net Reduction (tonnes CO_2e)
Scope 1	69,221	13,686	-55,535
Scope 2	0	18,075	18,075
Scope 3	-	-	-
Total	**69,221**	**31,761**	**-37,459**

Table 26 - Project and Baseline Greenhouse Gas Comparison (Cumulative Total Lifespan to 2051)

Source	Baseline (tonnes CO_2e)	Project (tonnes CO_2e)	Net Reduction (tonnes CO_2e)
Scope 1	1,263,670	263,852	-999,818
Scope 2	0	148,217	148,217
Scope 3	-	-	-
Total	**1,263,670**	**412,069**	**-851,601**

The results presented in the above Tables demonstrate that there are annual reductions in GHG emissions with the implementation of the Project.

There is a significant reduction in GHG emissions across all Scope 1 and Scope 2 sources in all comparison scenarios largely driven by the decrease in emissions from removal of the incineration of cardboard.

6.0 Potential Mitigation Measures

The proposed landfill, WTS, and associated works will emit greenhouse gases (GHGs), and as with all similar projects, there will potentially be opportunities where these GHGs can be avoided or mitigated.

Mitigation measures have been put in place where practical and are summarized below. In other cases mitigation options are limited due to the unique nature and location of the project.

6.1 Options for Avoidance of Impacts

Options for GHG avoidance have been considered and are presented below. Due to the unique nature and location of the project there are likely limited potential other options for additional consideration.

As described in Section 2.3 the Project proposes to install and operate a biomass pellet boiler. This boiler will operate using recycled wood and cardboard, and will supply the majority of the transfer station's annual heating demand. Installation and usage of this pellet boiler mitigates GHG emissions via multiple pathways. These include displacing fossil fuel usages that would normally be required for the operation of a fuel-fired boiler. Furthermore, by using recycled wood and cardboard the facility is avoiding emissions from the generation of biomass pellets from raw biomass sources.

The implementation of construction and demolition (C&D) recycling and reuse practices is also anticipated to avoid potential GHG emissions. This process involves the recycling and re-use of commonly recovered construction and demolition materials for use as a filling and stabilizing agent within the landfill. This will limit the requirement for gravel to be brought in to the landfill to be used for

these purposes, which reduces both the emissions generated from extracting and transporting these raw materials.

Advanced avoidance of GHG emissions could be considered from other aspects of the project such as scope 1 activities (purchasing electric vehicles), and from scope 2 emissions (implementing renewable energy sources on site, to displace some of the proposed requirements for grid electricity usages). Under scope 2, renewable energy sources such as solar panels could provide additional benefits such as reducing dependency of electricity from power grid sources. However, it is likely that these options for avoidance of GHG emissions are cost prohibitive (capital and operating costs) and may not be further assessed or considered in the design and completion of the Project.

6.2 Options for Mitigation of Impacts

Currently there are a wide range of GHG emission mitigation strategies for waste transfer stations and landfills. These options are customized to each project, and their feasibilities are determined largely by waste composition, climate, neighboring industry, and available technologies[7]. This Project has already implemented several GHG mitigation options, which are described in this section. Further mitigation strategies that have been considered by other similar projects, but that may not be currently feasible, are also discussed.

The proposed landfill will first bale and wrap waste, prior to placement in the landfill, as opposed to the current scenario where waste is simply added the landfill and compacted. The designed methodology of placing baled and wrapped waste into the landfill is anticipated to generate significantly less leachate and have reduced generation of landfill gases. In addition to this, within 5-6 years the bales in the landfill will start to freeze limiting the generation and movement of leachate. These low temperatures would also likely be too low for methane to be generated. This in and of itself will mitigate the emission of GHGs by reducing the methane released from the landfill.

Mobile equipment accounts for significant contributions of GHG emissions within the waste management sector. GHG mitigation strategies that are readily feasible for this site include ensuring proper maintenance of mobile equipment, and right-sizing equipment. These strategies are straight-forward and have co-benefits for the operation of the Landfill and WTS.

[7] REF IPCC

7.0 Estimated Cost-per-Tonne

The financial analysis is based on the 30% design costing. The estimated construction costs were prepared by Dillon for the Landfill and for the waste transfer station and associated infrastructure at $4,356,031 and $26,778,000, respectively, for a total of $31,134,031.

The total requested federal contribution for the Project is $26,223,750.

The total cost per tonne$_{CO2e}$ of GHG reductions in the year 2030 (non-cumulative) associated with the operation and maintenance of this Project is $4,497.87 per tonne$_{CO2e}$.

The total cost per tonne$_{CO2e}$ of GHG reductions for the Project (construction cost and O&M costs over lifetime) over its anticipated lifespan is calculated to be $591.33 per tonne$_{CO2e}$.

8.0 Conclusion

The GHG mitigation assessment has demonstrated that the Project will results in significant reductions to GHG emissions when compared to the Baseline (Business-As-Usual) scenario. The reductions are found largely from Scope 1 emissions, which is driven by the removal of the cardboard incinerator activities. The assessment also demonstrates that emissions from the leachate treatment process will be negligible in comparison the total Project emissions, and that the majority of the Project emissions will be due to purchased electricity and landfill gas generation. The nature of the Project in comparison to that of the Business-As-Usual Scenario in and of itself will also likely result in significantly less GHG emissions. This is because baled and wrapped wastes are expected to generate much less landfill gas than traditional landfills. Within 5-6 years it is anticipated that the bales in the landfill will start to freeze limiting the generation and movement of leachate. These low temperatures would also likely be too low for methane to be generated. This in and of itself will mitigate the emission of GHGs by reducing the methane released from the landfill.

Due to the location and unique nature of the Project, potential GHG avoidance and mitigation options are limited.

Appendix A

GHG Emissions Calculations

BASELINE GHG EMISSIONS

Table 1A - BASELINE
Climate Change Mitigation - Greenhouse Gas Emissions - Baseline (Year 2030)
Iqaluit Landfill

		Source Description	Emissions							CO2 Equivalents							Total (metric tonnes of CO2e/year)	Percent of Total Emission
			CO2	CH4	N20	PFCs	HFCs	SF6	NF3	CO2	CH4	N20	PFCs	HFCs	SF6	NF3		
			metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year		
Operation	Scope 1	Landfill Gas Generation	728	-	-	-	-	-	-	728	-	-	-	-	-	-	728	8.4%
		Mobile Equipment	355	0	0	-	-	-	-	355	0	7	-	-	-	-	362	4.2%
		Landfill Fires	85	5	0	-	-	-		85	113	1,302	-	-	-	-	1,501	17.4%
		Incinerator	5,679	14	0	-	-	-	-	5,679	354	0	-	-	-	-	6,033	70.0%
		Total	6,847	19	0	0	0	0	0	6,847	467	1,309	0	0	0	0	8,624	100.0%
	Scope 2	Purchased Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0.0%
		Purchased Heating	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0.0%
		Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
TOTAL			**6,847**	**19**	**0**	**0**	**0**	**0**	**0**	**6,847**	**467**	**1,309**	**0**	**0**	**0**	**0**	**8,624**	100.0%

Table 1B - BASELINE
Climate Change Mitigation - Greenhouse Gas Emissions - Baseline (Cumulative 2030)
Iqaluit Landfill

		Source Description	Emissions							CO2 Equivalents							Total (metric tonnes of CO2e/year)	Percent of Total Emission
			CO2	CH4	N20	PFCs	HFCs	SF6	NF3	CO2	CH4	N20	PFCs	HFCs	SF6	NF3		
			metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year		
Operation	Scope 1	Landfill Gas Generation	6,979	-	-	-	-	-	-	6,979	-	-	-	-	-	-	6,979	10.1%
		Mobile Equipment	3,745	0	0	-	-	-	-	3,745	1	2	-	-	-	-	3,747	5.4%
		Landfill Fires	849	45	1	-	-	-		849	1,133	780	-	-	-	-	2,762	4.0%
		Incinerator	51,098	127	2	-	-	-	-	51,098	3,186	1,449	-	-	-	-	55,733	80.5%
		Total	62,671	173	3	0	0	0	0	62,671	4,319	2,231	0	0	0	0	69,221	100.0%
	Scope 2	Purchased Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0.0%
		Purchased Heating	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0.0%
		Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0	0	0	0	0	0	0	0	0.0%
TOTAL			**62,671**	**173**	**3**	**0**	**0**	**0**	**0**	**62,671**	**4,319**	**2,231**	**0**	**0**	**0**	**0**	**69,221**	100.0%

Table 1C - BASELINE
Climate Change Mitigation - Greenhouse Gas Emissions - Baseline (Total Lifespan 2096)
Iqaluit Landfill

		Source Description	Emissions							CO2 Equivalents							Total (metric tonnes of CO2e/year)	Percent of Total Emission
			CO2	CH4	N20	PFCs	HFCs	SF6	NF3	CO2	CH4	N20	PFCs	HFCs	SF6	NF3		
			metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year		
Operation	Scope 1	Landfill Gas Generation	136,487	-	-	-	-	-	-	136,487	-	-	-	-	-	-	136,487	10.8%
		Mobile Equipment	61,754	0	0	-	-	-	-	61,754	8	0	-	-	-	-	61,763	4.9%
		Landfill Fires	6,626	353	6	-	-	-		6,626	8,835	0	-	-	-	-	15,461	1.2%
		Incinerator	988,338	2,465	35	-	-	-	-	988,338	61,622	0	-	-	-	-	1,049,959	83.1%
		Total	1,193,205	2,819	41	0	0	0	0	1,193,205	70,465	0	0	0	0	0	1,263,670	100.0%
	Scope 2	Purchased Electricity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0.0%
		Purchased Heating	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0.0%
		Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0	0	0	0	0	0	0	0	0.0%
TOTAL			**1,193,205**	**2,819**	**41**	**0**	**0**	**0**	**0**	**1,193,205**	**70,465**	**0**	**0**	**0**	**0**	**0**	**1,263,670**	100.0%

PROJECT GHG EMISSIONS

Table 1C - PROJECT
Climate Change Mitigation - Greenhouse Gas Emissions - Project (Year 2030)
Iqaluit Landfill

Source Description			Emissions							CO2 Equivalents							Total (metric tonnes of CO2e/year)	Percent of Total Emissions in 2030
			CO2	CH4	N20	PFCs	HFCs	SF6	NF3	CO2	CH4	N20	PFCs	HFCs	SF6	NF3		
			metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year		
Construction	Scope 1	Mobilization/Staging/Demobilization	0	-	-	-	-	-	-	0	-	-	-	-	-	-	0	0.0%
		Waste Transfer Station	0	-	-	-	-	-	-	0	-	-	-	-	-	-	0	0.0%
		Engineered Landfill	0	-	-	-	-	-	-	0	-	-	-	-	-	-	0	0.0%
		North-West Aggregate Road	0	-	-	-	-	-	-	0	-	-	-	-	-	-	0	0.0%
		Total	**0**	-	-	-	-	-	-	**0**	-	-	-	-	-	-	**0**	0.0%
Operation	Scope 1	Leachate Treatment	-	0	0	-	-	-	-	-	0	0	-	-	-	-	0	0.0%
		Landfill Gas Generation	258	-	-	-	-	-	-	258	-	-	-	-	-	-	258	9.2%
		WTS Biomass Boiler (75% of Load)	330	1	0	-	-	-	-	330	21	4	-	-	-	-	355	12.7%
		WTS Fuel Oil Boiler (25% of Load)	26	0	0	-	-	-	-	26	0	0	-	-	-	-	26	0.9%
		Mobile Equipment	183	0	0	-	-	-	-	183	0	0	-	-	-	-	183	6.5%
		Stationary Equipment	372	-	-	-	-	-	-	372	-	-	-	-	-	-		0.0%
	Scope 2	Purchased Electricity	1,972	-	-	-	-	-	-	1,972	-	-	-	-	-	-	1,972	70.6%
		Purchased Heating	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0.0%
		Total	**3,142**	**1**	**0**	-	-	-	-	**3,142**	**21**	**4**	-	-	-	-	**2,794**	100.0%
TOTAL			**3,142**	-	-	-	-	-	-	**3,142**	-	-	-	-	-	-	**2,794**	100.0%

Table 1D - PROJECT
Climate Change Mitigation - Greenhouse Gas Emissions - Project (Cumulative 2030)
Iqaluit Landfill

Source Description			Emissions							CO2 Equivalents							Total (metric tonnes of CO2e/year)	Percent of Total Emission
			CO2	CH4	N20	PFCs	HFCs	SF6	NF3	CO2	CH4	N20	PFCs	HFCs	SF6	NF3		
			metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year		
Construction	Scope 1	Mobilization/Staging/Demobilization	574	-	-	-	-	-	-	574	-	-	-	-	-	-	574	1.8%
		Waste Transfer Station	204	-	-	-	-	-	-	204	-	-	-	-	-	-	204	0.6%
		Engineered Landfill	3,602	-	-	-	-	-	-	3,602	-	-	-	-	-	-	3,602	11.3%
		North-West Aggregate Road	18	-	-	-	-	-	-	18	-	-	-	-	-	-	18	0.1%
		Total	**4,397**	**0**	**0**	-	-	-	-	**4,397**	**0**	**0**	-	-	-	-	**4,397**	13.8%
Operation	Scope 1	Leachate Treatment	0	0	0	-	-	-	-	0	0	0	-	-	-	-	0	0.0%
		Landfill Gas Generation	1,176	-	-	-	-	-	-	1,176	-	-	-	-	-	-	1,176	3.7%
		WTS Biomass Boiler (75% of Load)	3,029	8	0	-	-	-	-	3,029	189	32	-	-	-	-	3,250	10.2%
		WTS Fuel Oil Boiler (25% of Load)	239	0	0	-	-	-	-	239	0	1	-	-	-	-	240	0.8%
		Mobile Equipment	1,521	0	0	-	-	-	-	1,521	0	0	-	-	-	-	1,521	4.8%
		Stationary Equipment	3,102	-	-	-	-	-	-	3,102	-	-	-	-	-	-	3,102	9.8%
	Scope 2	Purchased Electricity	18,075	-	-	-	-	-	-	18,075	-	-	-	-	-	-	18,075	56.9%
		Purchased Heating	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0.0%
		Total	**27,142**	**8**	**0**	-	-	-	-	**27,142**	**189**	**33**	-	-	-	-	27,364	86.2%
TOTAL			**31,539**	**8**	**0**	-	-	-	-	**31,539**	**189**	**33**	-	-	-	-	**31,761**	100.0%

Table 1E - PROJECT
Climate Change Mitigation - Greenhouse Gas Emissions - Project (Total Lifespan, 2096)
Iqaluit Landfill

Source Description			Emissions							CO2 Equivalents							Total (metric tonnes of CO2e/year)	Percent of Total Emission
			CO2	CH4	N20	PFCs	HFCs	SF6	NF3	CO2	CH4	N20	PFCs	HFCs	SF6	NF3		
			metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year	metric tonnes of CO2e/year		
Construction	Scope 1	Mobilization/Staging/Demobilization	574	-	-	-	-	-	-	574	-	-	-	-	-	-	574	0.1%
		Waste Transfer Station	204	-	-	-	-	-	-	204	-	-	-	-	-	-	204	0.0%
		Engineered Landfill	3,602	-	-	-	-	-	-	3,602	-	-	-	-	-	-	3,602	0.9%
		North-West Aggregate Road	18	-	-	-	-	-	-	18	-	-	-	-	-	-	18	0.0%
		Total	**4,397**	**0**	**0**	-	-	-	-	**4,397**	**0**	**0**	-	-	-	-	**4,397**	1.1%
Operation	Scope 1	Leachate Treatment	0	0	0	-	-	-	-	0	3	0	-	-	-	-	3	0.0%
		Landfill Gas Generation	135,473	-	-	-	-	-	-	135,473	-	-	-	-	-	-	135,473	32.9%
		WTS Biomass Boiler (75% of Load)	24,835	62	1	-	-	-	-	24,835	1,548	264	-	-	-	-	26,648	6.5%
		WTS Fuel Oil Boiler (25% of Load)	1,958	0	0	-	-	-	-	1,958	0	7	-	-	-	-	1,965	0.5%
		Mobile Equipment	31,377	0	0	-	-	-	-	31,377	1	2	-	-	-	-	31,380	7.6%
		Stationary Equipment	63,987	0	0	-	-	-	-	63,987	0	0	-	-	-	-	63,987	15.5%
	Scope 2	Purchased Electricity	148,217	-	-	-	-	-	-	148,217	-	-	-	-	-	-	148,217	36.0%
		Purchased Heating	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0.0%
		Total	**405,847**	**62**	**1**	-	-	-	-	405,847	1,552	273	-	-	-	-	**407,672**	98.9%
TOTAL			**410,244**	**62**	**1**	-	-	-	-	**410,244**	**1,552**	**273**	-	-	-	-	**412,069**	100.0%

COST ASSESSMENT

Construction Costs

Landfill	$4,356,031
Waste transfer station	$26,778,000
TOTAL	$31,134,031

Operations and Maintenance Costs

TOTAL O&M Costs	$472,442,178.31

Federal Funding

Federal Funding	$26,223,750.00

Total Reductions (Year 2030)

Source	Baseline (tonnes CO2e)	Project (tonnes CO2e)	Net Increase or Reduction (tonnes CO2e)
Scope 1	8,624	822	-7,802
Scope 2	0	1,972	1,972
Scope 3	-	-	-
Total	8,624	2,794	-5,830

Federal Cost per Reduction in Year 2030

-$ 4,497.87

Total Reductions in (Cumulative to 2030)

Source	Baseline (tonnes CO2e)	Project (tonnes CO2e)	Net Increase or Reduction (tonnes CO2e)
Scope 1	69,221	13,686	-55,535
Scope 2	0	18,075	18,075
Scope 3	-	-	-
Total	69,221	31,761	-37,459

Total Reductions in (Total Lifespan)

Source	Baseline (tonnes CO2e)	Project (tonnes CO2e)	Net Increase or Reduction (tonnes CO2e)
Scope 1	1,263,670	263,852	-999,818
Scope 2	0	148,217	148,217
Scope 3	-	-	-
Total	1,263,670	412,069	-851,601

Cost per Reduction Total Lifespan

-$ 591.33

PROJECT GHG EMISSIONS

Project: **Iqaluit Landfill Operation and Maintenance GHG Emissions**

GHG Estimate by Activity (tonnes CO_2e)													
Year	Scope 1									Scope 2			Combined Total
	Constructed Wetland (VSSF)	Landfill Gas	Pellets - Biomass Boiler	Fuel Oil - Hydronic Boiler	Composting	Mobile Combustion	Stationary Combustion	Emergency Diesel Generator	Total	Electricity Usage	Purchased Heat	Total	
2021	0.0	0	59	4	N/Ap	25	51	-	140	329	N/Ap	329	**468**
2022	0.0	7	355	26	N/Ap	151	307	-	846	1,972	N/Ap	1,972	**2,818**
2023	0.0	37	355	26	N/Ap	154	315	-	887	1,972	N/Ap	1,972	**2,859**
2024	0.0	67	355	26	N/Ap	158	323	-	929	1,972	N/Ap	1,972	**2,900**
2025	0.0	98	355	26	N/Ap	162	330	-	971	1,972	N/Ap	1,972	**2,943**
2026	0.0	129	355	26	N/Ap	166	338	-	1,014	1,972	N/Ap	1,972	**2,986**
2027	0.0	161	355	26	N/Ap	170	347	-	1,058	1,972	N/Ap	1,972	**3,030**
2028	0.0	193	355	26	N/Ap	174	355	-	1,102	1,972	N/Ap	1,972	**3,074**
2029	0.0	225	355	26	N/Ap	178	364	-	1,148	1,972	N/Ap	1,972	**3,120**
2030	0.0	258	355	26	N/Ap	183	372	-	1,194	1,972	N/Ap	1,972	**3,166**
2031	0.0	292	355	26	N/Ap	187	382	-	1,241	1,972	N/Ap	1,972	**3,213**
2032	0.0	326	355	26	N/Ap	192	391	-	1,289	1,972	N/Ap	1,972	**3,261**
2033	0.0	361	355	26	N/Ap	196	400	-	1,338	1,972	N/Ap	1,972	**3,310**
2034	0.0	396	355	26	N/Ap	201	410	-	1,388	1,972	N/Ap	1,972	**3,360**
2035	0.0	432	355	26	N/Ap	206	420	-	1,439	1,972	N/Ap	1,972	**3,410**
2036	0.0	469	355	26	N/Ap	211	430	-	1,490	1,972	N/Ap	1,972	**3,462**
2037	0.0	506	355	26	N/Ap	216	441	-	1,543	1,972	N/Ap	1,972	**3,515**
2038	0.0	543	355	26	N/Ap	221	451	-	1,597	1,972	N/Ap	1,972	**3,569**
2039	0.0	582	355	26	N/Ap	227	462	-	1,652	1,972	N/Ap	1,972	**3,623**
2040	0.0	621	355	26	N/Ap	232	474	-	1,707	1,972	N/Ap	1,972	**3,679**
2041	0.0	661	355	26	N/Ap	238	485	-	1,764	1,972	N/Ap	1,972	**3,736**
2042	0.0	701	355	26	N/Ap	244	497	-	1,823	1,972	N/Ap	1,972	**3,794**
2043	0.0	743	355	26	N/Ap	250	509	-	1,882	1,972	N/Ap	1,972	**3,854**
2044	0.0	785	355	26	N/Ap	256	521	-	1,942	1,972	N/Ap	1,972	**3,914**
2045	0.0	827	355	26	N/Ap	262	534	-	2,004	1,972	N/Ap	1,972	**3,976**
2046	0.0	871	355	26	N/Ap	268	547	-	2,067	1,972	N/Ap	1,972	**4,039**
2047	0.0	916	355	26	N/Ap	275	560	-	2,131	1,972	N/Ap	1,972	**4,103**
2048	0.0	961	355	26	N/Ap	281	574	-	2,197	1,972	N/Ap	1,972	**4,169**
2049	0.0	1,007	355	26	N/Ap	288	588	-	2,264	1,972	N/Ap	1,972	**4,236**
2050	0.0	1,054	355	26	N/Ap	295	602	-	2,332	1,972	N/Ap	1,972	**4,304**
2051	0.0	1,102	355	26	N/Ap	302	617	-	2,402	1,972	N/Ap	1,972	**4,374**
2052	0.0	1,151	355	26	N/Ap	310	632	-	2,473	1,972	N/Ap	1,972	**4,445**
2053	0.0	1,201	355	26	N/Ap	317	647	-	2,546	1,972	N/Ap	1,972	**4,518**
2054	0.0	1,252	355	26	N/Ap	325	663	-	2,620	1,972	N/Ap	1,972	**4,592**
2055	0.0	1,304	355	26	N/Ap	333	679	-	2,696	1,972	N/Ap	1,972	**4,668**
2056	0.0	1,357	355	26	N/Ap	341	695	-	2,774	1,972	N/Ap	1,972	**4,746**
2057	0.0	1,411	355	26	N/Ap	349	712	-	2,853	1,972	N/Ap	1,972	**4,825**
2058	0.0	1,466	355	26	N/Ap	358	730	-	2,934	1,972	N/Ap	1,972	**4,906**
2059	0.0	1,522	355	26	N/Ap	367	747	-	3,017	1,972	N/Ap	1,972	**4,989**
2060	0.0	1,580	355	26	N/Ap	375	766	-	3,101	1,972	N/Ap	1,972	**5,073**
2061	0.0	1,638	355	26	N/Ap	385	784	-	3,188	1,972	N/Ap	1,972	**5,159**
2062	0.0	1,698	355	26	N/Ap	394	803	-	3,276	1,972	N/Ap	1,972	**5,248**
2063	0.0	1,759	355	26	N/Ap	403	823	-	3,366	1,972	N/Ap	1,972	**5,338**
2064	0.0	1,822	355	26	N/Ap	413	843	-	3,458	1,972	N/Ap	1,972	**5,430**
2065	0.0	1,885	355	26	N/Ap	423	863	-	3,553	1,972	N/Ap	1,972	**5,524**
2066	0.0	1,951	355	26	N/Ap	434	884	-	3,649	1,972	N/Ap	1,972	**5,621**
2067	0.0	2,017	355	26	N/Ap	444	906	-	3,747	1,972	N/Ap	1,972	**5,719**
2068	0.0	2,085	355	26	N/Ap	455	928	-	3,848	1,972	N/Ap	1,972	**5,820**
2069	0.0	2,154	355	26	N/Ap	466	950	-	3,951	1,972	N/Ap	1,972	**5,923**
2070	0.0	2,225	355	26	N/Ap	477	973	-	4,056	1,972	N/Ap	1,972	**6,028**
2071	0.1	2,297	355	26	N/Ap	489	997	-	4,164	1,972	N/Ap	1,972	**6,136**
2072	0.1	2,371	355	26	N/Ap	501	1,021	-	4,274	1,972	N/Ap	1,972	**6,246**
2073	0.1	2,447	355	26	N/Ap	513	1,046	-	4,387	1,972	N/Ap	1,972	**6,358**
2074	0.1	2,524	355	26	N/Ap	525	1,071	-	4,502	1,972	N/Ap	1,972	**6,474**
2075	0.1	2,603	355	26	N/Ap	538	1,097	-	4,620	1,972	N/Ap	1,972	**6,591**
2076	0.1	2,684	355	26	N/Ap	551	1,124	-	4,740	1,972	N/Ap	1,972	**6,712**
2077	0.1	2,766	355	26	N/Ap	565	1,151	-	4,863	1,972	N/Ap	1,972	**6,835**
2078	0.1	2,851	355	26	N/Ap	578	1,179	-	4,989	1,972	N/Ap	1,972	**6,961**
2079	0.1	2,937	355	26	N/Ap	592	1,208	-	5,118	1,972	N/Ap	1,972	**7,090**
2080	0.1	3,025	355	26	N/Ap	607	1,237	-	5,250	1,972	N/Ap	1,972	**7,222**
2081	0.1	3,115	355	26	N/Ap	622	1,267	-	5,385	1,972	N/Ap	1,972	**7,357**
2082	0.1	3,207	355	26	N/Ap	637	1,298	-	5,523	1,972	N/Ap	1,972	**7,495**
2083	0.1	3,301	355	26	N/Ap	652	1,330	-	5,664	1,972	N/Ap	1,972	**7,636**
2084	0.1	3,398	355	26	N/Ap	668	1,362	-	5,809	1,972	N/Ap	1,972	**7,780**
2085	0.1	3,496	355	26	N/Ap	684	1,395	-	5,956	1,972	N/Ap	1,972	**7,928**
2086	0.1	3,597	355	26	N/Ap	701	1,429	-	6,108	1,972	N/Ap	1,972	**8,079**
2087	0.1	3,700	355	26	N/Ap	718	1,464	-	6,262	1,972	N/Ap	1,972	**8,234**
2088	0.1	3,805	355	26	N/Ap	735	1,499	-	6,421	1,972	N/Ap	1,972	**8,393**
2089	0.1	3,913	355	26	N/Ap	753	1,536	-	6,583	1,972	N/Ap	1,972	**8,555**
2090	0.1	4,023	355	26	N/Ap	772	1,573	-	6,749	1,972	N/Ap	1,972	**8,721**
2091	0.1	4,136	355	26	N/Ap	790	1,611	-	6,919	1,972	N/Ap	1,972	**8,890**
2092	0.1	4,252	355	26	N/Ap	809	1,651	-	7,092	1,972	N/Ap	1,972	**9,064**
2093	0.1	4,370	355	26	N/Ap	829	1,691	-	7,270	1,972	N/Ap	1,972	**9,242**
2094	0.1	4,490	355	26	N/Ap	849	1,732	-	7,452	1,972	N/Ap	1,972	**9,424**
2095	0.1	4,614	355	26	N/Ap	870	1,774	-	7,638	1,972	N/Ap	1,972	**9,610**
2096	0.1	4,740	355	26	N/Ap	891	1,817	-	7,829	1,972	N/Ap	1,972	**9,801**

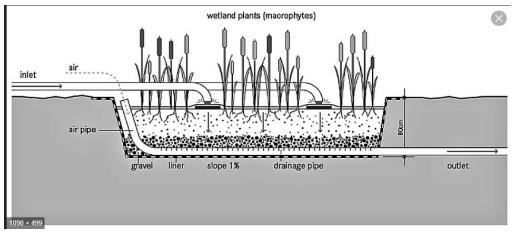
Operation (Year 2030)	0	258	355	26	N/Ap	183	372	-	1,194	1,972	N/Ap	1,972	3,166
Operation (2021 to 2030)	0	1,176	3,250	240	N/Ap	1,521	3,102	-	9,289	18,075	N/Ap	18,075	27,364
Operation (Lifespan - 2096)	3	135,473	26,648	1,965	N/Ap	31,380	63,987	-	259,455	148,217	N/Ap	148,217	407,672

PROJECT GHG EMISSIONS

Table S1-A
Engineered Wetland for Leachate Treatment (Wetland Treatment Area - WTA)

Description of Activity:

Leachate from the new landfill is collected and treated in a vertical engineered wetland. This activity is assumed to include the treatment of leachate from the landfill, and excludes any pumping, construction, repair and maintenance activities. The leachate is collected from the landfill and flows via gravity to the engineered wetland, where it is applied at the top of the wetland, and allowed to percolate through the wetland and substrate, being treated, and flow passively out of the wetland.



Vertical subsurface flow CWs comprise a flat bed of graded gravel topped with sand or other porous filter materials planted with macrophytes. In contrast to HSSF CWs, VSSF CWs are fed intermittently with large batches, thus flooding the surface. Wastewater then percolates down through the bed and is collected by a drainage network at the bottom. The bed drains completely, which allows air to refill the bed. The VSSF CWs provide greater oxygen transfer into the bed, thus producing a nitrified (high NO_3^-) effluent (Cooper et al., 1996; Cooper, 2005). On the other hand, VSSF CWs do not provide suitable conditions for denitrification to complete conversion to gaseous nitrogen forms which escape to the atmosphere. Removal of organics and suspended solids is high (Vymazal and Kröpfelova, 2008). As compared to HSSF CWs, which need 5–6 m^2 per population equivalent (PE), vertical flow systems require less land, usually 1–3 m^2 PE^{-1} (Cooper, 2005).

Both VSSF and HSSF CWs with the ability to insulate the surface of the bed are capable of operation under colder conditions than are FWS systems (Mander and Jenssen, 2003).

As a bias of the water purification, the CWs for wastewater treatment have been found to be sources of greenhouse gases (GHG). Carbon dioxide (CO_2) emission has been measured in few full-scale CWs (Mander et al., 2003, 2005a,b, 2008; Teiter and Mander, 2005; Liikanen et al., 2006; Ström et al., 2006; Garcia et al., 2007; Picek et al., 2007; Van der Zaag et al., 2010), and C balance has been compiled in only one HSSF CW based on the long-term direct measurement of C in inflow and outflow, accumulation in filter material (sand), microbes, above ground and below ground plant biomass, and the emission of CO_2 and CH_4 (Mander et al., 2008). On the other hand, there are more measurements of CH_4 and N_2O emission from full-scale CWs: CH_4 by Tanner et al. (1997), Xue et al. (1999), Johansson et al. (2004), and Chiemchaisri et al. (2008); N_2O by Fey et al. (1999) and Johansson et al. (2003); and both CH_4 and N_2O by Tai et al. (2002), Wild et al. (2001), Mander et al. (2003, 2005a,b, 2008, 2011), Stadmark and Leonardson (2005), Teiter and Mander (2005), Liikanen et al. (2006), Søvik et al. (2006), Gui et al. (2007), Picek et al. (2007), Søvik and Kløve (2007), Ström et al. (2006), Liu et al. (2009), and Van der Zaag et al. (2010).

Assumptions

Assumed wetland operating at all times, and emissions are commensurate with increases in leachate flow.

Assumed CO2 emissions are negligible, based on sequestration potential of CWs and research studies referenced below.

"The removal efficiency of carbon (C) and nitrogen (N) in constructed wetlands (CWs) is very inconsistent and frequently does not reveal whether the removal processes are due to physical attenuation or whether the different species have been transformed to other reactive forms. Previous research on nutrient removal in CWs did not consider the dynamics of pollution swapping (the increase of one pollutant as a result of a measure introduced to reduce a different pollutant) driven by transformational processes within and around the system." from *https://www.hydrol-earth-syst-sci.net/20/109/2016/ Jahangir, M. M. R., Richards, K. G., Healy, M. G., Gill, L., Müller, C., Johnston, P., and Fenton, O.: Carbon and nitrogen dynamics and greenhouse gas emissions in constructed wetlands treating wastewater: a review, Hydrol. Earth Syst. Sci., 20, 109-123, https://doi.org/10.5194/hess-20-109-2016, 2016.*

Assumed only significant emissions are from N2O and CH4. Due to the lack of significant and verifiable data, and literature remarking the difficulty in estimating GHG emissions from constructed wetlands, only the total average N2O and CH4 emission factors for Vertical Sub Surface Flow (VSSF) wetland were considered.

Assumed leachate influent quality does not change with time

Assumed : TOC = 0.5 BOD (Garcia et al., 2007)
Assumed leachate generation proportional to annual waste tonnages
Only NH3-N available. Therefore assumed all N in NH3-N consumed and converted to N2O

Activity Data

Influent Quality

$BOD_{5\ day}$	100	mg/l
TOC[1]	50	mg/l
NH3 - N	40	mg/l

Note: Influent quality data obtained from Phase I Design Report (30% Submission), Landfill and Waste Transfer Station - City of Iqaluit (June 2019)

[1]Estimate of TOC from BOD obtained from Mander et Al. (2014), Greenhouse gas emission in constructed wetlands for wastewater treatment: A review (Accessed: August 28 2019)
https://ainfo.cnptia.embrapa.br/digital/bitstream/item/96779/1/Mander-et-al-2014-EcolEng-on-GHGs-in-CWs-ONLINE.pdf

Annual Leachate Generation (2096)

4400 m3/year

Note: Annual leachate generation data obtained from Phase I Design Report (30% Submission), Landfill and Waste Transfer Station - City of Iqaluit (June 2019)

Emission Factors

Vertical Subsurface Flow Wetlands

CH4-C/TOC (median)	1.28%
N2O-N/TOC (median)	0.018%

Note: VSSF emission factors obtained from Mander et Al. (2014), *Greenhouse gas emission in constructed wetlands for wastewater treatment: A review (Accessed: August 28 2019)*
https://ainfo.cnptia.embrapa.br/digital/bitstream/item/96779/1/Mander-et-al-2014-EcolEng-on-GHGs-in-CWs-ONLINE.pdf

Total Annual Emissions (2096)

CH4

TOC	220	kg/year
CH4-C	2.82	kg/year
CH4	3.76	kg/year

Note: Emissions estimated following equations from Mander et Al. (2014), Greenhouse gas emission in constructed wetlands for wastewater treatment: A review (Accessed: August 28 2019)
https://ainfo.cnptia.embrapa.br/digital/bitstream/item/96779/1/Mander-et-al-2014-EcolEng-on-GHGs-in-CWs-ONLINE.pdf

N2O

NH3-N	176.00	kg/year
N2O-N	0.032	kg/year
N2O	0.05	kg/year

Note: Emissions estimated following equations from Mander et Al. (2014), Greenhouse gas emission in constructed wetlands for wastewater treatment: A review (Accessed: August 28 2019)
https://ainfo.cnptia.embrapa.br/digital/bitstream/item/96779/1/Mander-et-al-2014-EcolEng-on-GHGs-in-CWs-ONLINE.pdf

Base Year Emissions (2096) - Constructed Wetland Leachate Treatment

Source	Emissions (tonnes)			Emissions (tonnes CO_2e)		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Constructed Wetland - Leachate Treatment	-	0.00	0.000	-	0.09	0.015

Global Warming Potentials	CO_2	CH_4	N_2O
	1	25	298

Project 2030 - Constructed Wetland Leachate Treatment						
-	Emissions (tonnes)			Emissions (tonnes CO_2e)		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Total Emissions in 2030	-	0.00 tonnes	0.00 tonnes	-	0.01 tonnes	0.00 tonnes
Total Cumulative Emissions from 2021 to 2030	0 tonnes	0.00 tonnes	0.00 tonnes	0.00 tonnes	0.03 tonnes	0.00 tonnes

Project Year	Year	Annual MSW (tonnes)	Cumulative MSW (tonnes)	Annual Leachate (m3)	Constructed Wetland Leachate Treatment Emissions						Total CO_2e Emissions
					CO_2 emissions (tonnes)	CH_4 emissions (tonnes)	N_2O emissions (tonnes)	CO_2 emissions (tonnes CO_2e)	CH_4 emissions (tonnes CO_2e)	N_2O emissions (tonnes CO_2e)	
1	2021	8,789	17,369	40	-	0.0000	0.0000	-	0.00	0.00	0.00
2	2022	9,002	26,371	61	-	0.0001	0.0000	-	0.00	0.00	0.00
3	2023	9,221	35,591	83	-	0.0001	0.0000	-	0.00	0.00	0.00
4	2024	9,445	45,036	105	-	0.0001	0.0000	-	0.00	0.00	0.00
5	2025	9,674	54,711	127	-	0.0001	0.0000	-	0.00	0.00	0.00
6	2026	9,910	64,620	150	-	0.0001	0.0000	-	0.00	0.00	0.00
7	2027	10,150	74,771	174	-	0.0001	0.0000	-	0.00	0.00	0.00
8	2028	10,397	85,168	198	-	0.0002	0.0000	-	0.00	0.00	0.00
9	2029	10,650	95,818	223	-	0.0002	0.0000	-	0.00	0.00	0.01
10	2030	10,909	106,726	248	-	0.0002	0.0000	-	0.01	0.00	0.01
11	2031	11,174	117,900	275	-	0.0002	0.0000	-	0.01	0.00	0.01
12	2032	11,445	129,345	301	-	0.0003	0.0000	-	0.01	0.00	0.01
13	2033	11,723	141,068	328	-	0.0003	0.0000	-	0.01	0.00	0.01
14	2034	12,008	153,076	356	-	0.0003	0.0000	-	0.01	0.00	0.01
15	2035	12,300	165,376	385	-	0.0003	0.0000	-	0.01	0.00	0.01
16	2036	12,599	177,975	414	-	0.0004	0.0000	-	0.01	0.00	0.01
17	2037	12,905	190,880	444	-	0.0004	0.0000	-	0.01	0.00	0.01
18	2038	13,219	204,099	475	-	0.0004	0.0000	-	0.01	0.00	0.01
19	2039	13,540	217,639	507	-	0.0004	0.0000	-	0.01	0.00	0.01
20	2040	13,869	231,508	539	-	0.0005	0.0000	-	0.01	0.00	0.01
21	2041	14,206	245,714	572	-	0.0005	0.0000	-	0.01	0.00	0.01
22	2042	14,551	260,265	606	-	0.0005	0.0000	-	0.01	0.00	0.02
23	2043	14,905	275,170	641	-	0.0005	0.0000	-	0.01	0.00	0.02
24	2044	15,267	290,437	676	-	0.0006	0.0000	-	0.01	0.00	0.02
25	2045	15,638	306,075	713	-	0.0006	0.0000	-	0.02	0.00	0.02
26	2046	16,018	322,093	750	-	0.0006	0.0000	-	0.02	0.00	0.02
27	2047	16,407	338,501	788	-	0.0007	0.0000	-	0.02	0.00	0.02
28	2048	16,806	355,307	827	-	0.0007	0.0000	-	0.02	0.00	0.02
29	2049	17,215	372,521	867	-	0.0007	0.0000	-	0.02	0.00	0.02
30	2050	17,633	390,154	908	-	0.0008	0.0000	-	0.02	0.00	0.02
31	2051	18,061	408,215	950	-	0.0008	0.0000	-	0.02	0.00	0.02
32	2052	18,500	426,716	994	-	0.0008	0.0000	-	0.02	0.00	0.02
33	2053	18,950	445,666	1038	-	0.0009	0.0000	-	0.02	0.00	0.03
34	2054	19,410	465,076	1083	-	0.0009	0.0000	-	0.02	0.00	0.03
35	2055	19,882	484,958	1129	-	0.0010	0.0000	-	0.02	0.00	0.03
36	2056	20,365	505,323	1177	-	0.0010	0.0000	-	0.03	0.00	0.03
37	2057	20,860	526,183	1225	-	0.0010	0.0000	-	0.03	0.00	0.03
38	2058	21,367	547,551	1275	-	0.0011	0.0000	-	0.03	0.00	0.03
39	2059	21,886	569,437	1326	-	0.0011	0.0000	-	0.03	0.00	0.03
40	2060	22,418	591,855	1378	-	0.0012	0.0000	-	0.03	0.00	0.03
41	2061	22,963	614,818	1431	-	0.0012	0.0000	-	0.03	0.00	0.04
42	2062	23,521	638,339	1486	-	0.0013	0.0000	-	0.03	0.01	0.04
43	2063	24,093	662,432	1542	-	0.0013	0.0000	-	0.03	0.01	0.04
44	2064	24,678	687,110	1600	-	0.0014	0.0000	-	0.03	0.01	0.04
45	2065	25,278	712,388	1659	-	0.0014	0.0000	-	0.04	0.01	0.04
46	2066	25,892	738,280	1719	-	0.0015	0.0000	-	0.04	0.01	0.04
47	2067	26,521	764,801	1781	-	0.0015	0.0000	-	0.04	0.01	0.04
48	2068	27,166	791,967	1844	-	0.0016	0.0000	-	0.04	0.01	0.05
49	2069	27,826	819,793	1909	-	0.0016	0.0000	-	0.04	0.01	0.05
50	2070	28,502	848,296	1975	-	0.0017	0.0000	-	0.04	0.01	0.05
51	2071	29,195	877,490	2043	-	0.0017	0.0000	-	0.04	0.01	0.05
52	2072	29,904	907,395	2113	-	0.0018	0.0000	-	0.05	0.01	0.05
53	2073	30,631	938,026	2184	-	0.0019	0.0000	-	0.05	0.01	0.05
54	2074	31,376	969,402	2257	-	0.0019	0.0000	-	0.05	0.01	0.06
55	2075	32,138	1,001,540	2332	-	0.0020	0.0000	-	0.05	0.01	0.06
56	2076	32,919	1,034,459	2409	-	0.0021	0.0000	-	0.05	0.01	0.06
57	2077	33,719	1,068,178	2487	-	0.0021	0.0000	-	0.05	0.01	0.06
58	2078	34,538	1,102,716	2567	-	0.0022	0.0000	-	0.05	0.01	0.06
59	2079	35,378	1,138,094	2650	-	0.0023	0.0000	-	0.06	0.01	0.07
60	2080	36,237	1,174,331	2734	-	0.0023	0.0000	-	0.06	0.01	0.07
61	2081	37,118	1,211,449	2821	-	0.0024	0.0000	-	0.06	0.01	0.07
62	2082	38,020	1,249,469	2909	-	0.0025	0.0000	-	0.06	0.01	0.07
63	2083	38,944	1,288,414	3000	-	0.0026	0.0000	-	0.06	0.01	0.07
64	2084	39,890	1,328,304	3093	-	0.0026	0.0000	-	0.07	0.01	0.08
65	2085	40,860	1,369,164	3188	-	0.0027	0.0000	-	0.07	0.01	0.08
66	2086	41,853	1,411,017	3285	-	0.0028	0.0000	-	0.07	0.01	0.08
67	2087	42,870	1,453,887	3385	-	0.0029	0.0000	-	0.07	0.01	0.08
68	2088	43,912	1,497,798	3487	-	0.0030	0.0000	-	0.07	0.01	0.09
69	2089	44,979	1,542,777	3592	-	0.0031	0.0000	-	0.08	0.01	0.09

70	2090	46,072	1,588,849	3699	-	0.0032	0.0000	-	0.08	0.01	0.09
71	2091	47,192	1,636,041	3809	-	0.0033	0.0000	-	0.08	0.01	0.09
72	2092	48,338	1,684,379	3922	-	0.0034	0.0000	-	0.08	0.01	0.10
73	2093	49,513	1,733,892	4037	-	0.0035	0.0000	-	0.09	0.01	0.10
74	2094	50,716	1,784,609	4155	-	0.0036	0.0000	-	0.09	0.01	0.10
75	2095	51,949	1,836,557	4276	-	0.0037	0.0000	-	0.09	0.01	0.11
76	2096	53,211	1,889,769	4400	-	0.0038	0.0000	-	0.09	0.01	0.11

References and Data Sources

Mander-et-al-2014-EcolEng-on-GHGs-in-CWs-ONLINE

Supports assumption that CO2 emissions are negligible

Average emission rates for CH4 and N20

Jahangir, M. M. R., Richards, K. G., Healy, M. G., Gill, L., Müller, C., Johnston, P., and Fent -

Supports assumption that CO2 emissions are negligible

PROJECT GHG EMISSIONS

Table S1-B

RESULTS

Landfill Name or Identifier: Iqaluit Landfill

Closure Year (with 80-year limit) = 2095

Methane = 50 *% by volume*

Please choose a third unit of measure to represent all of the emission rates below.

User-specified Unit: av ft^3/min

2: DETERMINE MODEL PARAMETERS		
Methane Generation Rate, k ($year^{-1}$)	User specified value	0.010
Potential Methane Generation Capacity, L_o (m^3/Mg)	User specified value	18
NMOC Concentration (*ppmv as hexane*)	User specified value	4,000
Methane Content (*% by volume*)	User specified value	50

Year	Waste Accepted		Waste-In-Place		Total landfill gas			Methane			Carbon dioxide			NMOC			CO2e
	(Mg/year)	(short tons/year)	(Mg)	(short tons)	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)	(tonne/year)
2021	2,197	2,417	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
2022	9,002	9,902	2,197	2,417	9.833E-01	7.874E+02	5.290E-02	2.626E-01	3.937E+02	2.645E-02	7.206E-01	3.937E+02	2.645E-02	1.129E-02	3.149E+00	2.116E-04	7.29
2023	9,221	10,143	11,199	12,319	5.002E+00	4.006E+03	2.691E-01	1.336E+00	2.003E+03	1.346E-01	3.666E+00	2.003E+03	1.346E-01	5.743E-02	1.602E+01	1.077E-03	37.07
2024	9,445	10,390	20,420	22,462	9.080E+00	7.271E+03	4.885E-01	2.425E+00	3.635E+03	2.443E-01	6.654E+00	3.635E+03	2.443E-01	1.042E-01	2.908E+01	1.954E-03	67.29
2025	9,674	10,641	29,865	32,852	1.322E+01	1.058E+04	7.111E-01	3.530E+00	5.292E+03	3.555E-01	9.686E+00	5.292E+03	3.555E-01	1.517E-01	4.233E+01	2.844E-03	97.94
2026	9,910	10,901	39,539	43,493	1.741E+01	1.394E+04	9.370E-01	4.652E+00	6.972E+03	4.685E-01	1.276E+01	6.972E+03	4.685E-01	1.999E-01	5.578E+01	3.748E-03	129.05
2027	10,150	11,165	49,449	54,394	2.168E+01	1.736E+04	1.166E+00	5.790E+00	8.679E+03	5.831E-01	1.589E+01	8.679E+03	5.831E-01	2.489E-01	6.943E+01	4.665E-03	160.64
2028	10,397	11,437	59,599	65,559	2.600E+01	2.082E+04	1.399E+00	6.946E+00	1.041E+04	6.995E-01	1.906E+01	1.041E+04	6.995E-01	2.986E-01	8.329E+01	5.596E-03	192.70
2029	10,650	11,715	69,996	76,996	3.040E+01	2.434E+04	1.636E+00	8.120E+00	1.217E+04	8.178E-01	2.228E+01	1.217E+04	8.178E-01	3.490E-01	9.737E+01	6.542E-03	225.27
2030	10,909	12,000	80,646	88,711	3.486E+01	2.792E+04	1.876E+00	9.312E+00	1.396E+04	9.378E-01	2.555E+01	1.396E+04	9.378E-01	4.003E-01	1.117E+02	7.503E-03	258.35
2031	11,174	12,291	91,555	100,711	3.940E+01	3.155E+04	2.120E+00	1.052E+01	1.577E+04	1.060E+00	2.887E+01	1.577E+04	1.060E+00	4.523E-01	1.262E+02	8.479E-03	291.96
2032	11,445	12,590	102,729	113,002	4.401E+01	3.524E+04	2.368E+00	1.175E+01	1.762E+04	1.184E+00	3.225E+01	1.762E+04	1.184E+00	5.052E-01	1.410E+02	9.471E-03	326.12
2033	11,723	12,895	114,174	125,591	4.869E+01	3.899E+04	2.620E+00	1.301E+01	1.949E+04	1.310E+00	3.569E+01	1.949E+04	1.310E+00	5.590E-01	1.560E+02	1.048E-02	360.83
2034	12,008	13,209	125,897	138,487	5.345E+01	4.280E+04	2.876E+00	1.428E+01	2.140E+04	1.438E+00	3.918E+01	2.140E+04	1.438E+00	6.137E-01	1.712E+02	1.150E-02	396.13
2035	12,300	13,530	137,905	151,696	5.830E+01	4.668E+04	3.136E+00	1.557E+01	2.334E+04	1.568E+00	4.272E+01	2.334E+04	1.568E+00	6.693E-01	1.867E+02	1.255E-02	432.01
2036	12,599	13,859	150,205	165,226	6.322E+01	5.062E+04	3.401E+00	1.689E+01	2.531E+04	1.701E+00	4.633E+01	2.531E+04	1.701E+00	7.258E-01	2.025E+02	1.361E-02	468.51
2037	12,905	14,196	162,804	179,084	6.823E+01	5.464E+04	3.671E+00	1.823E+01	2.732E+04	1.835E+00	5.001E+01	2.732E+04	1.835E+00	7.834E-01	2.185E+02	1.468E-02	505.63
2038	13,219	14,541	175,709	193,280	7.333E+01	5.872E+04	3.945E+00	1.959E+01	2.936E+04	1.973E+00	5.374E+01	2.936E+04	1.973E+00	8.419E-01	2.349E+02	1.578E-02	543.41
2039	13,540	14,894	188,928	207,821	7.851E+01	6.287E+04	4.224E+00	2.097E+01	3.144E+04	2.112E+00	5.754E+01	3.144E+04	2.112E+00	9.014E-01	2.515E+02	1.690E-02	581.84
2040	13,869	15,256	202,468	222,715	8.379E+01	6.710E+04	4.508E+00	2.238E+01	3.355E+04	2.254E+00	6.141E+01	3.355E+04	2.254E+00	9.620E-01	2.684E+02	1.803E-02	620.96
2041	14,206	15,627	216,337	237,971	8.917E+01	7.140E+04	4.797E+00	2.382E+01	3.570E+04	2.399E+00	6.535E+01	3.570E+04	2.399E+00	1.024E+00	2.856E+02	1.919E-02	660.78
2042	14,551	16,006	230,543	253,597	9.464E+01	7.578E+04	5.092E+00	2.528E+01	3.789E+04	2.546E+00	6.936E+01	3.789E+04	2.546E+00	1.087E+00	3.031E+02	2.037E-02	701.32
2043	14,905	16,396	245,094	269,603	1.002E+02	8.024E+04	5.391E+00	2.677E+01	4.012E+04	2.696E+00	7.344E+01	4.012E+04	2.696E+00	1.150E+00	3.210E+02	2.157E-02	742.61
2044	15,267	16,794	259,999	285,999	1.059E+02	8.479E+04	5.697E+00	2.828E+01	4.239E+04	2.848E+00	7.760E+01	4.239E+04	2.848E+00	1.216E+00	3.391E+02	2.279E-02	784.65
2045	15,638	17,202	275,266	302,793	1.117E+02	8.941E+04	6.008E+00	2.983E+01	4.471E+04	3.004E+00	8.184E+01	4.471E+04	3.004E+00	1.282E+00	3.577E+02	2.403E-02	827.48
2046	16,018	17,620	290,904	319,994	1.175E+02	9.413E+04	6.324E+00	3.140E+01	4.706E+04	3.162E+00	8.615E+01	4.706E+04	3.162E+00	1.350E+00	3.765E+02	2.530E-02	871.12
2047	16,407	18,048	306,922	337,614	1.235E+02	9.893E+04	6.647E+00	3.300E+01	4.947E+04	3.324E+00	9.055E+01	4.947E+04	3.324E+00	1.418E+00	3.957E+02	2.659E-02	915.58
2048	16,806	18,487	323,329	355,662	1.297E+02	1.038E+05	6.976E+00	3.463E+01	5.191E+04	3.488E+00	9.503E+01	5.191E+04	3.488E+00	1.489E+00	4.153E+02	2.790E-02	960.88
2049	17,215	18,937	340,135	374,149	1.359E+02	1.088E+05	7.311E+00	3.630E+01	5.441E+04	3.656E+00	9.960E+01	5.441E+04	3.656E+00	1.560E+00	4.353E+02	2.925E-02	1,007.06
2050	17,633	19,396	357,350	393,085	1.422E+02	1.139E+05	7.653E+00	3.800E+01	5.695E+04	3.827E+00	1.043E+02	5.695E+04	3.827E+00	1.633E+00	4.556E+02	3.061E-02	1,054.14
2051	18,061	19,867	374,983	412,481	1.487E+02	1.191E+05	8.002E+00	3.973E+01	5.955E+04	4.001E+00	1.090E+02	5.955E+04	4.001E+00	1.708E+00	4.764E+02	3.201E-02	1,102.13
2052	18,500	20,350	393,044	432,348	1.553E+02	1.244E+05	8.357E+00	4.149E+01	6.219E+04	4.178E+00	1.138E+02	6.219E+04	4.178E+00	1.783E+00	4.975E+02	3.343E-02	1,151.07
2053	18,950	20,845	411,544	452,698	1.621E+02	1.298E+05	8.719E+00	4.329E+01	6.489E+04	4.360E+00	1.188E+02	6.489E+04	4.360E+00	1.861E+00	5.191E+02	3.488E-02	1,200.98
2054	19,410	21,351	430,494	473,543	1.689E+02	1.353E+05	9.089E+00	4.512E+01	6.764E+04	4.544E+00	1.238E+02	6.764E+04	4.544E+00	1.939E+00	5.411E+02	3.636E-02	1,251.88
2055	19,882	21,870	449,904	494,894	1.759E+02	1.409E+05	9.466E+00	4.699E+01	7.044E+04	4.733E+00	1.289E+02	7.044E+04	4.733E+00	2.020E+00	5.635E+02	3.786E-02	1,303.80
2056	20,365	22,402	469,786	516,765	1.831E+02	1.466E+05	9.850E+00	4.890E+01	7.330E+04	4.925E+00	1.342E+02	7.330E+04	4.925E+00	2.102E+00	5.864E+02	3.940E-02	1,356.77
2057	20,860	22,946	490,151	539,166	1.904E+02	1.524E+05	1.024E+01	5.085E+01	7.622E+04	5.121E+00	1.395E+02	7.622E+04	5.121E+00	2.186E+00	6.098E+02	4.097E-02	1,410.81
2058	21,367	23,504	511,011	562,112	1.978E+02	1.584E+05	1.064E+01	5.284E+01	7.920E+04	5.322E+00	1.450E+02	7.920E+04	5.322E+00	2.271E+00	6.336E+02	4.257E-02	1,465.96
2059	21,886	24,075	532,378	585,616	2.054E+02	1.645E+05	1.105E+01	5.487E+01	8.224E+04	5.526E+00	1.505E+02	8.224E+04	5.526E+00	2.358E+00	6.579E+02	4.421E-02	1,522.24
2060	22,418	24,660	554,264	609,690	2.132E+02	1.707E+05	1.147E+01	5.694E+01	8.535E+04	5.734E+00	1.562E+02	8.535E+04	5.734E+00	2.447E+00	6.828E+02	4.588E-02	1,579.69
2061	22,963	25,259	576,682	634,350	2.211E+02	1.770E+05	1.189E+01	5.905E+01	8.851E+04	5.947E+00	1.620E+02	8.851E+04	5.947E+00	2.538E+00	7.081E+02	4.758E-02	1,638.32
2062	23,521	25,873	599,645	659,610	2.292E+02	1.835E+05	1.233E+01	6.121E+01	9.175E+04	6.165E+00	1.679E+02	9.175E+04	6.165E+00	2.631E+00	7.340E+02	4.932E-02	1,698.18
2063	24,093	26,502	623,166	685,483	2.374E+02	1.901E+05	1.277E+01	6.341E+01	9.505E+04	6.386E+00	1.740E+02	9.505E+04	6.386E+00	2.726E+00	7.604E+02	5.109E-02	1,759.30
2064	24,678	27,146	647,259	711,985	2.458E+02	1.968E+05	1.323E+01	6.566E+01	9.842E+04	6.613E+00	1.802E+02	9.842E+04	6.613E+00	2.822E+00	7.874E+02	5.290E-02	1,821.70
2065	25,278	27,806	671,937	739,131	2.544E+02	2.037E+05	1.369E+01	6.796E+01	1.019E+05	6.844E+00	1.865E+02	1.019E+05	6.844E+00	2.921E+00	8.149E+02	5.475E-02	1,885.43
2066	25,892	28,481	697,215	766,937	2.632E+02	2.108E+05	1.416E+01	7.030E+01	1.054E+05	7.080E+00	1.929E+02	1.054E+05	7.080E+00	3.022E+00	8.430E+02	5.664E-02	1,950.51
2067	26,521	29,173	723,107	795,418	2.722E+02	2.179E+05	1.464E+01	7.270E+01	1.090E+05	7.322E+00	1.995E+02	1.090E+05	7.322E+00	3.125E+00	8.718E+02	5.857E-02	2,016.97
2068	27,166	29,883	749,628	824,591	2.813E+02	2.253E+05	1.514E+01	7.515E+01	1.126E+05	7.568E+00	2.062E+02	1.126E+05	7.568E+00	3.230E+00	9.011E+02	6.055E-02	2,084.87
2069	27,826	30,609	776,794	854,473	2.907E+02	2.328E+05	1.564E+01	7.765E+01	1.164E+05	7.820E+00	2.130E+02	1.164E+05	7.820E+00	3.337E+00	9.311E+02	6.256E-02	2,154.22
2070	28,502	31,352	804,620	885,082	3.003E+02	2.404E+05	1.615E+01	8.020E+01	1.202E+05	8.077E+00	2.201E+02	1.202E+05	8.077E+00	3.447E+00	9.617E+02	6.462E-02	2,225.08
2071	29,195	32,115	833,122	916,434	3.100E+02	2.483E+05	1.668E+01	8.281E+01	1.241E+05	8.340E+00	2.272E+02	1.241E+05	8.340E+00	3.559E+00	9.930E+02	6.672E-02	2,297.47
2072	29,904	32,894	862,317	948,549	3.200E+02	2.562E+05	1.722E+01	8.548E+01	1.281E+05	8.609E+00	2.345E+02	1.281E+05	8.609E+00	3.674E+00	1.025E+03	6.887E-02	2,371.44
2073	30,631	33,694	892,221	981,443	3.302E+02	2.644E+05	1.777E+01	8.820E+01	1.322E+05	8.883E+00	2.420E+02	1.322E+05	8.883E+00	3.791E+00	1.058E+03	7.106E-02	2,447.03
2074	31,376	34,514	922,852	1,015,137	3.406E+02	2.728E+05	1.833E+01	9.099E+01	1.364E+05	9.163E+00	2.496E+02	1.364E+05	9.163E+00	3.911E+00	1.091E+03	7.331E-02	2,524.28
2075	32,138	35,352	954,228	1,049,651	3.513E+02	2.813E+05	1.890E+01	9.383E+01	1.406E+05	9.450E+00	2.575E+02	1.406E+05	9.450E+00	4.033E+00	1.125E+03	7.560E-02	2,603.23
2076	32,919	36,211	986,366	1,085,003	3.622E+02	2.900E+05	1.949E+01	9.674E+01	1.450E+05	9.743E+00	2.654E+02	1.450E+05	9.743E+00	4.158E+00	1.160E+03	7.794E-02	2,683.92
2077	33,719	37,091	1,019,285	1,121,214	3.733E+02	2.989E+05	2.008E+01	9.971E+01	1.495E+05	1.004E+01	2.736E+02	1.495E+05	1.004E+01	4.286E+00	1.196E+03	8.034E-02	2,766.39
2078	34,538	37,992	1,053,004	1,158,304	3.847E+02	3.080E+05	2.070E+01	1.028E+02	1.540E+05	1.035E+01	2.819E+02	1.540E+05	1.035E+01	4.417E+00	1.232E+03	8.279E-02	2,850.70
2079	35,378	38,916	1,087,542	1,196,296	3.963E+02	3.173E+05	2.132E+01	1.059E+02	1.587E+05	1.066E+01	2.904E+02	1.587E+05	1.066E+01	4.550E+00	1.269E+03	8.529E-02	2,936.89
2080	36,237	39,861	1,122,920	1,235,212	4.082E+02	3.269E+05	2.196E+01	1.090E+02	1.634E+05	1.098E+01	2.992E+02	1.634E+05	1.098E+01	4.687E+00	1.307E+03	8.785E-02	3,025.01
2081	37,118	40,830	1,159,157	1,275,073	4.204E+02	3.366E+05	2.262E+01	1.123E+02	1.683E+05	1.131E+01	3.081E+02	1.683E+05	1.131E+01	4.826E+00	1.346E+03	9.046E-02	3,115.09
2082	38,020	41,822	1,196,275	1,315,903	4.328E+02	3.466E+05	2.328E+01	1.156E+02	1.733E+05	1.164E+01	3.172E+02	1.733E+05	1.164E+01	4.969E+00	1.386E+03	9.314E-02	3,207.21
2083	38,944	42,838	1,234,295	1,357,725	4.455E+02	3.567E+05	2.397E+01	1.190E+02	1.784E+05	1.198E+01	3.265E+02	1.784E+05	1.198E+01	5.115E+00	1.427E+03	9.587E-02	3,301.40
2084	39,890	43,879	1,273,239	1,400,563	4.585E+02	3.671E+05	2.467E+01	1.225E+02	1.836E+05	1.233E+01	3.360E+02	1.836E+05	1.233E+01	5.264E+00	1.469E+03	9.867E-02	3,397.71
2085	40,860	44,946	1,313,129	1,444,442	4.718E+02	3.778E+05	2.538E+01	1.260E+02	1.889E+05	1.269E+01	3.458E+02	1.889E+05	1.269E+01	5.417E+00	1.511E+03	1.015E-01	3,496.21
2086	41,853	46,038	1,353,989	1,489,388	4.854E+02	3.887E+05	2.611E+01	1.296E+02	1.943E+05	1.306E+01	3.557E+02	1.943E+05	1.306E+01	5.573E+00	1.555E+03	1.045E-01	3,596.94
2087	42,870	47,157	1,395,842	1,535,426	4.993E+02	3.998E+05	2.686E+01	1.334E+02	1.999E+05	1.343E+01	3.659E+02	1.999E+05	1.343E+01	5.732E+00	1.599E+03	1.074E-01	3,699.97
2088	43,912	48,303	1,438,712	1,582,583	5.135E+02	4.112E+05	2.763E+01	1.372E+02	2.056E+05	1.381E+01	3.763E+02	2.056E+05	1.381E+01	5.895E+00	1.645E+03	1.105E-01	3,805.34
2089	44,979	49,477	1,482,624	1,630,886	5.280E+02	4.228E+05	2.841E+01	1.410E+02	2.114E+05	1.420E+01	3.870E+02	2.114E+05	1.420E+01	6.062E+00	1.691E+03	1.136E-01	3,913.12
2090	46,072	50,679	1,527,603	1,680,363	5.429E+02	4.347E+05	2.921E+01	1.450E+02	2.174E+05	1.461E+01	3.979E+02	2.174E+05	1.461E+01	6.233E+00	1.739E+03	1.168E-01	4,023.37
2091	47,192	51,911	1,573,675	1,731,043	5.581E+02	4.469E+05	3.003E+01	1.491E+02	2.235E+05	1.501E+01	4.091E+02	2.235E+05	1.501E+01	6.408E+00	1.788E+03	1.201E-01	4,136.14
2092	48,338	53,172	1,620,867	1,782,954	5.737E+02	4.594E+05	3.087E+01	1.532E+02	2.297E+05	1.543E+01	4.205E+02	2.297E+05	1.543E+01	6.587E+00	1.838E+03	1.235E-01	4,251.51
2093	49,513	54,464	1,669,205	1,836,126	5.896E+02	4.721E+05	3.172E+01	1.575E+02	2.361E+05	1.586E+01	4.321E+02	2.361E+05	1.586E+01	6.770E+00	1.889E+03	1.269E-01	4,369.53
2094	50,716	55,788	1,718,718	1,890,590	6.059E+02	4.852E+05	3.260E+01	1.618E+02	2.426E+05	1.630E+01	4.441E+02	2.426E+05	1.630E+01	6.957E+00	1.941E+03	1.304E-01	4,490.27
2095	51,949	57,144	1,769,434	1,946,377	6.226E+02	4.985E+05	3.350E+01	1.663E+02	2.493E+05	1.675E+01	4.563E+02	2.493E+05	1.675E+01	7.148E+00	1.994E+03	1.340E-01	4,613.80
2096	0	0	1,821,383	2,003,521	6.396E+02	5.122E+05	3.441E+01	1.709E+02	2.561E+05	1.721E+01	4.688E+02	2.561E+05	1.721E+01	7.344E+00	2.049E+03	1.377E-01	4,740.19
2097	0	0	1,821,383	2,003,521	6.333E+02	5.071E+05	3.407E+01	1.692E+02	2.536E+05	1.704E+01	4.641E+02	2.536E+05	1.704E+01	7.271E+00	2.028E+03	1.363E-01	
2098	0	0	1,821,383	2,003,521	6.270E+02	5.021E+05	3.373E+01	1.675E+02	2.510E+05	1.687E+01	4.595E+02	2.510E+05	1.687E+01	7.198E+00	2.008E+03	1.349E-01	
2099	0	0	1,821,383	2,003,521	6.207E+02	4.971E+05	3.340E+01	1.658E+02	2.485E+05	1.670E+01	4.549E+02	2.485E+05	1.670E+01	7.127E+00	1.988E+03	1.336E-01	
2100	0	0	1,821,383	2,003,521	6.146E+02	4.921E+05	3.307E+01	1.642E+02	2.461E+05	1.653E+01	4.504E+02	2.461E+05	1.653E+01	7.056E+00	1.968E+03	1.323E-01	
2101	0	0	1,821,383	2,003,521	6.084E+02	4.872E+05	3.274E+01	1.625E+02	2.436E+05	1.637E+01	4.459E+02	2.436E+05	1.637E+01	6.986E+00	1.949E+03	1.309E-01	
2102	0	0	1,821,383	2,003,521	6.024E+02	4.824E+05	3.241E+01	1.609E+02	2.412E+05	1.621E+01	4.415E+02	2.412E+05	1.621E+01	6.916E+00	1.929E+03	1.296E-01	
2103	0	0	1,821,383	2,003,521	5.964E+02	4.776E+05	3.209E+01	1.593E+02	2.388E+05	1.604E+01	4.371E+02	2.388E+05	1.604E+01	6.847E+00	1.910E+03	1.284E-01	
2104	0	0	1,821,383	2,003,521	5.905E+02	4.728E+05	3.177E+01	1.577E+02	2.364E+05	1.588E+01	4.327E+02	2.364E+05	1.588E+01	6.779E+00	1.891E+03	1.271E-01	
2105	0	0	1,821,383	2,003,521	5.846E+02	4.681E+05	3.145E+01	1.562E+02	2.341E+05	1.573E+01	4.284E+02	2.341E+05	1.573E+01	6.712E+00	1.872E+03	1.258E-01	
2106	0	0	1,821,383	2,003,521	5.788E+02	4.635E+05	3.114E+01	1.546E+02	2.317E+05	1.557E+01	4.242E+02	2.317E+05	1.557E+01	6.645E+00	1.854E+03	1.246E-01	
2107	0	0	1,821,383	2,003,521	5.730E+02	4.588E+05	3.083E+01	1.531E+02	2.294E+05	1.541E+01	4.200E+02	2.294E+05	1.541E+01	6.579E+00	1.835E+03	1.233E-01	
2108	0	0	1,821,383	2,003,521	5.673E+02	4.543E+05	3.052E+01	1.515E+02	2.271E+05	1.526E+01	4.158E+02	2.271E+05	1.526E+01	6.513E+00	1.817E+03	1.221E-01	
2109	0	0	1,821,383	2,003,521	5.617E+02	4.498E+05	3.022E+01	1.500E+02	2.249E+05	1.511E+01	4.116E+02	2.249E+05	1.511E+01	6.449E+00	1.799E+03	1.209E-01	
2110	0	0	1,821,383	2,003,521	5.561E+02	4.453E+05	2.992E+01	1.485E+02	2.226E+05	1.496E+01	4.075E+02	2.226E+05	1.496E+01	6.384E+00	1.781E+03	1.197E-01	
2111	0	0	1,821,383	2,003,521	5.505E+02	4.409E+05	2.962E+01	1.471E+02	2.204E+05	1.481E+01	4.035E+02	2.204E+05	1.481E+01	6.321E+00	1.763E+03	1.185E-01	
2112	0	0	1,821,383	2,003,521	5.451E+02	4.365E+05	2.933E+01	1.456E+02	2.182E+05	1.466E+01	3.995E+02	2.182E+05	1.466E+01	6.258E+00	1.746E+03	1.173E-01	
2113	0	0	1,821,383	2,003,521	5.396E+02	4.321E+05	2.903E+01	1.441E+02	2.161E+05	1.452E+01	3.955E+02	2.161E+05	1.452E+01	6.196E+00	1.728E+03	1.161E-01	
2114	0	0	1,821,383	2,003,521	5.343E+02	4.278E+05	2.875E+01	1.427E+02	2.139E+05	1.437E+01	3.916E+02	2.139E+05	1.437E+01	6.134E+00	1.711E+03	1.150E-01	
2115	0	0	1,821,383	2,003,521	5.290E+02	4.236E+05	2.846E+01	1.413E+02	2.118E+05	1.423E+01	3.877E+02	2.118E+05	1.423E+01	6.073E+00	1.694E+03	1.138E-01	
2116	0	0	1,821,383	2,003,521	5.237E+02	4.194E+05	2.818E+01	1.399E+02	2.097E+05	1.409E+01	3.838E+02	2.097E+05	1.409E+01	6.013E+00	1.677E+03	1.127E-01	
2117	0	0	1,821,383	2,003,521	5.185E+02	4.152E+05	2.790E+01	1.385E+02	2.076E+05	1.395E+01	3.800E+02	2.076E+05	1.395E+01	5.953E+00	1.661E+03	1.116E-01	
2118	0	0	1,821,383	2,003,521	5.133E+02	4.110E+05	2.762E+01	1.371E+02	2.055E+05	1.381E+01	3.762E+02	2.055E+05	1.381E+01	5.894E+00	1.644E+03	1.105E-01	
2119	0	0	1,821,383	2,003,521	5.082E+02	4.070E+05	2.734E+01	1.358E+02	2.035E+05	1.367E+01	3.725E+02	2.035E+05	1.367E+01	5.835E+00	1.628E+03	1.094E-01	
2120	0	0	1,821,383	2,003,521	5.032E+02	4.029E+05	2.707E+01	1.344E+02	2.015E+05	1.354E+01	3.688E+02	2.015E+05	1.354E+01	5.777E+00	1.612E+03	1.083E-01	
2121	0	0	1,821,383	2,003,521	4.982E+02	3.989E+05	2.680E+01	1.331E+02	1.995E+05	1.340E+01	3.651E+02	1.995E+05	1.340E+01	5.719E+00	1.596E+03	1.072E-01	
2122	0	0	1,821,383	2,003,521	4.932E+02	3.949E+05	2.654E+01	1.317E+02	1.975E+05	1.327E+01	3.615E+02	1.975E+05	1.327E+01	5.662E+00	1.580E+03	1.061E-01	
2123	0	0	1,821,383	2,003,521	4.883E+02	3.910E+05	2.627E+01	1.304E+02	1.955E+05	1.314E+01	3.579E+02	1.955E+05	1.314E+01	5.606E+00	1.564E+03	1.051E-01	
2124	0	0	1,821,383	2,003,521	4.834E+02	3.871E+05	2.601E+01	1.291E+02	1.936E+05	1.300E+01	3.543E+02	1.936E+05	1.300E+01	5.550E+00	1.548E+03	1.040E-01	
2125	0	0	1,821,383	2,003,521	4.786E+02	3.833E+05	2.575E+01	1.278E+02	1.916E+05	1.288E+01	3.508E+02	1.916E+05	1.288E+01	5.495E+00	1.533E+03	1.030E-01	
2126	0	0	1,821,383	2,003,521	4.739E+02	3.794E+05	2.549E+01	1.266E+02	1.897E+05	1.275E+01	3.473E+02	1.897E+05	1.275E+01	5.440E+00	1.518E+03	1.020E-01	
2127	0	0	1,821,383	2,003,521	4.691E+02	3.757E+05	2.524E+01	1.253E+02	1.878E+05	1.262E+01	3.438E+02	1.878E+05	1.262E+01	5.386E+00	1.503E+03	1.010E-01	
2128	0	0	1,821,383	2,003,521	4.645E+02	3.719E+05	2.499E+01	1.241E+02	1.860E+05	1.250E+01	3.404E+02	1.860E+05	1.250E+01	5.333E+00	1.488E+03	9.996E-02	
2129	0	0	1,821,383	2,003,521	4.599E+02	3.682E+05	2.474E+01	1.228E+02	1.841E+05	1.237E+01	3.370E+02	1.841E+05	1.237E+01	5.280E+00	1.473E+03	9.897E-02	
2130	0	0	1,821,383	2,003,521	4.553E+02	3.646E+05	2.450E+01	1.216E+02	1.823E+05	1.225E+01	3.337E+02	1.823E+05	1.225E+01	5.227E+00	1.458E+03	9.798E-02	
2131	0	0	1,821,383	2,003,521	4.508E+02	3.609E+05	2.425E+01	1.204E+02	1.805E+05	1.213E+01	3.304E+02	1.805E+05	1.213E+01	5.175E+00	1.444E+03	9.701E-02	
2132	0	0	1,821,383	2,003,521	4.463E+02	3.573E+05	2.401E+01	1.192E+02	1.787E+05	1.201E+01	3.271E+02	1.787E+05	1.201E+01	5.124E+00	1.429E+03	9.604E-02	
2133	0	0	1,821,383	2,003,521	4.418E+02	3.538E+05	2.377E+01	1.180E+02	1.769E+05	1.189E+01	3.238E+02	1.769E+05	1.189E+01	5.073E+00	1.415E+03	9.509E-02	
2134	0	0	1,821,383	2,003,521	4.374E+02	3.503E+05	2.353E+01	1.168E+02	1.751E+05	1.177E+01	3.206E+02	1.751E+05	1.177E+01	5.022E+00	1.401E+03	9.414E-02	
2135	0	0	1,821,383	2,003,521	4.331E+02	3.468E+05	2.330E+01	1.157E+02	1.734E+05	1.165E+01	3.174E+02	1.734E+05	1.165E+01	4.972E+00	1.387E+03	9.320E-02	
2136	0	0	1,821,383	2,003,521	4.288E+02	3.433E+05	2.307E+01	1.145E+02	1.717E+05	1.153E+01	3.142E+02	1.717E+05	1.153E+01	4.923E+00	1.373E+03	9.228E-02	
2137	0	0	1,821,383	2,003,521	4.245E+02	3.399E+05	2.284E+01	1.134E+02	1.700E+05	1.142E+01	3.111E+02	1.700E+05	1.142E+01	4.874E+00	1.360E+03	9.136E-02	
2138	0	0	1,821,383	2,003,521	4.203E+02	3.365E+05	2.261E+01	1.123E+02	1.683E+05	1.131E+01	3.080E+02	1.683E+05	1.131E+01	4.825E+00	1.346E+03	9.045E-02	
2139	0	0	1,821,383	2,003,521	4.161E+02	3.332E+05	2.239E+01	1.111E+02	1.666E+05	1.119E+01	3.050E+02	1.666E+05	1.119E+01	4.777E+00	1.333E+03	8.955E-02	
2140	0	0	1,821,383	2,003,521	4.120E+02	3.299E+05	2.216E+01	1.100E+02	1.649E+05	1.108E+01	3.019E+02	1.649E+05	1.108E+01	4.730E+00	1.319E+03	8.866E-02	
2141	0	0	1,821,383	2,003,521	4.079E+02	3.266E+05	2.194E+01	1.089E+02	1.633E+05	1.097E+01	2.989E+02	1.633E+05	1.097E+01	4.683E+00	1.306E+03	8.777E-02	
2142	0	0	1,821,383	2,003,521	4.038E+02	3.233E+05	2.173E+01	1.079E+02	1.617E+05	1.086E+01	2.959E+02	1.617E+05	1.086E+01	4.636E+00	1.293E+03	8.690E-02	
2143	0	0	1,821,383	2,003,521	3.998E+02	3.201E+05	2.151E+01	1.068E+02	1.601E+05	1.075E+01	2.930E+02	1.601E+05	1.075E+01	4.590E+00	1.281E+03	8.604E-02	
2144	0	0	1,821,383	2,003,521	3.958E+02	3.169E+05	2.130E+01	1.057E+02	1.585E+05	1.065E+01	2.901E+02	1.585E+05	1.065E+01	4.544E+00	1.268E+03	8.518E-02	
2145	0	0	1,821,383	2,003,521	3.919E+02	3.138E+05	2.108E+01	1.047E+02	1.569E+05	1.054E+01	2.872E+02	1.569E+05	1.054E+01	4.499E+00	1.255E+03	8.433E-02	
2146	0	0	1,821,383	2,003,521	3.880E+02	3.107E+05	2.087E+01	1.036E+02	1.553E+05	1.044E+01	2.843E+02	1.553E+05	1.044E+01	4.454E+00	1.243E+03	8.349E-02	
2147	0	0	1,821,383	2,003,521	3.841E+02	3.076E+05	2.067E+01	1.026E+02	1.538E+05	1.033E+01	2.815E+02	1.538E+05	1.033E+01	4.410E+00	1.230E+03	8.266E-02	
2148	0	0	1,821,383	2,003,521	3.803E+02	3.045E+05	2.046E+01	1.016E+02	1.523E+05	1.023E+01	2.787E+02	1.523E+05	1.023E+01	4.366E+00	1.218E+03	8.184E-02	
2149	0	0	1,821,383	2,003,521	3.765E+02	3.015E+05	2.026E+01	1.006E+02	1.507E+05	1.013E+01	2.759E+02	1.507E+05	1.013E+01	4.323E+00	1.206E+03	8.103E-02	
2150	0	0	1,821,383	2,003,521	3.728E+02	2.985E+05	2.006E+01	9.957E+01	1.492E+05	1.003E+01	2.732E+02	1.492E+05	1.003E+01	4.280E+00	1.194E+03	8.022E-02	
2151	0	0	1,821,383	2,003,521	3.690E+02	2.955E+05	1.986E+01	9.858E+01	1.478E+05	9.928E+00	2.705E+02	1.478E+05	9.928E+00	4.237E+00	1.182E+03	7.942E-02	
2152	0	0	1,821,383	2,003,521	3.654E+02	2.926E+05	1.966E+01	9.759E+01	1.463E+05	9.829E+00	2.678E+02	1.463E+05	9.829E+00	4.195E+00	1.170E+03	7.863E-02	
2153	0	0	1,821,383	2,003,521	3.617E+02	2.897E+05	1.946E+01	9.662E+01	1.448E+05	9.731E+00	2.651E+02	1.448E+05	9.731E+00	4.153E+00	1.159E+03	7.785E-02	

2154	0	0	1,821,383	2,003,521	3.581E+02	2.868E+05	1.927E+01	9.566E+01	1.434E+05	9.634E+00	2.625E+02	1.434E+05	9.634E+00	4.112E+00	1.147E+03	7.707E-02
2155	0	0	1,821,383	2,003,521	3.546E+02	2.839E+05	1.908E+01	9.471E+01	1.420E+05	9.538E+00	2.599E+02	1.420E+05	9.538E+00	4.071E+00	1.136E+03	7.631E-02
2156	0	0	1,821,383	2,003,521	3.510E+02	2.811E+05	1.889E+01	9.377E+01	1.406E+05	9.444E+00	2.573E+02	1.406E+05	9.444E+00	4.030E+00	1.124E+03	7.555E-02
2157	0	0	1,821,383	2,003,521	3.476E+02	2.783E+05	1.870E+01	9.283E+01	1.392E+05	9.350E+00	2.547E+02	1.392E+05	9.350E+00	3.990E+00	1.113E+03	7.480E-02
2158	0	0	1,821,383	2,003,521	3.441E+02	2.755E+05	1.851E+01	9.191E+01	1.378E+05	9.257E+00	2.522E+02	1.378E+05	9.257E+00	3.951E+00	1.102E+03	7.405E-02
2159	0	0	1,821,383	2,003,521	3.407E+02	2.728E+05	1.833E+01	9.100E+01	1.364E+05	9.164E+00	2.497E+02	1.364E+05	9.164E+00	3.911E+00	1.091E+03	7.332E-02
2160	0	0	1,821,383	2,003,521	3.373E+02	2.701E+05	1.815E+01	9.009E+01	1.350E+05	9.073E+00	2.472E+02	1.350E+05	9.073E+00	3.872E+00	1.080E+03	7.259E-02
2161	0	0	1,821,383	2,003,521	3.339E+02	2.674E+05	1.797E+01	8.919E+01	1.337E+05	8.983E+00	2.447E+02	1.337E+05	8.983E+00	3.834E+00	1.070E+03	7.186E-02

Data source	Date	Author	PW Link
	2019-05-28	31RJM (Robert Morgi	pw:\\pwintsrv.dillon.ca:Projects_2019\Documents\Projects\199543 LF-TS Design & CA Services\2. Work\Analysis & Design\LandGEM\LandGEM - Iqaluit Landfill - Project - New Landfill.xlsx

PROJECT GHG EMISSIONS

Table S1-C
Wood Waste Combustion

Description of Activity:

Waste wood and cardboard will be shredded and pelletized for use as a fuel source for an on-site biomass boiler.

Combustion Calculation of Wood Pellets and Cardboard

Assumed Waste Transfer Station (WTS) will require 200tonnes of biomass pellets per year to meet designed heat load from biomass boiler (75% of total WTS heating load, as outlined in Internal Memo dated May 30 2019, Subject: *Design and Construction Options Technical Brief* , File number 19-9543). With the remaining 25% of the heating load being covered by the oil-based heater (designed for on-peak heating).

Assumed all wood waste combusted in dutch oven style biomass boiler. Calculations used emission factors provided in Canada's National Inventory Report 1990-2017 Part 2 (Published 2019) for biomass combustion of wood fuel/wood waste.

Assumed all cardboard waste combusted in dutch oven style biomass boiler. No emission factors for combustion of cardboard in biomass boiler available. Only emission factors for cardboard combustion available from cardboard incineration. Therefore calculations used emission factors provided in Canada's National Inventory Report 1990-2017 Part 2 (Published 2019) for municipal solid waste incineration of cardboard. Assumed additional biomass pellets are sold, and part of Scope 3 emissions.

Mass of Pellets 200 tonnes

Emissions Factor - Biomass Combustion[1,2,3]				
Source	Description	Emission Factor (g/kg fuel)		
		CO_2	CH_4	N_2O
Pellet Stove - WTS Boiler	Conservative estimate of biomass boiler emissions	1652	4.12	0.059

[1] National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada—Part 2—Table A6-56. Environment and Climate Change Canada, 2019. (Accessed 12AUG2019).

Global Warming Potentials	CO_2	CH_4	N_2O
	1	25	298

2030 Emissions - Biomass Combustion[1, 2]							
Source	Description	Emissions (tonnes)			Emissions (tonnes CO_2e)		
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Pellet Stove - WTS Boiler	Conservative estimate of biomass boiler emissions	330	0.824	0.012	330	21	4
Total in Year 2030		**330**	**0.824**	**0.012**	**330**	**21**	**4**

Cumulative (2021 to 2030) Emissions - Biomass Combustion[1, 2]								
Source	Description	Emissions (tonnes)			Emissions (tonnes CO_2e)			
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	
Pellet Stove - WTS Boiler	Conservative estimate of biomass boiler emissions	3,029	7.55	0.11	3,029	189	32	
Total Cumulative (2021 to 2030)		**3,029**	**8**	**0.11**	**3,029**	**189**	**32**	

Project Year	Year	Biomass Pellets (tonnes/yr)1	Biomass Boiler Combustion Emissions						Total CO_2e Emissions
			CO_2 emissions (tonnes)	CH_4 emissions (tonnes)	N_2O emissions (tonnes)	CO_2 emissions (tonnes CO_2e)	CH_4 emissions (tonnes CO_2e)	N_2O emissions (tonnes CO_2e)	
1	2021	33.33	55.07	0.14	0.00	55.07	3.43	0.59	59.09
2	2022	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
3	2023	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
4	2024	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
5	2025	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
6	2026	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
7	2027	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
8	2028	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
9	2029	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
10	***2030***	***200.00***	***330.40***	***0.82***	***0.01***	330.40	20.60	3.52	354.52
11	2031	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
12	2032	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
13	2033	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
14	2034	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
15	2035	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
16	2036	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
17	2037	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
18	2038	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
19	2039	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
20	2040	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
21	2041	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
22	2042	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
23	2043	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
24	2044	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
25	2045	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
26	2046	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
27	2047	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
28	2048	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
29	2049	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
30	2050	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
31	2051	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
32	2052	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
33	2053	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
34	2054	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
35	2055	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
36	2056	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
37	2057	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
38	2058	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
39	2059	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
40	2060	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
41	2061	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
42	2062	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
43	2063	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
44	2064	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
45	2065	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
46	2066	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
47	2067	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
48	2068	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
49	2069	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
50	2070	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
51	2071	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
52	2072	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
53	2073	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
54	2074	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
55	2075	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
56	2076	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
57	2077	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
58	2078	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
59	2079	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
60	2080	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
61	2081	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
62	2082	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
63	2083	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
64	2084	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
65	2085	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
66	2086	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
67	2087	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
68	2088	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
69	2089	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
70	2090	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
71	2091	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
72	2092	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
73	2093	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
74	2094	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
75	2095	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52
76	2096	200.00	330.40	0.82	0.01	330.40	20.60	3.52	354.52

PROJECT GHG EMISSIONS

Table S1-D
Wood Waste Combustion

Description of Activity:

Oil fired hydronic boiler will be used to provide approximately 25% of the Waste Transfer Stations Heat.

Combustion Calculation of Fuel Oil Boiler

Assumed Waste Transfer Station (WTS) will require 200tonnes of biomass pellets per year to meet designed heat load from biomass boiler (75% of total WTS heating load, as outlined in Internal Memo dated May 30 2019, Subject: *Design and Construction Options Technical Brief* , File number 19-9543). With the remaining 25% of the heating load being covered by the oil-based heater (designed for on-peak heating).

Assumed 2500 US gallons of fuel oil required per year for oil fired hydronic boiler, as noted in 30% design report (dated June 2019)

Volume of fuel oil	2500 US gallons
Conversion of US gallons to L	3.79 Litres per US gallon

Emissions Factor - Boiler Fuel Oil Combustion[1,2,3]				
Source	Description	Emission Factor (g/L fuel)		
		CO_2	CH_4	N_2O
Oil Fired Hydronic Boiler	Conservative estimate of hydronic boiler emissions, bas	2753	0.006	0.031

[1] Table A6-4 Emission Factors for Refined Petroleum Products

Global Warming Potentials	CO_2	CH_4	N_2O
	1	25	298

2030 Emissions - Boiler Fuel Oil Combustion[1, 2]							
Source	Description	Emissions (tonnes)			Emissions (tonnes CO_2e)		
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Oil Fired Hydronic Boiler	Conservative estimate of biomass boiler emissions	26	0.0001	0.0003	26	0.00	0.09
Total in Year 2030		**26**	**0.00**	**0.00**	**26**	**0.00**	**0.09**

Cumulative (2021 to 2030) Emissions - Boiler Fuel Oil Combustion[1, 2]							
Source	Description	Emissions (tonnes)			Emissions (tonnes CO_2e)		
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Oil Fired Hydronic Boiler	Conservative estimate of biomass boiler emissions	239	0.00	0.00	239	0.01	0.80
Total Cumulative (2021 to 2030)		**239**	**0.00**	**0.00**	**239**	**0.01**	**0.80**

Project Year	Year	Fuel Oil (US Gallons/yr)1	Biomass Boiler Fuel Oil Combustion Emissions						Total CO_2e Emissions (tonnes CO2e)
			CO_2 emissions (tonnes)	CH_4 emissions (tonnes)	N_2O emissions (tonnes)	CO_2 emissions (tonnes CO_2e)	CH_4 emissions (tonnes CO_2e)	N_2O emissions (tonnes CO_2e)	
1	2021	416.67	4.34	0.00	0.00	4.34	0.00	0.01	4.36
2	2022	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
3	2023	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
4	2024	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
5	2025	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
6	2026	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
7	2027	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
8	2028	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
9	2029	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
10	***2030***	***2,500.00***	26.05	0.00	0.00	26.05	0.00	0.09	26.14
11	2031	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
12	2032	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
13	2033	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
14	2034	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
15	2035	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
16	2036	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
17	2037	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
18	2038	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
19	2039	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
20	2040	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
21	2041	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
22	2042	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
23	2043	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
24	2044	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
25	2045	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
26	2046	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
27	2047	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
28	2048	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
29	2049	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
30	2050	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
31	2051	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
32	2052	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
33	2053	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
34	2054	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
35	2055	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
36	2056	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
37	2057	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
38	2058	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
39	2059	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
40	2060	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
41	2061	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
42	2062	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14

43	2063	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
44	2064	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
45	2065	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
46	2066	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
47	2067	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
48	2068	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
49	2069	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
50	2070	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
51	2071	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
52	2072	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
53	2073	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
54	2074	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
55	2075	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
56	2076	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
57	2077	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
58	2078	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
59	2079	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
60	2080	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
61	2081	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
62	2082	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
63	2083	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
64	2084	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
65	2085	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
66	2086	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
67	2087	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
68	2088	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
69	2089	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
70	2090	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
71	2091	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
72	2092	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
73	2093	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
74	2094	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
75	2095	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14
76	2096	2,500.00	26.05	0.00	0.00	26.05	0.00	0.09	26.14

PROJECT GHG EMISSIONS

Table S1-E
Onsite Mobile Equipment

Description of Activity:

Onsite equipment moving waste within the Waste Transfer Station (WTS) and from the WTS to the landfill. These activities are assumed to include all non-road and on-road onsite mobile equipment such as:

Non-Road: Two wheel loaders (one for WTS and one for the Landfill) and a Skid Steer

On-Road: Two (2) Ford F-250 Trucks (flatbed trucks for general use)

Other Mobile Equipment Assumptions

Assumed that only one of the flatbed trucks is operating at any given time. And that the flatbed trucks would be similar in make/model to the previous trucks (therefore assuming that they are gasoline and F-250 size)
Assumed Landfill operating 8 hours per day, 260 days per year. This is based on emails from Keith Barnes (Dillon) and Erik Marko (Colliers), dated May 17, 2019

Assumed that operating effort of the mobile equipment would increase proportionally to increasing MSW tonnages
Assumed driving distance is 10km (based on 1-way trip of 5km) based on proposed landfill and WTS locations (see front picture of Proposal). Assumed 4 trips per day.
Assumed that wheel loader at the landfill would be same model, size, and year as the wheel loader at the WTS
Assumed new wheel loaders would fall within Tier 4.

Activity Data

WTS Operating Hours per Day	**8 Hrs**
WTS Operating Days per Year	**260 Days**
Annual KMs in Year 1 - F-250 Trucks (for both trucks)	**10,400 km**

Type	Source	Description	Equipment and Activity Data				
			No. Operating	Hrs/Day	Fuel Type	Engine HP	Operating Data
Non-Road	Wheel loader	with bucket thumb (110-120hp)	1	4 Hrs/Day	Diesel	120 HP	1,040 Hrs/Year
	Skid Steer	John Deere Skid Steer (Tier 4)	1	1 Hrs/Day	Diesel	50 to 100 HP	260 Hrs/Year
	Wheel loader	with forklifts (110-120hp)	1	4 Hrs/Day	Diesel	120 HP	1,040 Hrs/Year
On-Road	Ford F-250 Truck	flatbed truck used for transportation of bales from WTS to Engineered Landfill	1		Gasoline		10,400 km/Year

Notes

[1] Marko, L. May 10, 2019. Dillon Question Response 60571501 pdf.

[2] National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada—National Inventory Report 1990–2017—Part 2—A6.1.6 © Her Majesty the Queen in Right of Canada, represented by the Minister of Environment and Climate Change, 2019

3. Assumes that equipment activity hours will be similar to previous operations

4. Assumes that the wheel loaders will be at the upper end of the design values for horsepower.

Non-Road Emission Factors

	Loader (>100-175 HP)	Skid Steer (75-100 HP)
EFss HC	0.1314	0.1314
BSFC	0.367	0.408
DF	N/Ap	N/Ap
"A" - relative Deterioration F	N/Ap	N/Ap
Assumption - Fraction of Use	N/Ap	N/Ap
TAF	N/Ap	N/Ap
EFadj HC	0.131	0.131
CO_2 (g/hp-hr)	**530.6**	**590.0**

Note 1. Assumed EFs for *Bulldozer (75-100HP)* which are the same as *Equipment (>50-100 HP)* and *Forklift (*

2. Tier 4 emissions factors are considered to be transient, rather than steady-state. Therefore no conversion or deterioration calculations are required.

Emissions Factors - Onsite Mobile Equipment[1,2,3]					
Type	Source	Description	Emission Factors		
			CO_2	CH_4	N_2O
Non-Road	Wheel loader	with bucket thumb (110-120hp)	530.62 g/hp-hr	-	-
	Skid Steer	John Deere Skid Steer (Tier 4)	589.95 g/hp-hr	-	-
	Wheel loader	with forklifts (110-120hp)	530.62 g/hp-hr	-	-
On-Road	Ford F-250 Truck	flatbed truck used for transportation of bales from WTS to Engineered Landfill	284 g/km travel	0.017 g/km travel	0.003 g/km travel

[1] National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada—Part 2—Table A6-13. Environment and Climate Change Canada, 2019. (Accessed 12AUG2019).

[2] LD Truck - 2004 or later classification used for emission factors for F250 pickup trucks

[3]. Average fuel efficiency for LD Trucks obtained from Natural Resource Canada's comprehensive energy use database

Base Year Emissions (2020) - Onsite Mobile Equipment[1,2,3]								
Type	Source	Description	Emissions (tonnes)			Emissions (tonnes CO_2e)		
			CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Non-Road	Wheel loader	with bucket thumb (110-120hp)	66 tonnes	-	-	66 tonnes	-	-
	Skid Steer	John Deere Skid Steer (Tier 4)	15 tonnes	-	-	15 tonnes	-	-
	Wheel loader	with forklifts (110-120hp)	66 tonnes	-	-	66 tonnes	-	-
On-Road	Ford F-250 Truck	flatbed truck used for transportation of bales from WTS to Engineered Landfill	3 tonnes	0.0002 tonnes	0.0000 tonnes	3 tonnes	0.00 tonnes	0.01 tonnes
Total			151 tonnes	0.0002 tonnes	0.0000 tonnes	151 tonnes	0.00 tonnes	0.01 tonnes

2. LD Truck - 2004 or later classification used for emission factors for F250 pickup trucks

3. Assumed worst case for skid steer (largest diesel model by John Deere)

Global Warming Potentials	CO_2	CH_4	N_2O
	1	25	298

2030 Emissions - Onsite Mobile Equipment[1,2,3]								
Type	Source	Description	Emissions (tonnes)			Emissions (tonnes CO_2e)		
Total Emissions in 2030			183 tonnes	0.0002 tonnes	0.0000 tonnes	183 tonnes	0.01 tonnes	0.01 tonnes
Total Cumulative Emissions from 2021 to 2030			1,521 tonnes	0.0018 tonnes	0.0003 tonnes	1,521 tonnes	0.05 tonnes	0.08 tonnes

[1] National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada—Part 2—Table A6-13. Environment and Climate Change Canada, 2019. (Accessed 12AUG2019).

2. LD Truck - 2004 or later classification used for emission factors for F250 pickup trucks

3. Assumed worst case for skid steer (largest diesel model by John Deere)

Population Growth Rate 1.42%
Municipal Solid Waste Growth Rate 1.00%

Project Year	Year	Annual MSW (tonnes)	Onsite Mobile Equipment Emissions						Total CO_2e Emissions
			CO_2 emissions (tonnes)	CH_4 emissions (tonnes)	N_2O emissions (tonnes)	CO_2 emissions (tonnes CO_2e)	CH_4 emissions (tonnes CO_2e)	N_2O emissions (tonnes CO_2e)	
1	2021	8,789	25.12	0.00003	0.00000	25.12	0.00	0.00	25.12
2	2022	9,002	151	0.0002	0.0000	150.73	0.00	0.01	150.75
3	2023	9,221	154	0.0002	0.0000	154.40	0.00	0.01	154.41
4	2024	9,445	158	0.0002	0.0000	158.15	0.00	0.01	158.16
5	2025	9,674	162	0.0002	0.0000	161.99	0.00	0.01	162.01
6	2026	9,910	166	0.0002	0.0000	165.93	0.00	0.01	165.94
7	2027	10,150	170	0.0002	0.0000	169.96	0.01	0.01	169.98
8	2028	10,397	174	0.0002	0.0000	174.09	0.01	0.01	174.11
9	2029	10,650	178	0.0002	0.0000	178.32	0.01	0.01	178.34
10	2030	10,909	183	0.0002	0.0000	182.66	0.01	0.01	182.67
11	2031	11,174	187	0.0002	0.0000	187.09	0.01	0.01	187.11
12	2032	11,445	192	0.0002	0.0000	191.64	0.01	0.01	191.66
13	2033	11,723	196	0.0002	0.0000	196.30	0.01	0.01	196.31
14	2034	12,008	201	0.0002	0.0000	201.07	0.01	0.01	201.09
15	2035	12,300	206	0.0002	0.0000	205.95	0.01	0.01	205.97
16	2036	12,599	211	0.0003	0.0000	210.96	0.01	0.01	210.98
17	2037	12,905	216	0.0003	0.0000	216.09	0.01	0.01	216.10
18	2038	13,219	221	0.0003	0.0000	221.34	0.01	0.01	221.36
19	2039	13,540	227	0.0003	0.0000	226.72	0.01	0.01	226.74
20	2040	13,869	232	0.0003	0.0000	232.23	0.01	0.01	232.25
21	2041	14,206	238	0.0003	0.0000	237.87	0.01	0.01	237.89
22	2042	14,551	244	0.0003	0.0000	243.65	0.01	0.01	243.67
23	2043	14,905	250	0.0003	0.0000	249.57	0.01	0.01	249.59
24	2044	15,267	256	0.0003	0.0000	255.64	0.01	0.01	255.66
25	2045	15,638	262	0.0003	0.0000	261.85	0.01	0.01	261.87
26	2046	16,018	268	0.0003	0.0001	268.21	0.01	0.01	268.23
27	2047	16,407	275	0.0003	0.0001	274.73	0.01	0.02	274.75
28	2048	16,806	281	0.0003	0.0001	281.41	0.01	0.02	281.43
29	2049	17,215	288	0.0003	0.0001	288.25	0.01	0.02	288.27
30	2050	17,633	295	0.0004	0.0001	295.25	0.01	0.02	295.28
31	2051	18,061	302	0.0004	0.0001	302.42	0.01	0.02	302.45
32	2052	18,500	310	0.0004	0.0001	309.77	0.01	0.02	309.80
33	2053	18,950	317	0.0004	0.0001	317.30	0.01	0.02	317.33
34	2054	19,410	325	0.0004	0.0001	325.01	0.01	0.02	325.04
35	2055	19,882	333	0.0004	0.0001	332.91	0.01	0.02	332.94
36	2056	20,365	341	0.0004	0.0001	341.00	0.01	0.02	341.03
37	2057	20,860	349	0.0004	0.0001	349.29	0.01	0.02	349.32
38	2058	21,367	358	0.0004	0.0001	357.78	0.01	0.02	357.81
39	2059	21,886	366	0.0004	0.0001	366.47	0.01	0.02	366.50
40	2060	22,418	375	0.0004	0.0001	375.38	0.01	0.02	375.41
41	2061	22,963	384	0.0005	0.0001	384.50	0.01	0.02	384.53
42	2062	23,521	394	0.0005	0.0001	393.84	0.01	0.02	393.88
43	2063	24,093	403	0.0005	0.0001	403.41	0.01	0.02	403.45
44	2064	24,678	413	0.0005	0.0001	413.22	0.01	0.02	413.25
45	2065	25,278	423	0.0005	0.0001	423.26	0.01	0.02	423.30
46	2066	25,892	434	0.0005	0.0001	433.55	0.01	0.02	433.58
47	2067	26,521	444	0.0005	0.0001	444.08	0.01	0.02	444.12
48	2068	27,166	455	0.0005	0.0001	454.87	0.01	0.03	454.91
49	2069	27,826	466	0.0006	0.0001	465.93	0.01	0.03	465.97
50	2070	28,502	477	0.0006	0.0001	477.25	0.01	0.03	477.29
51	2071	29,195	489	0.0006	0.0001	488.85	0.01	0.03	488.89
52	2072	29,904	501	0.0006	0.0001	500.73	0.01	0.03	500.77
53	2073	30,631	513	0.0006	0.0001	512.90	0.02	0.03	512.94
54	2074	31,376	525	0.0006	0.0001	525.36	0.02	0.03	525.41
55	2075	32,138	538	0.0006	0.0001	538.13	0.02	0.03	538.17
56	2076	32,919	551	0.0007	0.0001	551.21	0.02	0.03	551.25
57	2077	33,719	565	0.0007	0.0001	564.60	0.02	0.03	564.65
58	2078	34,538	578	0.0007	0.0001	578.32	0.02	0.03	578.37
59	2079	35,378	592	0.0007	0.0001	592.38	0.02	0.03	592.43
60	2080	36,237	607	0.0007	0.0001	606.77	0.02	0.03	606.82
61	2081	37,118	622	0.0007	0.0001	621.52	0.02	0.03	621.57
62	2082	38,020	637	0.0008	0.0001	636.62	0.02	0.04	636.67
63	2083	38,944	652	0.0008	0.0001	652.09	0.02	0.04	652.15
64	2084	39,890	668	0.0008	0.0001	667.94	0.02	0.04	668.00
65	2085	40,860	684	0.0008	0.0001	684.17	0.02	0.04	684.23
66	2086	41,853	701	0.0008	0.0001	700.80	0.02	0.04	700.86
67	2087	42,870	718	0.0009	0.0001	717.83	0.02	0.04	717.89
68	2088	43,912	735	0.0009	0.0001	735.27	0.02	0.04	735.33
69	2089	44,979	753	0.0009	0.0001	753.14	0.02	0.04	753.20
70	2090	46,072	771	0.0009	0.0001	771.44	0.02	0.04	771.51
71	2091	47,192	790	0.0009	0.0001	790.19	0.02	0.04	790.26
72	2092	48,338	809	0.0010	0.0002	809.39	0.02	0.05	809.46
73	2093	49,513	829	0.0010	0.0002	829.06	0.02	0.05	829.13
74	2094	50,716	849	0.0010	0.0002	849.21	0.03	0.05	849.28
75	2095	51,949	870	0.0010	0.0002	869.85	0.03	0.05	869.92
76	2096	53,211	891	0.0011	0.0002	890.99	0.03	0.05	891.06

PROJECT GHG EMISSIONS

Table S1-F
Project - Stationary Equipment

Description of Activity:

Onsite stationary equipment within the Project Scenario includes the following:
- ~~MSW Compactor and Baler (electric - no combustion emissions)~~ <- Not combustion equipment
- ~~MSW Bale Wrapper (electric - no combustion emissions)~~ <- Not combustion equipment
- Cardboard/wood shredder (330HP) - also used for misc shredding and tires
- ~~Cardboard/wood pelletizer~~ <-Assumed not combustion equipment
- Car Crusher (6 Cylinder Tier IV Engine)
- ~~Emergency Generator~~ <- Assumed negligible

Project Stationary Equipment Assumptions

Assume shredder operation time based on Wood
Car Logger/crusher noted that it can process up to 250 cars per day (noted in promotional video here:https://www.overbuilt.com/baler_logger/)

Activity Data

WTS Operating Hours per Day	**8 Hrs**
WTS Operating Days per Year	**260 Days**
Cardboard/Wood Shredder Operating Capacity	**6 tonnes/Hr**
Total Cardboard, wood, and tire material shredded in base year (2022)	**10,501 tonnes**
Cars received in base year (2022)	**84**
Car logger/crusher Operating Capacity	**250.0 tonnes/Hr**

Type	Source	Description	Equipment and Activity Data				
			No. Operating	Hrs/Day	Fuel Type	Engine HP	Operating Data
WTS	Cardboard/Wood Shredder	Shredder (330HP), with a capacity of 6 tonnes /Hr	1		Diesel	330 HP	1,750 Hrs/Year in 2022
	Car Logger/Crusher	6 Cylinder Tier IV Engine. Diesel, 173-215 HP	1	8 Hrs/Day	Diesel	215 HP	8 Hrs/Year in 2022

Notes

3. Assumes that equipment activity hours will be similar to previous operations

4. assumes both pieces of equipment are Tier 4

5. Assumes car logger operates for 1 day per year under base conditions (year 2022)

6. Assumes worst case max size of 215HP

Non-Road Emission Factors

	Shredder (>300 to 600 hp)	6 Cylinder Engine (>175 to 300 hp)
EFss HC	0.1314	0.1314
BSFC	0.367	0.367
DF	N/Ap	N/Ap
"A" - relative Deterioration Factor [Equatio	N/Ap	N/Ap
Assumption - Fraction of Useful Life Expen	N/Ap	N/Ap
TAF	N/Ap	N/Ap
EFadj HC	0.131	0.131
CO_2 (g/hp-hr)	530.6	530.6

Note 1. Assumed EFs for *Bulldozer (75-100HP)* which are the same as *Equipment (>50-100 HP)* and *Forklift (50-75 HP). Obtained from* US EPA NONROAD 2008

2. Tier 4 emissions factors are considered to be transient, rather than steady-state. Therefore no conversion or deterioration calculations are required.

Emissions Factors - Onsite Stationary Equipment[1]					
Type	Source	Description	Emission Factors		
			CO_2	CH_4	N_2O
Non-Road	Cardboard/Wood Shredder	Shredder (330HP), with a capacity of 6 tonnes /Hr	530.62 g/hp-hr	-	-
	Car Logger/Crusher	6 Cylinder Tier IV Engine. Diesel, 173-215 HP	530.62 g/hp-hr	-	-

[1] National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada—Part 2—Table A6-13. Environment and Climate Change Canada, 2019. (Accessed 12AUG2019).

Base Year Emissions (2022) - Onsite Stationary Equipment[1,2,3]								
Type	Source	Description	Emissions (tonnes)			Emissions (tonnes CO_2e)		
			CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Non-Road	Cardboard/Wood Shredder	Shredder (330HP), with a capacity of 6 tonnes /Hr	306 tonnes	-	-	306 tonnes	-	-
	Car Logger/Crusher	6 Cylinder Tier IV Engine. Diesel, 173-215 HP	1 tonnes	-	-	1 tonnes	-	-
Total			307 tonnes	-	-	307 tonnes	-	-

2. LD Truck - 2004 or later classification used for emission factors for F250 pickup trucks

3. Assumed worst case for skid steer (largest diesel model by John Deere)

Global Warming Potentials	CO_2	CH_4	N_2O
	1	25	298

2030 Emissions - Onsite Stationary Equipment[1]								
Type	Source	Description	Emissions (tonnes)			Emissions (tonnes CO_2e)		
Total Emissions in 2030			372 tonnes	-	-	372 tonnes	-	-
Total Cumulative Emissions from 2021 to 2030			3,102 tonnes	-	-	3,102 tonnes	-	-

[1] National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada—Part 2—Table A6-56. Environment and Climate Change Canada, 2019. (Accessed 12AUG2019).

2. LD Truck - 2004 or later classification used for emission factors for F250 pickup trucks

3. Assumed worst case for skid steer (largest diesel model by John Deere)

Population Growth Rate 1.42%
Municipal Solid Waste Growth Rate 1.00%

Project Year	Year	Annual MSW (tonnes)	Onsite Mobile Equipment Emissions						Total CO_2e Emissions
			CO_2 emissions (tonnes)	CH_4 emissions (tonnes)	N_2O emissions (tonnes)	CO_2 emissions (tonnes CO_2e)	CH_4 emissions (tonnes CO_2e)	N_2O emissions (tonnes CO_2e)	
1	2021	8,789	51.23	-	-	51.23	-	-	51.23
2	2022	9,002	307	-	-	307.39	-	-	307.39
3	2023	9,221	315	-	-	314.86	-	-	314.86
4	2024	9,445	323	-	-	322.51	-	-	322.51
5	2025	9,674	330	-	-	330.35	-	-	330.35
6	2026	9,910	338	-	-	338.38	-	-	338.38
7	2027	10,150	347	-	-	346.60	-	-	346.60
8	2028	10,397	355	-	-	355.02	-	-	355.02
9	2029	10,650	364	-	-	363.65	-	-	363.65
10	2030	10,909	372	-	-	372.49	-	-	372.49
11	2031	11,174	382	-	-	381.54	-	-	381.54
12	2032	11,445	391	-	-	390.81	-	-	390.81
13	2033	11,723	400	-	-	400.31	-	-	400.31
14	2034	12,008	410	-	-	410.04	-	-	410.04
15	2035	12,300	420	-	-	420.00	-	-	420.00
16	2036	12,599	430	-	-	430.21	-	-	430.21
17	2037	12,905	441	-	-	440.66	-	-	440.66
18	2038	13,219	451	-	-	451.37	-	-	451.37
19	2039	13,540	462	-	-	462.34	-	-	462.34
20	2040	13,869	474	-	-	473.57	-	-	473.57
21	2041	14,206	485	-	-	485.08	-	-	485.08

22	2042	14,551	497	-	-	496.87	-	-	496.87
23	2043	14,905	509	-	-	508.95	-	-	508.95
24	2044	15,267	521	-	-	521.31	-	-	521.31
25	2045	15,638	534	-	-	533.98	-	-	533.98
26	2046	16,018	547	-	-	546.96	-	-	546.96
27	2047	16,407	560	-	-	560.25	-	-	560.25
28	2048	16,806	574	-	-	573.87	-	-	573.87
29	2049	17,215	588	-	-	587.81	-	-	587.81
30	2050	17,633	602	-	-	602.10	-	-	602.10
31	2051	18,061	617	-	-	616.73	-	-	616.73
32	2052	18,500	632	-	-	631.72	-	-	631.72
33	2053	18,950	647	-	-	647.07	-	-	647.07
34	2054	19,410	663	-	-	662.79	-	-	662.79
35	2055	19,882	679	-	-	678.90	-	-	678.90
36	2056	20,365	695	-	-	695.40	-	-	695.40
37	2057	20,860	712	-	-	712.30	-	-	712.30
38	2058	21,367	730	-	-	729.61	-	-	729.61
39	2059	21,886	747	-	-	747.34	-	-	747.34
40	2060	22,418	766	-	-	765.50	-	-	765.50
41	2061	22,963	784	-	-	784.10	-	-	784.10
42	2062	23,521	803	-	-	803.16	-	-	803.16
43	2063	24,093	823	-	-	822.68	-	-	822.68
44	2064	24,678	843	-	-	842.67	-	-	842.67
45	2065	25,278	863	-	-	863.15	-	-	863.15
46	2066	25,892	884	-	-	884.12	-	-	884.12
47	2067	26,521	906	-	-	905.61	-	-	905.61
48	2068	27,166	928	-	-	927.62	-	-	927.62
49	2069	27,826	950	-	-	950.16	-	-	950.16
50	2070	28,502	973	-	-	973.25	-	-	973.25
51	2071	29,195	997	-	-	996.90	-	-	996.90
52	2072	29,904	1,021	-	-	1021.13	-	-	1,021.13
53	2073	30,631	1,046	-	-	1045.94	-	-	1,045.94
54	2074	31,376	1,071	-	-	1071.36	-	-	1,071.36
55	2075	32,138	1,097	-	-	1097.40	-	-	1,097.40
56	2076	32,919	1,124	-	-	1124.06	-	-	1,124.06
57	2077	33,719	1,151	-	-	1151.38	-	-	1,151.38
58	2078	34,538	1,179	-	-	1179.36	-	-	1,179.36
59	2079	35,378	1,208	-	-	1208.02	-	-	1,208.02
60	2080	36,237	1,237	-	-	1237.38	-	-	1,237.38
61	2081	37,118	1,267	-	-	1267.45	-	-	1,267.45
62	2082	38,020	1,298	-	-	1298.25	-	-	1,298.25
63	2083	38,944	1,330	-	-	1329.80	-	-	1,329.80
64	2084	39,890	1,362	-	-	1362.11	-	-	1,362.11
65	2085	40,860	1,395	-	-	1395.22	-	-	1,395.22
66	2086	41,853	1,429	-	-	1429.12	-	-	1,429.12
67	2087	42,870	1,464	-	-	1463.85	-	-	1,463.85
68	2088	43,912	1,499	-	-	1499.43	-	-	1,499.43
69	2089	44,979	1,536	-	-	1535.86	-	-	1,535.86
70	2090	46,072	1,573	-	-	1573.19	-	-	1,573.19
71	2091	47,192	1,611	-	-	1611.42	-	-	1,611.42
72	2092	48,338	1,651	-	-	1650.58	-	-	1,650.58
73	2093	49,513	1,691	-	-	1690.69	-	-	1,690.69
74	2094	50,716	1,732	-	-	1731.78	-	-	1,731.78
75	2095	51,949	1,774	-	-	1773.86	-	-	1,773.86
76	2096	53,211	1,817	-	-	1816.97	-	-	1,816.97

PROJECT GHG EMISSIONS

Table S2-A
Project - Electricity Consumption

Project Year	Year	Loading (MW) [2]	CO2 emissions (tonnes)	CO2e (tonnes)
1	2021	0.20	329	329
2	2022	1.20	1,972	1,972
3	2023	1.20	1,972	1,972
4	2024	1.20	1,972	1,972
5	2025	1.20	1,972	1,972
6	2026	1.20	1,972	1,972
7	2027	1.20	1,972	1,972
8	2028	1.20	1,972	1,972
9	2029	1.20	1,972	1,972
10	2030	1.20	1,972	1,972
11	2031	1.20	1,972	1,972
12	2032	1.20	1,972	1,972
13	2033	1.20	1,972	1,972
14	2034	1.20	1,972	1,972
15	2035	1.20	1,972	1,972
16	2036	1.20	1,972	1,972
17	2037	1.20	1,972	1,972
18	2038	1.20	1,972	1,972
19	2039	1.20	1,972	1,972
20	2040	1.20	1,972	1,972
21	2041	1.20	1,972	1,972
22	2042	1.20	1,972	1,972
23	2043	1.20	1,972	1,972
24	2044	1.20	1,972	1,972
25	2045	1.20	1,972	1,972
26	2046	1.20	1,972	1,972
27	2047	1.20	1,972	1,972
28	2048	1.20	1,972	1,972
29	2049	1.20	1,972	1,972
30	2050	1.20	1,972	1,972
31	2051	1.20	1,972	1,972
32	2052	1.20	1,972	1,972
33	2053	1.20	1,972	1,972
34	2054	1.20	1,972	1,972
35	2055	1.20	1,972	1,972
36	2056	1.20	1,972	1,972
37	2057	1.20	1,972	1,972
38	2058	1.20	1,972	1,972
39	2059	1.20	1,972	1,972
40	2060	1.20	1,972	1,972
41	2061	1.20	1,972	1,972
42	2062	1.20	1,972	1,972
43	2063	1.20	1,972	1,972
44	2064	1.20	1,972	1,972
45	2065	1.20	1,972	1,972
46	2066	1.20	1,972	1,972
47	2067	1.20	1,972	1,972
48	2068	1.20	1,972	1,972
49	2069	1.20	1,972	1,972
50	2070	1.20	1,972	1,972
51	2071	1.20	1,972	1,972
52	2072	1.20	1,972	1,972
53	2073	1.20	1,972	1,972
54	2074	1.20	1,972	1,972
55	2075	1.20	1,972	1,972
56	2076	1.20	1,972	1,972
57	2077	1.20	1,972	1,972
58	2078	1.20	1,972	1,972
59	2079	1.20	1,972	1,972
60	2080	1.20	1,972	1,972
61	2081	1.20	1,972	1,972
62	2082	1.20	1,972	1,972
63	2083	1.20	1,972	1,972
64	2084	1.20	1,972	1,972
65	2085	1.20	1,972	1,972
66	2086	1.20	1,972	1,972
67	2087	1.20	1,972	1,972
68	2088	1.20	1,972	1,972
69	2089	1.20	1,972	1,972
70	2090	1.20	1,972	1,972
71	2091	1.20	1,972	1,972
72	2092	1.20	1,972	1,972
73	2093	1.20	1,972	1,972
74	2094	1.20	1,972	1,972
75	2095	1.20	1,972	1,972
76	2096	1.20	1,972	1,972

Operation Time		
Operating Hours	8	hours/day
Annual Days of Operation	260	days/year
Total Annual Operating Hours	2,080	hours/year

[Provinces/Territories] [1]

Location	g GHG / kWh electricity generated Consumption Intensity (g CO2 eq / kWh)
Alberta	800
British Colombia	9.7
Manitoba	2.1
New Brunswick	330
Newfoundland and Labrador	40
Northwest Territories	180
Nova Scotia	720
Nunavut	*790*
Ontario	20
Prince Edward Island	330
Quebec	1.5
Saskatchewan	710
Yukon	57

Notes:
[1] National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada—National Inventory Report 1
[2] Verbal Correspondance Dillon Consulting B. Moore.; May 28, 2019
*Assumes no increase in electricity requirements at transfer station

PROJECT GHG EMISSIONS

Baseline: **Iqaluit Landfill Operation and Maintenance GHG Emissions**

GHG Estimate by Activity (tonnes CO_2e)										
Year	Scope 1						Scope 2			Combined Total
	Landfill Gas	Mobile Combustion	Stationary Combustion	Landfill Fires	Incinerator	Total	Electricity Usage	Purchased Heat	Total	
2019	444	273	N/Ap	221	4,793	5,731	N/Ap	N/Ap	0	5,731
2020	468	279	N/Ap	221	4,793	5,761	N/Ap	N/Ap	0	5,761
2021	492	286	N/Ap	221	4,910	5,908	N/Ap	N/Ap	0	5,908
2022	516	293	N/Ap	221	5,029	6,058	N/Ap	N/Ap	0	6,058
2023	541	300	N/Ap	221	5,151	6,213	N/Ap	N/Ap	0	6,213
2024	566	307	N/Ap	221	5,276	6,370	N/Ap	N/Ap	0	6,370
2025	591	315	N/Ap	221	5,404	6,532	N/Ap	N/Ap	0	6,532
2026	618	323	N/Ap	221	5,536	6,697	N/Ap	N/Ap	0	6,697
2027	644	330	N/Ap	221	5,670	6,866	N/Ap	N/Ap	0	6,866
2028	672	338	N/Ap	221	5,808	7,039	N/Ap	N/Ap	0	7,039
2029	699	347	N/Ap	221	5,949	7,216	N/Ap	N/Ap	0	7,216
2030	728	355	N/Ap	221	6,094	7,397	N/Ap	N/Ap	0	7,397
2031	757	364	N/Ap	221	6,242	7,583	N/Ap	N/Ap	0	7,583
2032	786	373	N/Ap	221	6,394	7,773	N/Ap	N/Ap	0	7,773
2033	816	382	N/Ap	221	6,549	7,968	N/Ap	N/Ap	0	7,968
2034	847	391	N/Ap	221	6,708	8,167	N/Ap	N/Ap	0	8,167
2035	879	400	N/Ap	221	6,871	8,371	N/Ap	N/Ap	0	8,371
2036	911	410	N/Ap	221	7,038	8,580	N/Ap	N/Ap	0	8,580
2037	943	420	N/Ap	221	7,209	8,793	N/Ap	N/Ap	0	8,793
2038	977	430	N/Ap	221	7,384	9,012	N/Ap	N/Ap	0	9,012
2039	1,011	441	N/Ap	221	7,564	9,236	N/Ap	N/Ap	0	9,236
2040	1,046	451	N/Ap	221	7,748	9,466	N/Ap	N/Ap	0	9,466
2041	1,081	462	N/Ap	221	7,936	9,700	N/Ap	N/Ap	0	9,700
2042	1,118	474	N/Ap	221	8,129	9,941	N/Ap	N/Ap	0	9,941
2043	1,155	485	N/Ap	221	8,326	10,187	N/Ap	N/Ap	0	10,187
2044	1,193	497	N/Ap	221	8,529	10,439	N/Ap	N/Ap	0	10,439
2045	1,232	509	N/Ap	221	8,736	10,697	N/Ap	N/Ap	0	10,697
2046	1,271	521	N/Ap	221	8,948	10,962	N/Ap	N/Ap	0	10,962
2047	1,312	534	N/Ap	221	9,166	11,232	N/Ap	N/Ap	0	11,232
2048	1,353	547	N/Ap	221	9,388	11,509	N/Ap	N/Ap	0	11,509
2049	1,395	560	N/Ap	221	9,617	11,793	N/Ap	N/Ap	0	11,793
2050	1,439	574	N/Ap	221	9,850	12,083	N/Ap	N/Ap	0	12,083
2051	1,483	588	N/Ap	221	10,090	12,381	N/Ap	N/Ap	0	12,381
2052	1,528	602	N/Ap	221	10,335	12,686	N/Ap	N/Ap	0	12,686
2053	1,574	617	N/Ap	221	10,586	12,998	N/Ap	N/Ap	0	12,998
2054	1,621	632	N/Ap	221	10,843	13,317	N/Ap	N/Ap	0	13,317
2055	1,669	647	N/Ap	221	11,107	13,644	N/Ap	N/Ap	0	13,644
2056	1,719	663	N/Ap	221	11,377	13,979	N/Ap	N/Ap	0	13,979
2057	1,769	679	N/Ap	221	11,653	14,322	N/Ap	N/Ap	0	14,322
2058	1,821	695	N/Ap	221	11,936	14,673	N/Ap	N/Ap	0	14,673
2059	1,874	712	N/Ap	221	12,226	15,033	N/Ap	N/Ap	0	15,033
2060	1,927	730	N/Ap	221	12,524	15,401	N/Ap	N/Ap	0	15,401
2061	1,983	747	N/Ap	221	12,828	15,779	N/Ap	N/Ap	0	15,779
2062	2,039	766	N/Ap	221	13,140	16,165	N/Ap	N/Ap	0	16,165
2063	2,097	784	N/Ap	221	13,459	16,561	N/Ap	N/Ap	0	16,561
2064	2,156	803	N/Ap	221	13,786	16,966	N/Ap	N/Ap	0	16,966
2065	2,216	823	N/Ap	221	14,121	17,381	N/Ap	N/Ap	0	17,381
2066	2,278	843	N/Ap	221	14,464	17,806	N/Ap	N/Ap	0	17,806
2067	2,341	863	N/Ap	221	14,816	18,241	N/Ap	N/Ap	0	18,241
2068	2,406	884	N/Ap	221	15,176	18,687	N/Ap	N/Ap	0	18,687
2069	2,472	906	N/Ap	221	15,545	19,143	N/Ap	N/Ap	0	19,143
2070	2,540	928	N/Ap	221	15,922	19,610	N/Ap	N/Ap	0	19,610
2071	2,609	950	N/Ap	221	16,309	20,089	N/Ap	N/Ap	0	20,089
2072	2,680	973	N/Ap	221	16,706	20,580	N/Ap	N/Ap	0	20,580

2073	2,752	997	N/Ap	221	17,112	21,082	N/Ap	N/Ap	0	**21,082**
2074	2,827	1,021	N/Ap	221	17,527	21,596	N/Ap	N/Ap	0	**21,596**
2075	2,903	1,046	N/Ap	221	17,953	22,123	N/Ap	N/Ap	0	**22,123**
2076	2,874	1,071	N/Ap	221	18,390	22,555	N/Ap	N/Ap	0	**22,555**
2077	2,845	1,097	N/Ap	221	18,837	23,000	N/Ap	N/Ap	0	**23,000**
2078	2,817	1,124	N/Ap	221	19,294	23,456	N/Ap	N/Ap	0	**23,456**
2079	2,789	1,151	N/Ap	221	19,763	23,924	N/Ap	N/Ap	0	**23,924**
2080	2,761	1,179	N/Ap	221	20,243	24,405	N/Ap	N/Ap	0	**24,405**
2081	2,734	1,208	N/Ap	221	20,735	24,898	N/Ap	N/Ap	0	**24,898**
2082	2,706	1,237	N/Ap	221	21,239	25,404	N/Ap	N/Ap	0	**25,404**
2083	2,679	1,268	N/Ap	221	21,755	25,923	N/Ap	N/Ap	0	**25,923**
2084	2,653	1,298	N/Ap	221	22,284	26,456	N/Ap	N/Ap	0	**26,456**
2085	2,626	1,330	N/Ap	221	22,826	27,003	N/Ap	N/Ap	0	**27,003**
2086	2,600	1,362	N/Ap	221	23,380	27,564	N/Ap	N/Ap	0	**27,564**
2087	2,574	1,395	N/Ap	221	23,949	28,139	N/Ap	N/Ap	0	**28,139**
2088	2,549	1,429	N/Ap	221	24,531	28,729	N/Ap	N/Ap	0	**28,729**
2089	2,523	1,464	N/Ap	221	25,127	29,335	N/Ap	N/Ap	0	**29,335**
2090	2,498	1,499	N/Ap	221	25,737	29,956	N/Ap	N/Ap	0	**29,956**
2091	2,473	1,536	N/Ap	221	26,363	30,593	N/Ap	N/Ap	0	**30,593**
2092	2,449	1,573	N/Ap	221	27,003	31,246	N/Ap	N/Ap	0	**31,246**
2093	2,424	1,611	N/Ap	221	27,660	31,916	N/Ap	N/Ap	0	**31,916**
2094	2,400	1,651	N/Ap	221	28,332	32,604	N/Ap	N/Ap	0	**32,604**
2095	2,376	1,691	N/Ap	221	29,020	33,308	N/Ap	N/Ap	0	**33,308**
2096	2,353	1,732	N/Ap	221	29,726	34,031	N/Ap	N/Ap	0	**34,031**

Operation (Year 2030)	728	355	N/Ap	221	6,094	7,397	N/Ap	N/Ap	0	7,397
Operation (2021 to 2030)	6,066	3,194	N/Ap	2,208	54,828	66,296	0	N/Ap	0	66,296
Operation (Lifespan - 2096)	135,575	61,227	N/Ap	16,779	1,050,892	1,264,473	0	N/Ap	0	1,264,473

BASELINE GHG EMISSIONS

BASELINE - Table S1-A

RESULTS

Landfill Name or Identifier: Iqaluit Landfill

Closure Year (with 80-year limit) = 2095

Methane = 50 *% by volume*

Please choose a third unit of measure to represent all of the emission rates below.

User-specified Unit: av ft^3/min

2: DETERMINE MODEL PARAMETERS		
Methane Generation Rate, k (*year^{-1}*)	User specified value	0.010
Potential Methane Generation Capacity, L_o (*m^3/Mg*)	User specified value	18
NMOC Concentration (*ppmv as hexane*)	User specified value	4,000
Methane Content (*% by volume*)	User specified value	50

Year	Waste Accepted		Waste-In-Place		Total landfill gas			Methane			Carbon dioxide			NMOC			CO2e
	(Mg/year)	(short tons/year)	(Mg)	(short tons)	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)	(tonne/year)
1995	4,532	4,985	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
1996	4,650	5,115	4,532	4,985	2.028E+00	1.624E+03	1.091E-01	5.418E-01	8.121E+02	5.456E-02	1.487E+00	8.121E+02	5.456E-02	2.329E-02	6.497E+00	4.365E-04	15.03
1997	4,770	5,247	9,182	10,100	4.089E+00	3.275E+03	2.200E-01	1.092E+00	1.637E+03	1.100E-01	2.997E+00	1.637E+03	1.100E-01	4.695E-02	1.310E+01	8.801E-04	30.30
1998	4,893	5,382	13,952	15,347	6.183E+00	4.951E+03	3.327E-01	1.652E+00	2.476E+03	1.663E-01	4.532E+00	2.476E+03	1.663E-01	7.099E-02	1.981E+01	1.331E-03	45.82
1999	5,020	5,522	18,845	20,730	8.312E+00	6.656E+03	4.472E-01	2.220E+00	3.328E+03	2.236E-01	6.092E+00	3.328E+03	2.236E-01	9.543E-02	2.662E+01	1.789E-03	61.60
2000	5,149	5,664	23,865	26,252	1.048E+01	8.389E+03	5.636E-01	2.798E+00	4.194E+03	2.818E-01	7.678E+00	4.194E+03	2.818E-01	1.203E-01	3.355E+01	2.255E-03	77.63
2001	5,283	5,811	29,014	31,915	1.268E+01	1.015E+04	6.820E-01	3.386E+00	5.075E+03	3.410E-01	9.290E+00	5.075E+03	3.410E-01	1.455E-01	4.060E+01	2.728E-03	93.94
2002	5,419	5,961	34,297	37,727	1.491E+01	1.194E+04	8.024E-01	3.984E+00	5.971E+03	4.012E-01	1.093E+01	5.971E+03	4.012E-01	1.712E-01	4.777E+01	3.210E-03	110.53
2003	5,559	6,115	39,716	43,688	1.719E+01	1.377E+04	9.249E-01	4.592E+00	6.883E+03	4.625E-01	1.260E+01	6.883E+03	4.625E-01	1.974E-01	5.506E+01	3.700E-03	127.40
2004	5,703	6,273	45,275	49,803	1.951E+01	1.562E+04	1.050E+00	5.211E+00	7.811E+03	5.248E-01	1.430E+01	7.811E+03	5.248E-01	2.240E-01	6.249E+01	4.198E-03	144.57
2005	5,851	6,436	50,978	56,076	2.187E+01	1.751E+04	1.176E+00	5.841E+00	8.755E+03	5.882E-01	1.603E+01	8.755E+03	5.882E-01	2.511E-01	7.004E+01	4.706E-03	162.05
2006	6,002	6,602	56,829	62,512	2.427E+01	1.943E+04	1.306E+00	6.482E+00	9.716E+03	6.528E-01	1.779E+01	9.716E+03	6.528E-01	2.786E-01	7.773E+01	5.223E-03	179.84
2007	6,157	6,773	62,831	69,114	2.671E+01	2.139E+04	1.437E+00	7.135E+00	1.070E+04	7.186E-01	1.958E+01	1.070E+04	7.186E-01	3.067E-01	8.556E+01	5.749E-03	197.96
2008	6,316	6,948	68,988	75,887	2.920E+01	2.338E+04	1.571E+00	7.800E+00	1.169E+04	7.856E-01	2.140E+01	1.169E+04	7.856E-01	3.353E-01	9.354E+01	6.285E-03	216.41
2009	6,479	7,127	75,304	82,834	3.174E+01	2.541E+04	1.708E+00	8.478E+00	1.271E+04	8.538E-01	2.326E+01	1.271E+04	8.538E-01	3.644E-01	1.017E+02	6.830E-03	235.20
2010	6,647	7,312	81,783	89,961	3.432E+01	2.748E+04	1.847E+00	9.168E+00	1.374E+04	9.233E-01	2.515E+01	1.374E+04	9.233E-01	3.941E-01	1.099E+02	7.387E-03	254.35
2011	6,819	7,501	88,430	97,273	3.696E+01	2.959E+04	1.988E+00	9.871E+00	1.480E+04	9.942E-01	2.708E+01	1.480E+04	9.942E-01	4.243E-01	1.184E+02	7.953E-03	273.87
2012	6,995	7,695	95,249	104,774	3.964E+01	3.174E+04	2.133E+00	1.059E+01	1.587E+04	1.066E+00	2.905E+01	1.587E+04	1.066E+00	4.551E-01	1.270E+02	8.531E-03	293.76
2013	7,176	7,894	102,244	112,468	4.238E+01	3.393E+04	2.280E+00	1.132E+01	1.697E+04	1.140E+00	3.106E+01	1.697E+04	1.140E+00	4.865E-01	1.357E+02	9.120E-03	314.04
2014	7,362	8,098	109,420	120,362	4.517E+01	3.617E+04	2.430E+00	1.206E+01	1.808E+04	1.215E+00	3.310E+01	1.808E+04	1.215E+00	5.186E-01	1.447E+02	9.720E-03	334.71
2015	7,552	8,307	116,782	128,460	4.801E+01	3.845E+04	2.583E+00	1.282E+01	1.922E+04	1.292E+00	3.519E+01	1.922E+04	1.292E+00	5.512E-01	1.538E+02	1.033E-02	355.80
2016	7,747	8,522	124,334	136,767	5.091E+01	4.077E+04	2.739E+00	1.360E+01	2.038E+04	1.370E+00	3.731E+01	2.038E+04	1.370E+00	5.846E-01	1.631E+02	1.096E-02	377.31
2017	7,947	8,742	132,081	145,289	5.387E+01	4.314E+04	2.899E+00	1.439E+01	2.157E+04	1.449E+00	3.948E+01	2.157E+04	1.449E+00	6.185E-01	1.726E+02	1.159E-02	399.25
2018	8,153	8,968	140,028	154,031	5.690E+01	4.556E+04	3.061E+00	1.520E+01	2.278E+04	1.531E+00	4.170E+01	2.278E+04	1.531E+00	6.532E-01	1.822E+02	1.224E-02	421.63
2019	8,364	9,200	148,181	162,999	5.998E+01	4.803E+04	3.227E+00	1.602E+01	2.401E+04	1.613E+00	4.396E+01	2.401E+04	1.613E+00	6.886E-01	1.921E+02	1.291E-02	444.48
2020	8,580	9,438	156,545	172,200	6.312E+01	5.055E+04	3.396E+00	1.686E+01	2.527E+04	1.698E+00	4.626E+01	2.527E+04	1.698E+00	7.247E-01	2.022E+02	1.359E-02	467.80
2021	8,789	9,668	165,125	181,638	6.634E+01	5.312E+04	3.569E+00	1.772E+01	2.656E+04	1.785E+00	4.862E+01	2.656E+04	1.785E+00	7.616E-01	2.125E+02	1.428E-02	491.60
2022	9,002	9,902	173,914	191,305	6.961E+01	5.574E+04	3.745E+00	1.859E+01	2.787E+04	1.873E+00	5.102E+01	2.787E+04	1.873E+00	7.992E-01	2.230E+02	1.498E-02	515.86
2023	9,221	10,143	182,916	201,208	7.295E+01	5.841E+04	3.925E+00	1.948E+01	2.921E+04	1.962E+00	5.346E+01	2.921E+04	1.962E+00	8.375E-01	2.336E+02	1.570E-02	540.58
2024	9,445	10,390	192,137	211,351	7.635E+01	6.114E+04	4.108E+00	2.039E+01	3.057E+04	2.054E+00	5.595E+01	3.057E+04	2.054E+00	8.766E-01	2.445E+02	1.643E-02	565.79
2025	9,674	10,641	201,582	221,740	7.982E+01	6.391E+04	4.294E+00	2.132E+01	3.196E+04	2.147E+00	5.850E+01	3.196E+04	2.147E+00	9.164E-01	2.556E+02	1.718E-02	591.48
2026	9,910	10,901	211,256	232,382	8.335E+01	6.674E+04	4.484E+00	2.226E+01	3.337E+04	2.242E+00	6.109E+01	3.337E+04	2.242E+00	9.570E-01	2.670E+02	1.794E-02	617.69
2027	10,150	11,165	221,166	243,283	8.696E+01	6.963E+04	4.679E+00	2.323E+01	3.482E+04	2.339E+00	6.373E+01	3.482E+04	2.339E+00	9.984E-01	2.785E+02	1.871E-02	644.41
2028	10,397	11,437	231,316	254,448	9.063E+01	7.258E+04	4.876E+00	2.421E+01	3.629E+04	2.438E+00	6.642E+01	3.629E+04	2.438E+00	1.041E+00	2.903E+02	1.951E-02	671.66
2029	10,650	11,715	241,713	265,884	9.439E+01	7.558E+04	5.078E+00	2.521E+01	3.779E+04	2.539E+00	6.917E+01	3.779E+04	2.539E+00	1.084E+00	3.023E+02	2.031E-02	699.46
2030	10,909	12,000	252,363	277,599	9.821E+01	7.864E+04	5.284E+00	2.623E+01	3.932E+04	2.642E+00	7.198E+01	3.932E+04	2.642E+00	1.128E+00	3.146E+02	2.114E-02	727.82
2031	11,174	12,291	263,272	289,599	1.021E+02	8.177E+04	5.494E+00	2.728E+01	4.089E+04	2.747E+00	7.484E+01	4.089E+04	2.747E+00	1.172E+00	3.271E+02	2.198E-02	756.76
2032	11,445	12,590	274,446	301,891	1.061E+02	8.496E+04	5.709E+00	2.834E+01	4.248E+04	2.854E+00	7.776E+01	4.248E+04	2.854E+00	1.218E+00	3.399E+02	2.283E-02	786.30
2033	11,723	12,895	285,891	314,480	1.102E+02	8.822E+04	5.927E+00	2.943E+01	4.411E+04	2.964E+00	8.074E+01	4.411E+04	2.964E+00	1.265E+00	3.529E+02	2.371E-02	816.43
2034	12,008	13,209	297,614	327,375	1.143E+02	9.154E+04	6.151E+00	3.054E+01	4.577E+04	3.075E+00	8.378E+01	4.577E+04	3.075E+00	1.313E+00	3.662E+02	2.460E-02	847.19
2035	12,300	13,530	309,622	340,584	1.186E+02	9.494E+04	6.379E+00	3.167E+01	4.747E+04	3.189E+00	8.689E+01	4.747E+04	3.189E+00	1.361E+00	3.797E+02	2.551E-02	878.59
2036	12,599	13,859	321,922	354,114	1.229E+02	9.840E+04	6.611E+00	3.282E+01	4.920E+04	3.306E+00	9.006E+01	4.920E+04	3.306E+00	1.411E+00	3.936E+02	2.645E-02	910.64
2037	12,905	14,196	334,521	367,973	1.273E+02	1.019E+05	6.849E+00	3.400E+01	5.097E+04	3.424E+00	9.330E+01	5.097E+04	3.424E+00	1.462E+00	4.077E+02	2.740E-02	943.37
2038	13,219	14,541	347,426	382,169	1.318E+02	1.055E+05	7.092E+00	3.521E+01	5.277E+04	3.546E+00	9.660E+01	5.277E+04	3.546E+00	1.513E+00	4.222E+02	2.837E-02	976.78
2039	13,540	14,894	360,645	396,710	1.364E+02	1.092E+05	7.339E+00	3.644E+01	5.462E+04	3.670E+00	9.998E+01	5.462E+04	3.670E+00	1.566E+00	4.369E+02	2.936E-02	1,010.91
2040	13,869	15,256	374,185	411,604	1.411E+02	1.130E+05	7.592E+00	3.769E+01	5.650E+04	3.796E+00	1.034E+02	5.650E+04	3.796E+00	1.620E+00	4.520E+02	3.037E-02	1,045.76
2041	14,206	15,627	388,054	426,859	1.459E+02	1.168E+05	7.851E+00	3.898E+01	5.842E+04	3.925E+00	1.069E+02	5.842E+04	3.925E+00	1.675E+00	4.674E+02	3.140E-02	1,081.35
2042	14,551	16,006	402,260	442,486	1.508E+02	1.208E+05	8.115E+00	4.029E+01	6.039E+04	4.057E+00	1.105E+02	6.039E+04	4.057E+00	1.732E+00	4.831E+02	3.246E-02	1,117.71
2043	14,905	16,396	416,811	458,492	1.558E+02	1.248E+05	8.384E+00	4.163E+01	6.239E+04	4.192E+00	1.142E+02	6.239E+04	4.192E+00	1.789E+00	4.991E+02	3.354E-02	1,154.85
2044	15,267	16,794	431,716	474,888	1.610E+02	1.289E+05	8.660E+00	4.299E+01	6.444E+04	4.330E+00	1.180E+02	6.444E+04	4.330E+00	1.848E+00	5.155E+02	3.464E-02	1,192.79
2045	15,638	17,202	446,983	491,681	1.662E+02	1.331E+05	8.941E+00	4.439E+01	6.654E+04	4.471E+00	1.218E+02	6.654E+04	4.471E+00	1.908E+00	5.323E+02	3.577E-02	1,231.56
2046	16,018	17,620	462,621	508,883	1.715E+02	1.374E+05	9.229E+00	4.582E+01	6.868E+04	4.614E+00	1.257E+02	6.868E+04	4.614E+00	1.969E+00	5.494E+02	3.692E-02	1,271.17
2047	16,407	18,048	478,639	526,503	1.770E+02	1.417E+05	9.523E+00	4.728E+01	7.086E+04	4.761E+00	1.297E+02	7.086E+04	4.761E+00	2.032E+00	5.669E+02	3.809E-02	1,311.65
2048	16,806	18,487	495,046	544,551	1.826E+02	1.462E+05	9.823E+00	4.877E+01	7.310E+04	4.912E+00	1.338E+02	7.310E+04	4.912E+00	2.096E+00	5.848E+02	3.929E-02	1,353.02
2049	17,215	18,937	511,852	563,037	1.883E+02	1.508E+05	1.013E+01	5.029E+01	7.538E+04	5.065E+00	1.380E+02	7.538E+04	5.065E+00	2.162E+00	6.031E+02	4.052E-02	1,395.30
2050	17,633	19,396	529,067	581,974	1.941E+02	1.554E+05	1.044E+01	5.185E+01	7.772E+04	5.222E+00	1.423E+02	7.772E+04	5.222E+00	2.229E+00	6.217E+02	4.178E-02	1,438.51
2051	18,061	19,867	546,700	601,370	2.001E+02	1.602E+05	1.076E+01	5.344E+01	8.010E+04	5.382E+00	1.466E+02	8.010E+04	5.382E+00	2.297E+00	6.408E+02	4.306E-02	1,482.68
2052	18,500	20,350	564,761	621,237	2.062E+02	1.651E+05	1.109E+01	5.507E+01	8.254E+04	5.546E+00	1.511E+02	8.254E+04	5.546E+00	2.367E+00	6.604E+02	4.437E-02	1,527.83
2053	18,950	20,845	583,261	641,587	2.124E+02	1.701E+05	1.143E+01	5.673E+01	8.504E+04	5.714E+00	1.557E+02	8.504E+04	5.714E+00	2.439E+00	6.803E+02	4.571E-02	1,573.99
2054	19,410	21,351	602,211	662,432	2.188E+02	1.752E+05	1.177E+01	5.843E+01	8.759E+04	5.885E+00	1.603E+02	8.759E+04	5.885E+00	2.512E+00	7.007E+02	4.708E-02	1,621.18
2055	19,882	21,870	621,621	683,783	2.253E+02	1.804E+05	1.212E+01	6.017E+01	9.019E+04	6.060E+00	1.651E+02	9.019E+04	6.060E+00	2.586E+00	7.216E+02	4.848E-02	1,669.42
2056	20,365	22,402	641,503	705,653	2.319E+02	1.857E+05	1.248E+01	6.195E+01	9.286E+04	6.239E+00	1.700E+02	9.286E+04	6.239E+00	2.663E+00	7.429E+02	4.991E-02	1,718.76
2057	20,860	22,946	661,868	728,055	2.387E+02	1.912E+05	1.284E+01	6.377E+01	9.558E+04	6.422E+00	1.750E+02	9.558E+04	6.422E+00	2.741E+00	7.647E+02	5.138E-02	1,769.20
2058	21,367	23,504	682,728	751,001	2.457E+02	1.967E+05	1.322E+01	6.563E+01	9.837E+04	6.610E+00	1.801E+02	9.837E+04	6.610E+00	2.821E+00	7.870E+02	5.288E-02	1,820.78
2059	21,886	24,075	704,095	774,505	2.528E+02	2.024E+05	1.360E+01	6.753E+01	1.012E+05	6.801E+00	1.853E+02	1.012E+05	6.801E+00	2.903E+00	8.098E+02	5.441E-02	1,873.53
2060	22,418	24,660	725,981	798,579	2.601E+02	2.083E+05	1.399E+01	6.947E+01	1.041E+05	6.997E+00	1.906E+02	1.041E+05	6.997E+00	2.986E+00	8.331E+02	5.598E-02	1,927.48
2061	22,963	25,259	748,399	823,239	2.675E+02	2.142E+05	1.439E+01	7.146E+01	1.071E+05	7.197E+00	1.961E+02	1.071E+05	7.197E+00	3.072E+00	8.569E+02	5.758E-02	1,982.66
2062	23,521	25,873	771,362	848,498	2.752E+02	2.203E+05	1.480E+01	7.350E+01	1.102E+05	7.402E+00	2.017E+02	1.102E+05	7.402E+00	3.159E+00	8.813E+02	5.922E-02	2,039.09
2063	24,093	26,502	794,883	874,371	2.829E+02	2.266E+05	1.522E+01	7.558E+01	1.133E+05	7.612E+00	2.074E+02	1.133E+05	7.612E+00	3.249E+00	9.063E+02	6.089E-02	2,096.81
2064	24,678	27,146	818,976	900,874	2.909E+02	2.329E+05	1.565E+01	7.771E+01	1.165E+05	7.826E+00	2.132E+02	1.165E+05	7.826E+00	3.340E+00	9.318E+02	6.261E-02	2,155.86
2065	25,278	27,806	843,654	928,019	2.991E+02	2.395E+05	1.609E+01	7.988E+01	1.197E+05	8.045E+00	2.192E+02	1.197E+05	8.045E+00	3.434E+00	9.579E+02	6.436E-02	2,216.26
2066	25,892	28,481	868,932	955,825	3.074E+02	2.462E+05	1.654E+01	8.211E+01	1.231E+05	8.269E+00	2.253E+02	1.231E+05	8.269E+00	3.529E+00	9.846E+02	6.616E-02	2,278.04
2067	26,521	29,173	894,824	984,306	3.159E+02	2.530E+05	1.700E+01	8.439E+01	1.265E+05	8.499E+00	2.315E+02	1.265E+05	8.499E+00	3.627E+00	1.012E+03	6.799E-02	2,341.25
2068	27,166	29,883	921,345	1,013,480	3.247E+02	2.600E+05	1.747E+01	8.672E+01	1.300E+05	8.734E+00	2.379E+02	1.300E+05	8.734E+00	3.727E+00	1.040E+03	6.987E-02	2,405.92
2069	27,826	30,609	948,511	1,043,362	3.336E+02	2.671E+05	1.795E+01	8.910E+01	1.336E+05	8.974E+00	2.445E+02	1.336E+05	8.974E+00	3.830E+00	1.068E+03	7.179E-02	2,472.08
2070	28,502	31,352	976,337	1,073,971	3.427E+02	2.744E+05	1.844E+01	9.154E+01	1.372E+05	9.220E+00	2.512E+02	1.372E+05	9.220E+00	3.935E+00	1.098E+03	7.376E-02	2,539.78
2071	29,195	32,115	1,004,839	1,105,323	3.521E+02	2.819E+05	1.894E+01	9.404E+01	1.410E+05	9.471E+00	2.580E+02	1.410E+05	9.471E+00	4.042E+00	1.128E+03	7.577E-02	2,609.04
2072	29,904	32,894	1,034,034	1,137,437	3.616E+02	2.896E+05	1.946E+01	9.660E+01	1.448E+05	9.728E+00	2.650E+02	1.448E+05	9.728E+00	4.152E+00	1.158E+03	7.783E-02	2,679.91
2073	30,631	33,694	1,063,938	1,170,332	3.714E+02	2.974E+05	1.998E+01	9.921E+01	1.487E+05	9.992E+00	2.722E+02	1.487E+05	9.992E+00	4.264E+00	1.190E+03	7.993E-02	2,752.43
2074	31,376	34,514	1,094,569	1,204,026	3.814E+02	3.054E+05	2.052E+01	1.019E+02	1.527E+05	1.026E+01	2.795E+02	1.527E+05	1.026E+01	4.379E+00	1.222E+03	8.209E-02	2,826.63
2075	0	0	1,125,945	1,204,026	3.917E+02	3.136E+05	2.107E+01	1.046E+02	1.568E+05	1.054E+01	2.871E+02	1.568E+05	1.054E+01	4.497E+00	1.255E+03	8.429E-02	2,902.57
2076	0	0	1,125,945	1,204,026	3.878E+02	3.105E+05	2.086E+01	1.036E+02	1.553E+05	1.043E+01	2.842E+02	1.553E+05	1.043E+01	4.452E+00	1.242E+03	8.345E-02	2,873.69
2077	0	0	1,125,945	1,204,026	3.839E+02	3.074E+05	2.066E+01	1.025E+02	1.537E+05	1.033E+01	2.814E+02	1.537E+05	1.033E+01	4.408E+00	1.230E+03	8.262E-02	2,845.10
2078	0	0	1,125,945	1,204,026	3.801E+02	3.044E+05	2.045E+01	1.015E+02	1.522E+05	1.023E+01	2.786E+02	1.522E+05	1.023E+01	4.364E+00	1.217E+03	8.180E-02	2,816.79
2079	0	0	1,125,945	1,204,026	3.763E+02	3.013E+05	2.025E+01	1.005E+02	1.507E+05	1.012E+01	2.758E+02	1.507E+05	1.012E+01	4.321E+00	1.205E+03	8.099E-02	2,788.76
2080	0	0	1,125,945	1,204,026	3.726E+02	2.983E+05	2.005E+01	9.952E+01	1.492E+05	1.002E+01	2.731E+02	1.492E+05	1.002E+01	4.278E+00	1.193E+03	8.018E-02	2,761.01
2081	0	0	1,125,945	1,204,026	3.689E+02	2.954E+05	1.985E+01	9.853E+01	1.477E+05	9.923E+00	2.703E+02	1.477E+05	9.923E+00	4.235E+00	1.181E+03	7.938E-02	2,733.54
2082	0	0	1,125,945	1,204,026	3.652E+02	2.924E+05	1.965E+01	9.755E+01	1.462E+05	9.824E+00	2.676E+02	1.462E+05	9.824E+00	4.193E+00	1.170E+03	7.859E-02	2,706.34
2083	0	0	1,125,945	1,204,026	3.616E+02	2.895E+05	1.945E+01	9.658E+01	1.448E+05	9.726E+00	2.650E+02	1.448E+05	9.726E+00	4.151E+00	1.158E+03	7.781E-02	2,679.41
2084	0	0	1,125,945	1,204,026	3.580E+02	2.866E+05	1.926E+01	9.562E+01	1.433E+05	9.630E+00	2.623E+02	1.433E+05	9.630E+00	4.110E+00	1.147E+03	7.704E-02	2,652.75
2085	0	0	1,125,945	1,204,026	3.544E+02	2.838E+05	1.907E+01	9.466E+01	1.419E+05	9.534E+00	2.597E+02	1.419E+05	9.534E+00	4.069E+00	1.135E+03	7.627E-02	2,626.36
2086	0	0	1,125,945	1,204,026	3.509E+02	2.810E+05	1.888E+01	9.372E+01	1.405E+05	9.439E+00	2.572E+02	1.405E+05	9.439E+00	4.028E+00	1.124E+03	7.551E-02	2,600.22
2087	0	0	1,125,945	1,204,026	3.474E+02	2.782E+05	1.869E+01	9.279E+01	1.391E+05	9.345E+00	2.546E+02	1.391E+05	9.345E+00	3.988E+00	1.113E+03	7.476E-02	2,574.35
2088	0	0	1,125,945	1,204,026	3.439E+02	2.754E+05	1.850E+01	9.187E+01	1.377E+05	9.252E+00	2.521E+02	1.377E+05	9.252E+00	3.949E+00	1.102E+03	7.402E-02	2,548.74
2089	0	0	1,125,945	1,204,026	3.405E+02	2.727E+05	1.832E+01	9.095E+01	1.363E+05	9.160E+00	2.496E+02	1.363E+05	9.160E+00	3.909E+00	1.091E+03	7.328E-02	2,523.38
2090	0	0	1,125,945	1,204,026	3.371E+02	2.699E+05	1.814E+01	9.005E+01	1.350E+05	9.069E+00	2.471E+02	1.350E+05	9.069E+00	3.870E+00	1.080E+03	7.255E-02	2,498.27
2091	0	0	1,125,945	1,204,026	3.338E+02	2.673E+05	1.796E+01	8.915E+01	1.336E+05	8.979E+00	2.446E+02	1.336E+05	8.979E+00	3.832E+00	1.069E+03	7.183E-02	2,473.41
2092	0	0	1,125,945	1,204,026	3.304E+02	2.646E+05	1.778E+01	8.826E+01	1.323E+05	8.889E+00	2.422E+02	1.323E+05	8.889E+00	3.794E+00	1.058E+03	7.111E-02	2,448.80
2093	0	0	1,125,945	1,204,026	3.272E+02	2.620E+05	1.760E+01	8.739E+01	1.310E+05	8.801E+00	2.398E+02	1.310E+05	8.801E+00	3.756E+00	1.048E+03	7.041E-02	2,424.43
2094	0	0	1,125,945	1,204,026	3.239E+02	2.594E+05	1.743E+01	8.652E+01	1.297E+05	8.713E+00	2.374E+02	1.297E+05	8.713E+00	3.719E+00	1.037E+03	6.971E-02	2,400.31
2095	0	0	1,125,945	1,204,026	3.207E+02	2.568E+05	1.725E+01	8.566E+01	1.284E+05	8.627E+00	2.350E+02	1.284E+05	8.627E+00	3.682E+00	1.027E+03	6.901E-02	2,376.43
2096	0	0	1,125,945	1,204,026	3.175E+02	2.542E+05	1.708E+01	8.480E+01	1.271E+05	8.541E+00	2.327E+02	1.271E+05	8.541E+00	3.645E+00	1.017E+03	6.833E-02	2,352.78
2097	0	0	1,125,945	1,204,026	3.143E+02	2.517E+05	1.691E+01	8.396E+01	1.258E+05	8.456E+00	2.304E+02	1.258E+05	8.456E+00	3.609E+00	1.007E+03	6.765E-02	2,329.37
2098	0	0	1,125,945	1,204,026	3.112E+02	2.492E+05	1.674E+01	8.312E+01	1.246E+05	8.372E+00	2.281E+02	1.246E+05	8.372E+00	3.573E+00	9.968E+02	6.697E-02	2,306.19
2099	0	0	1,125,945	1,204,026	3.081E+02	2.467E+05	1.658E+01	8.230E+01	1.234E+05	8.288E+00	2.258E+02	1.234E+05	8.288E+00	3.537E+00	9.869E+02	6.631E-02	2,283.25
2100	0	0	1,125,945	1,204,026	3.050E+02	2.443E+05	1.641E+01	8.148E+01	1.221E+05	8.206E+00	2.236E+02	1.221E+05	8.206E+00	3.502E+00	9.770E+02	6.565E-02	2,260.53
2101	0	0	1,125,945	1,204,026	3.020E+02	2.418E+05	1.625E+01	8.067E+01	1.209E+05	8.124E+00	2.213E+02	1.209E+05	8.124E+00	3.467E+00	9.673E+02	6.499E-02	2,238.03
2102	0	0	1,125,945	1,204,026	2.990E+02	2.394E+05	1.609E+01	7.987E+01	1.197E+05	8.043E+00	2.191E+02	1.197E+05	8.043E+00	3.433E+00	9.577E+02	6.435E-02	2,215.77
2103	0	0	1,125,945	1,204,026	2.960E+02	2.370E+05	1.593E+01	7.907E+01	1.185E+05	7.963E+00	2.170E+02	1.185E+05	7.963E+00	3.399E+00	9.482E+02	6.371E-02	2,193.72
2104	0	0	1,125,945	1,204,026	2.931E+02	2.347E+05	1.577E+01	7.828E+01	1.173E+05	7.884E+00	2.148E+02	1.173E+05	7.884E+00	3.365E+00	9.387E+02	6.307E-02	2,171.89
2105	0	0	1,125,945	1,204,026	2.902E+02	2.323E+05	1.561E+01	7.750E+01	1.162E+05	7.806E+00	2.127E+02	1.162E+05	7.806E+00	3.331E+00	9.294E+02	6.245E-02	2,150.28
2106	0	0	1,125,945	1,204,026	2.873E+02	2.300E+05	1.546E+01	7.673E+01	1.150E+05	7.728E+00	2.105E+02	1.150E+05	7.728E+00	3.298E+00	9.201E+02	6.182E-02	2,128.88
2107	0	0	1,125,945	1,204,026	2.844E+02	2.277E+05	1.530E+01	7.597E+01	1.139E+05	7.651E+00	2.084E+02	1.139E+05	7.651E+00	3.265E+00	9.110E+02	6.121E-02	2,107.70
2108	0	0	1,125,945	1,204,026	2.816E+02	2.255E+05	1.515E+01	7.521E+01	1.127E+05	7.575E+00	2.064E+02	1.127E+05	7.575E+00	3.233E+00	9.019E+02	6.060E-02	2,086.73
2109	0	0	1,125,945	1,204,026	2.788E+02	2.232E+05	1.500E+01	7.447E+01	1.116E+05	7.500E+00	2.043E+02	1.116E+05	7.500E+00	3.201E+00	8.929E+02	6.000E-02	2,065.97
2110	0	0	1,125,945	1,204,026	2.760E+02	2.210E+05	1.485E+01	7.372E+01	1.105E+05	7.425E+00	2.023E+02	1.105E+05	7.425E+00	3.169E+00	8.841E+02	5.940E-02	2,045.41
2111	0	0	1,125,945	1,204,026	2.733E+02	2.188E+05	1.470E+01	7.299E+01	1.094E+05	7.351E+00	2.003E+02	1.094E+05	7.351E+00	3.137E+00	8.753E+02	5.881E-02	2,025.06
2112	0	0	1,125,945	1,204,026	2.705E+02	2.166E+05	1.456E+01	7.227E+01	1.083E+05	7.278E+00	1.983E+02	1.083E+05	7.278E+00	3.106E+00	8.666E+02	5.822E-02	2,004.91
2113	0	0	1,125,945	1,204,026	2.679E+02	2.145E+05	1.441E+01	7.155E+01	1.072E+05	7.206E+00	1.963E+02	1.072E+05	7.206E+00	3.075E+00	8.579E+02	5.764E-02	1,984.96
2114	0	0	1,125,945	1,204,026	2.652E+02	2.123E+05	1.427E+01	7.083E+01	1.062E+05	7.134E+00	1.944E+02	1.062E+05	7.134E+00	3.045E+00	8.494E+02	5.707E-02	1,965.21
2115	0	0	1,125,945	1,204,026	2.625E+02	2.102E+05	1.413E+01	7.013E+01	1.051E+05	7.063E+00	1.924E+02	1.051E+05	7.063E+00	3.014E+00	8.409E+02	5.650E-02	1,945.65
2116	0	0	1,125,945	1,204,026	2.599E+02	2.081E+05	1.399E+01	6.943E+01	1.041E+05	6.993E+00	1.905E+02	1.041E+05	6.993E+00	2.984E+00	8.326E+02	5.594E-02	1,926.29
2117	0	0	1,125,945	1,204,026	2.573E+02	2.061E+05	1.385E+01	6.874E+01	1.030E+05	6.923E+00	1.886E+02	1.030E+05	6.923E+00	2.955E+00	8.243E+02	5.538E-02	1,907.13
2118	0	0	1,125,945	1,204,026	2.548E+02	2.040E+05	1.371E+01	6.806E+01	1.020E+05	6.854E+00	1.867E+02	1.020E+05	6.854E+00	2.925E+00	8.161E+02	5.483E-02	1,888.15
2119	0	0	1,125,945	1,204,026	2.523E+02	2.020E+05	1.357E+01	6.738E+01	1.010E+05	6.786E+00	1.849E+02	1.010E+05	6.786E+00	2.896E+00	8.080E+02	5.429E-02	1,869.36
2120	0	0	1,125,945	1,204,026	2.497E+02	2.000E+05	1.344E+01	6.671E+01	9.999E+04	6.718E+00	1.830E+02	9.999E+04	6.718E+00	2.867E+00	7.999E+02	5.375E-02	1,850.76
2121	0	0	1,125,945	1,204,026	2.473E+02	1.980E+05	1.330E+01	6.605E+01	9.900E+04	6.652E+00	1.812E+02	9.900E+04	6.652E+00	2.839E+00	7.920E+02	5.321E-02	1,832.35
2122	0	0	1,125,945	1,204,026	2.448E+02	1.960E+05	1.317E+01	6.539E+01	9.801E+04	6.585E+00	1.794E+02	9.801E+04	6.585E+00	2.811E+00	7.841E+02	5.268E-02	1,814.11
2123	0	0	1,125,945	1,204,026	2.424E+02	1.941E+05	1.304E+01	6.474E+01	9.704E+04	6.520E+00	1.776E+02	9.704E+04	6.520E+00	2.783E+00	7.763E+02	5.216E-02	1,796.06
2124	0	0	1,125,945	1,204,026	2.400E+02	1.921E+05	1.291E+01	6.409E+01	9.607E+04	6.455E+00	1.759E+02	9.607E+04	6.455E+00	2.755E+00	7.686E+02	5.164E-02	1,778.19
2125	0	0	1,125,945	1,204,026	2.376E+02	1.902E+05	1.278E+01	6.346E+01	9.511E+04	6.391E+00	1.741E+02	9.511E+04	6.391E+00	2.727E+00	7.609E+02	5.113E-02	1,760.50
2126	0	0	1,125,945	1,204,026	2.352E+02	1.883E+05	1.265E+01	6.282E+01	9.417E+04	6.327E+00	1.724E+02	9.417E+04	6.327E+00	2.700E+00	7.533E+02	5.062E-02	1,742.98
2127	0	0	1,125,945	1,204,026	2.329E+02	1.865E+05	1.253E+01	6.220E+01	9.323E+04	6.264E+00	1.707E+02	9.323E+04	6.264E+00	2.673E+00	7.459E+02	5.011E-02	1,725.64
2128	0	0	1,125,945	1,204,026	2.305E+02	1.846E+05	1.240E+01	6.158E+01	9.230E+04	6.202E+00	1.690E+02	9.230E+04	6.202E+00	2.647E+00	7.384E+02	4.962E-02	1,708.47
2129	0	0	1,125,945	1,204,026	2.282E+02	1.828E+05	1.228E+01	6.097E+01	9.139E+04	6.140E+00	1.673E+02	9.139E+04	6.140E+00	2.621E+00	7.311E+02	4.912E-02	1,691.47
2130	0	0	1,125,945	1,204,026	2.260E+02	1.810E+05	1.216E+01	6.036E+01	9.048E+04	6.079E+00	1.656E+02	9.048E+04	6.079E+00	2.594E+00	7.238E+02	4.863E-02	1,674.64
2131	0	0	1,125,945	1,204,026	2.237E+02	1.792E+05	1.204E+01	5.976E+01	8.958E+04	6.019E+00	1.640E+02	8.958E+04	6.019E+00	2.569E+00	7.166E+02	4.815E-02	1,657.98

2132	0	0	1,125,945	1,204,026	2.215E+02	1.774E+05	1.192E+01	5.917E+01	8.868E+04	5.959E+00	1.623E+02	8.868E+04	5.959E+00	2.543E+00	7.095E+02	4.767E-02	1,641.48
2133	0	0	1,125,945	1,204,026	2.193E+02	1.756E+05	1.180E+01	5.858E+01	8.780E+04	5.899E+00	1.607E+02	8.780E+04	5.899E+00	2.518E+00	7.024E+02	4.720E-02	1,625.15
2134	0	0	1,125,945	1,204,026	2.171E+02	1.739E+05	1.168E+01	5.799E+01	8.693E+04	5.841E+00	1.591E+02	8.693E+04	5.841E+00	2.493E+00	6.954E+02	4.673E-02	1,608.98
2135	0	0	1,125,945	1,204,026	2.150E+02	1.721E+05	1.157E+01	5.742E+01	8.606E+04	5.783E+00	1.575E+02	8.606E+04	5.783E+00	2.468E+00	6.885E+02	4.626E-02	1,592.97

Data source	Date	Author	PW Link
	2019-05-28	31RJM (Robert Morga	pw:\\pwintsrv.dillon.ca:Projects_2019\Documents\Projects\199543 LF-TS Design & CA Services\2. Work\Analysis & Design\LandGEM\LandGEM - Iqaluit Landfill - Project - New Landfill.xlsx

BASELINE GHG EMISSIONS

BASELINE Table S1-B
Onsite Mobile Equipment

Description of Activity:

Onsite equipment moving waste within the Waste Transfer Station (WTS) and from the WTS to the landfill. These activities are assumed to include all non-road and on-road onsite mobile equipment such as:

Non-Road: Bucket Loader, Skid Steer, and Landfill Compactor

On-Road: Two (2) Ford F-250 Trucks (pickup trucks for general use)

Other Mobile Equipment Assumptions

Assumed that only one of the pickup trucks is operating at any given time.
Assumed Landfill operating 8 hours per day, 260 days per year. This is based on emails from Keith Barnes (Dillon) and Erik Marko (Colliers), dated May 17, 2019

Assumed that operating effort of the mobile equipment would increase proportionally to increasing MSW tonnages

Activity Data

WTS Operating Hours per Day	**8 Hrs**
WTS Operating Days per Year	**260 Days**
Gas Usage in 2018 - F-250 Trucks (for both trucks)	**10,651 L**

Type	Source	Description	Equipment and Activity Data				
			No. Operating	Hrs/Day	Fuel Type	Engine HP	Operating Data
Non-Road	Bucket Loader	Cat 950G Loader (Tier 2)	1	4 Hrs/Day	Diesel	240 HP	1,040 Hrs/Year
Non-Road	Skid Steer	John Deere Skid Steer (Tier 4)	1	1 Hrs/Day	Diesel	50 to 100 HP	260 Hrs/Year
Non-Road	Landfill Compactor	Cat 816F Landfill Compactor (Tier 2)	1	4 Hrs/Day	Diesel	183 HP	1,040 Hrs/Year
On-Road	Ford F-250 Truck	Pickup truck used for transportation around site	1		Gasoline		10,651 L/Year

Notes

[1] Marko, L. May 10, 2019. Dillon Question Response 60571501 pdf.

[2] National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada—National Inventory Report 1990–2017—Part 2—A6.1.6 © Her Majesty the Queen in Right of Canada, represented by the Minister of Environment and Climate Change, 2019

3. Assumes that 2018 was a representative year for Ford F250 Truck Use (provided in AECOM Memo, dated XXXX)

4. Assumes that the pick-up truck gasoline usages were attributed/included with the existing Landfill operations

Non-Road Emission Factors

	Front-End Loader (175-300 HP)	Skid Steer (75-100 HP)
EFss HC	0.3085	0.1314
BSFC	0.367	0.408
DF	1.017	N/Ap
"A" - relative Deterioration Fa	0.034	N/Ap
Assumption - Fraction of Use	0.5	N/Ap
TAF	2.29	N/Ap
EFadj HC	0.718	0.131
CO_2 (g/hp-hr)	528.8	590.0

Note
1. Assumed EFs for *Bulldozer (75-100HP)* which are the same as *Equipment (>50-100 HP)* and *Forklift (50-75 HP)*

2. Tier 4 emissions factors are considered to be transient, rather than steady-state. Therefore no conversion or deterioration calculations are required.

Emissions Factors - Onsite Mobile Equipment [1,2]					
Type	Source	Description	Emission Factors		
			CO_2	CH_4	N_2O
Non-Road	Bucket Loader	Cat 950G Loader	528.75 g/hp-hr	-	-
Non-Road	Skid Steer	John Deere Skid Steer	589.95 g/hp-hr	-	-
Non-Road	Landfill Compactor	Cat 816F Landfill Compactor	528.75 g/hp-hr	-	-
On-Road	Ford F-250 Truck	Pickup truck used for transportation of compacted MSW bales	2,307 g/L Fuel	0.14 g/L Fuel	0.02 g/L Fuel

[1] National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada—Part 2—Table A6-13. Environment and Climate Change Canada, 2019. (Accessed 12AUG2019).

[2] LD Truck - 2004 or later classification used for emission factors for F250 pickup trucks

Base Year Emissions (2019) - Onsite Mobile Equipment [1,2,3]								
Type	Source	Description	Emissions (tonnes)			Emissions (tonnes CO_2e)		
			CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Non-Road	Bucket Loader	Cat 950G Loader	132 tonnes	-	-	132 tonnes	-	-
Non-Road	Skid Steer	John Deere Skid Steer	15 tonnes	-	-	15 tonnes	-	-
Non-Road	Landfill Compactor	Cat 816F Landfill Compactor	101 tonnes	-	-	101 tonnes	-	-
On-Road	Ford F-250 Truck	Pickup truck used for transportation of compacted MSW bales	25 tonnes	0.0015 tonnes	0.0002 tonnes	25 tonnes	0.04 tonnes	0.07 tonnes
Total			273 tonnes	0.0015 tonnes	0.0002 tonnes	273 tonnes	0.04 tonnes	0.07 tonnes

[1] National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada—Part 2—Table A6-13. Environment and Climate Change Canada, 2019. (Accessed 12AUG2019).

[2] LD Truck - 2004 or later classification used for emission factors for F250 pickup trucks

[3] Assumed worst case for skid steer (largest diesel model by John Deere)

Global Warming Potentials	CO_2	CH_4	N_2O
	1	25	298

2030 Emissions - Onsite Mobile Equipment [1,2,3]								
Type	Source	Description	Emissions (tonnes)			Emissions (tonnes CO_2e)		
Total Emissions in 2030			355 tonnes	0.0019 tonnes	0.0003 tonnes	355 tonnes	0.05 tonnes	0.09 tonnes
Total Cumulative Emissions from 2019 to 2030			3,745 tonnes	0.0205 tonnes	0.0032 tonnes	3,745 tonnes	0.5123 tonnes	0.9595 tonnes

[1] National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada—Part 2—Table A6-13. Environment and Climate Change Canada, 2019. (Accessed 12AUG2019).

[2] LD Truck - 2004 or later classification used for emission factors for F250 pickup trucks

[3] Assumed worst case for skid steer (largest diesel model by John Deere)

Population Growth Rate 1.42%
Municipal Solid Waste Growth Rate 1.00%

Project Year	Baseline Year	Year	Annual MSW (tonnes)	Onsite Mobile Equipment Emissions						Total CO_2e Emissions
				CO_2 emissions (tonnes)	CH_4 emissions (tonnes)	N_2O emissions (tonnes)	CO_2 emissions (tonnes CO_2e)	CH_4 emissions (tonnes CO_2e)	N_2O emissions (tonnes CO_2e)	
-	1	2019	8,580	273	0.00149	0.00023	272.52	0.04	0.07	272.63
0	2	2020	8,580	279	0.00153	0.00024	279.14	0.04	0.07	279.25
1	3	2021	8,789	286	0.00156	0.00025	285.93	0.04	0.07	286.04
2	4	2022	9,002	293	0.00160	0.00025	292.87	0.04	0.08	292.99
3	5	2023	9,221	300	0.00164	0.00026	299.99	0.04	0.08	300.11
4	6	2024	9,445	307	0.00168	0.00026	307.28	0.04	0.08	307.40
5	7	2025	9,674	315	0.00172	0.00027	314.75	0.04	0.08	314.87
6	8	2026	9,910	322	0.00176	0.00028	322.40	0.04	0.08	322.52
7	9	2027	10,150	330	0.00181	0.00028	330.23	0.05	0.08	330.36
8	10	2028	10,397	338	0.00185	0.00029	338.26	0.05	0.09	338.39
9	11	2029	10,650	346	0.00190	0.00030	346.48	0.05	0.09	346.61
10	12	2030	10,909	355	0.00194	0.00031	354.90	0.05	0.09	355.04
11	13	2031	11,174	364	0.00199	0.00031	363.52	0.05	0.09	363.66
12	14	2032	11,445	372	0.00204	0.00032	372.36	0.05	0.10	372.50
13	15	2033	11,723	381	0.00209	0.00033	381.40	0.05	0.10	381.55
14	16	2034	12,008	391	0.00214	0.00034	390.67	0.05	0.10	390.83
15	17	2035	12,300	400	0.00219	0.00034	400.17	0.05	0.10	400.32
16	18	2036	12,599	410	0.00224	0.00035	409.89	0.06	0.11	410.05
17	19	2037	12,905	420	0.00230	0.00036	419.85	0.06	0.11	420.02
18	20	2038	13,219	430	0.00235	0.00037	430.06	0.06	0.11	430.23
19	21	2039	13,540	441	0.00241	0.00038	440.51	0.06	0.11	440.68
20	22	2040	13,869	451	0.00247	0.00039	451.21	0.06	0.12	451.39
21	23	2041	14,206	462	0.00253	0.00040	462.18	0.06	0.12	462.36
22	24	2042	14,551	473	0.00259	0.00041	473.41	0.06	0.12	473.60
23	25	2043	14,905	485	0.00265	0.00042	484.91	0.07	0.12	485.10
24	26	2044	15,267	497	0.00272	0.00043	496.70	0.07	0.13	496.89
25	27	2045	15,638	509	0.00278	0.00044	508.77	0.07	0.13	508.97
26	28	2046	16,018	521	0.00285	0.00045	521.13	0.07	0.13	521.34
27	29	2047	16,407	534	0.00292	0.00046	533.80	0.07	0.14	534.01
28	30	2048	16,806	547	0.00299	0.00047	546.77	0.07	0.14	546.98
29	31	2049	17,215	560	0.00306	0.00048	560.06	0.08	0.14	560.28
30	32	2050	17,633	574	0.00314	0.00049	573.67	0.08	0.15	573.89
31	33	2051	18,061	588	0.00322	0.00051	587.61	0.08	0.15	587.84
32	34	2052	18,500	602	0.00329	0.00052	601.89	0.08	0.15	602.12
33	35	2053	18,950	617	0.00337	0.00053	616.51	0.08	0.16	616.76
34	36	2054	19,410	631	0.00346	0.00054	631.50	0.09	0.16	631.74
35	37	2055	19,882	647	0.00354	0.00056	646.84	0.09	0.17	647.10
36	38	2056	20,365	663	0.00363	0.00057	662.56	0.09	0.17	662.82
37	39	2057	20,860	679	0.00371	0.00058	678.66	0.09	0.17	678.93
38	40	2058	21,367	695	0.00380	0.00060	695.16	0.10	0.18	695.43
39	41	2059	21,886	712	0.00390	0.00061	712.05	0.10	0.18	712.33
40	42	2060	22,418	729	0.00399	0.00063	729.35	0.10	0.19	729.64
41	43	2061	22,963	747	0.00409	0.00064	747.08	0.10	0.19	747.37
42	44	2062	23,521	765	0.00419	0.00066	765.23	0.10	0.20	765.53
43	45	2063	24,093	784	0.00429	0.00067	783.83	0.11	0.20	784.14
44	46	2064	24,678	803	0.00439	0.00069	802.88	0.11	0.21	803.19
45	47	2065	25,278	822	0.00450	0.00071	822.39	0.11	0.21	822.71
46	48	2066	25,892	842	0.00461	0.00072	842.37	0.12	0.22	842.71
47	49	2067	26,521	863	0.00472	0.00074	862.85	0.12	0.22	863.18
48	50	2068	27,166	884	0.00484	0.00076	883.81	0.12	0.23	884.16
49	51	2069	27,826	905	0.00495	0.00078	905.29	0.12	0.23	905.65
50	52	2070	28,502	927	0.00507	0.00080	927.29	0.13	0.24	927.66
51	53	2071	29,195	950	0.00520	0.00082	949.83	0.13	0.24	950.20
52	54	2072	29,904	973	0.00532	0.00084	972.91	0.13	0.25	973.29
53	55	2073	30,631	997	0.00545	0.00086	996.55	0.14	0.26	996.94
54	56	2074	31,376	1,021	0.00559	0.00088	1020.77	0.14	0.26	1,021.17
55	57	2075	32,138	1,046	0.00572	0.00090	1045.58	0.14	0.27	1,045.99
56	58	2076	32,919	1,071	0.00586	0.00092	1070.99	0.15	0.27	1,071.41
57	59	2077	33,719	1,097	0.00600	0.00094	1097.01	0.15	0.28	1,097.44
58	60	2078	34,538	1,124	0.00615	0.00097	1123.67	0.15	0.29	1,124.11
59	61	2079	35,378	1,151	0.00630	0.00099	1150.98	0.16	0.29	1,151.43
60	62	2080	36,237	1,179	0.00645	0.00101	1178.95	0.16	0.30	1,179.41
61	63	2081	37,118	1,208	0.00661	0.00104	1207.60	0.17	0.31	1,208.07
62	64	2082	38,020	1,237	0.00677	0.00106	1236.95	0.17	0.32	1,237.43
63	65	2083	38,944	1,267	0.00693	0.00109	1267.01	0.17	0.32	1,267.50
64	66	2084	39,890	1,298	0.00710	0.00112	1297.80	0.18	0.33	1,298.31
65	67	2085	40,860	1,329	0.00727	0.00114	1329.33	0.18	0.34	1,329.86
66	68	2086	41,853	1,362	0.00745	0.00117	1361.64	0.19	0.35	1,362.17
67	69	2087	42,870	1,395	0.00763	0.00120	1394.73	0.19	0.36	1,395.28
68	70	2088	43,912	1,429	0.00782	0.00123	1428.62	0.20	0.37	1,429.18
69	71	2089	44,979	1,463	0.00801	0.00126	1463.34	0.20	0.37	1,463.92
70	72	2090	46,072	1,499	0.00820	0.00129	1498.90	0.21	0.38	1,499.49
71	73	2091	47,192	1,535	0.00840	0.00132	1535.33	0.21	0.39	1,535.93
72	74	2092	48,338	1,573	0.00861	0.00135	1572.64	0.22	0.40	1,573.26
73	75	2093	49,513	1,611	0.00881	0.00139	1610.86	0.22	0.41	1,611.49
74	76	2094	50,716	1,650	0.00903	0.00142	1650.00	0.23	0.42	1,650.65
75	77	2095	51,949	1,690	0.00925	0.00145	1690.10	0.23	0.43	1,690.77
76	78	2096	53,211	1,731	0.00947	0.00149	1731.17	0.24	0.44	1,731.85

BASELINE GHG EMISSIONS

BASELINE Table S1-C
Baseline - Cardboard Incinerator, with Diesel as an Accelerant (Burn Box)

Description of Activity:

Currently, cardboard is stockpiled and combusted in an incinerator using diesel fuel as an accelerant.

The Landfill utilizes an Airburners S-220 Refractory Walled Air Curtain Burner with a Kubota V2403-TE Diesel Engine to burn cardboard

Incineration Calculation of Cardboard and Diesel

Assumed all cardboard is baled and Diesel fuel is used as an accelerant
Assumed all cardboard combusted in batch-stoker style burner. Only emission factors for cardboard combustion available from cardboard incineration. Therefore calculations used emission factors provided in Canada's National Inventory Report 1990-2017 Part 2 (Published 2019) for municipal solid waste incineration of cardboard.

Assumed that all diesel fuel used during the incineration processes is already captured under the site-wide diesel fuel usage (therefore excluded from the emissions calculations) as per Jim Clare, AECOM, letter dated May 10th 2019.

Assume all cardboard received continues to be incinerated as per current practises, and the usage of diesel fuel increases proportionally to the increases in cardboard being burned.

Average operating time in 2018	64 days
Volume of Diesel used as an Accelerant (2019)	3 US gallons per Hr
Mass of Cardboard Incinerated	3,438 tonnes
Volume of Diesel Used for the Kubota Engine (air fan)	2.5 US gallons per Hr
Conversion of US gallons to L	3.79 Litres per US gallon

Emissions Factor - Biomass Combustion[1,2,3]				
Source	Description	Emission Factor		
		CO_2	CH_4	N_2O
Cardboard Incineration[1]	Incineration of cardboard using the Airburner S220	1,652 g/kg fuel	4.12 g/kg fuel	0.059 g/kg fuel
Kubota Engine[2]	Diesel Engine powered fan for Air Curtain	2,681 g/L fuel	0.133 g/L fuel	0.40 g/L fuel
Accelerant Combustion[2]	Combustion of Diesel Fuel	2,681 g/L fuel	0.133 g/L fuel	0.40 g/L fuel

[1] National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada—Part 2—Table A6-56. Environment and Climate Change Canada, 2019. (Accessed 12AUG2019).

[2] National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada—Part 2—Table A6-4. Environment and Climate Change Canada, 2019. (Accessed 12AUG2019).

Global Warming Potentials	CO_2	CH_4	N_2O
	1	25	298

2030 Emissions - Biomass Combustion[1, 2]							
Source	Description	Emissions (tonnes)			Emissions (tonnes CO_2e)		
		CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Pellet Stove - WTS Boiler	Conservative estimate of biomass boiler emissions	5,679	14.16	0.203	5,679	354	60
Kubota Engine[1]	Diesel Engine powered fan for Air Curtain	*Captured under mobile s*	*Captured under mobile source*	*Captured under mobile so*	*Captured under mobile sources*	*Captured under mobile*	*Captured under mobile sourc*
Accelerant Combustion[1]	Combustion of Diesel Fuel	*Captured under mobile s*	*Captured under mobile source*	*Captured under mobile so*	*Captured under mobile sources*	*Captured under mobile*	*Captured under mobile sourc*
Total in Year 2030		**5,679**	**14.16**	**0.203**	**5,679**	**354**	**60**
Total Cumulative (2021 to 2030)		**51,098**	**127.44**	**1.82**	**51,098**	**3,186**	**544**

[1] Letter from Jim Clare, Project Manager at AECOM. Dated May 10th 2019, reference number 6057501. Letter stated: "Note the amount for diesel consumed in 2018 is included in the amount of diesel provided under landfill equipment."

Project Year	Baseline Year	Year	Cardboard Incinerated (tonnes/yr)[1]	Biomass Boiler Combustion Emissions						Total CO_2e Emissions
				CO_2 emissions (tonnes)	CH_4 emissions (tonnes)	N_2O emissions (tonnes)	CO_2 emissions (tonnes CO_2e)	CH_4 emissions (tonnes CO_2e)	N_2O emissions (tonnes CO_2e)	
-	1	2019	2,704.00	4,467.01	11.14	0.16	4467.01	278.51	47.54	4,793.06
0	2	2020	2,704.00	4,467.01	11.14	0.16	4467.01	278.51	47.54	4,793.06
1	3	2021	2,769.71	4,575.56	11.41	0.16	4575.56	285.28	48.70	4,909.54
2	4	2022	2,837.02	4,686.76	11.69	0.17	4686.76	292.21	49.88	5,028.85
3	5	2023	2,905.96	4,800.65	11.97	0.17	4800.65	299.31	51.09	5,151.06
4	6	2024	2,976.58	4,917.32	12.26	0.18	4917.32	306.59	52.33	5,276.24
5	7	2025	3,048.92	5,036.81	12.56	0.18	5036.81	314.04	53.61	5,404.46
6	8	2026	3,123.01	5,159.22	12.87	0.18	5159.22	321.67	54.91	5,535.80
7	9	2027	3,198.91	5,284.59	13.18	0.19	5284.59	329.49	56.24	5,670.32
8	10	2028	3,276.65	5,413.02	13.50	0.19	5413.02	337.49	57.61	5,808.12
9	11	2029	3,356.27	5,544.56	13.83	0.20	5544.56	345.70	59.01	5,949.27
10	12	***2030***	3,437.84	***5,679.30***	***14.16***	***0.20***	5679.30	354.10	60.44	6,093.85
11	13	2031	3,521.38	5,817.32	14.51	0.21	5817.32	362.70	61.91	6,241.94
12	14	2032	3,606.96	5,958.69	14.86	0.21	5958.69	371.52	63.42	6,393.63
13	15	2033	3,694.61	6,103.50	15.22	0.22	6103.50	380.54	64.96	6,549.00
14	16	2034	3,784.40	6,251.82	15.59	0.22	6251.82	389.79	66.54	6,708.15
15	17	2035	3,876.36	6,403.75	15.97	0.23	6403.75	399.27	68.15	6,871.17
16	18	2036	3,970.56	6,559.37	16.36	0.23	6559.37	408.97	69.81	7,038.15
17	19	2037	4,067.06	6,718.78	16.76	0.24	6718.78	418.91	71.51	7,209.19
18	20	2038	4,165.89	6,882.05	17.16	0.25	6882.05	429.09	73.24	7,384.38
19	21	2039	4,267.13	7,049.30	17.58	0.25	7049.30	439.51	75.02	7,563.84
20	22	2040	4,370.83	7,220.61	18.01	0.26	7220.61	450.20	76.85	7,747.65
21	23	2041	4,477.04	7,396.08	18.45	0.26	7396.08	461.14	78.72	7,935.93
22	24	2042	4,585.84	7,575.81	18.89	0.27	7575.81	472.34	80.63	8,128.78
23	25	2043	4,697.29	7,759.92	19.35	0.28	7759.92	483.82	82.59	8,326.33
24	26	2044	4,811.44	7,948.50	19.82	0.28	7948.50	495.58	84.59	8,528.67
25	27	2045	4,928.36	8,141.66	20.30	0.29	8141.66	507.62	86.65	8,735.93
26	28	2046	5,048.13	8,339.51	20.80	0.30	8339.51	519.96	88.76	8,948.23
27	29	2047	5,170.81	8,542.18	21.30	0.31	8542.18	532.59	90.91	9,165.68
28	30	2048	5,296.47	8,749.77	21.82	0.31	8749.77	545.54	93.12	9,388.42
29	31	2049	5,425.18	8,962.40	22.35	0.32	8962.40	558.79	95.39	9,616.58
30	32	2050	5,557.02	9,180.20	22.89	0.33	9180.20	572.37	97.70	9,850.28
31	33	2051	5,692.07	9,403.29	23.45	0.34	9403.29	586.28	100.08	10,089.65
32	34	2052	5,830.39	9,631.81	24.02	0.34	9631.81	600.53	102.51	10,334.85
33	35	2053	5,972.08	9,865.88	24.60	0.35	9865.88	615.12	105.00	10,586.00
34	36	2054	6,117.21	10,105.63	25.20	0.36	10105.63	630.07	107.55	10,843.26
35	37	2055	6,265.87	10,351.21	25.82	0.37	10351.21	645.38	110.17	11,106.77
36	38	2056	6,418.14	10,602.77	26.44	0.38	10602.77	661.07	112.84	11,376.68
37	39	2057	6,574.11	10,860.43	27.09	0.39	10860.43	677.13	115.59	11,653.15
38	40	2058	6,733.87	11,124.36	27.74	0.40	11124.36	693.59	118.39	11,936.34
39	41	2059	6,897.52	11,394.69	28.42	0.41	11394.69	710.44	121.27	12,226.41
40	42	2060	7,065.14	11,671.60	29.11	0.42	11671.60	727.71	124.22	12,523.53
41	43	2061	7,236.83	11,955.24	29.82	0.43	11955.24	745.39	127.24	12,827.87
42	44	2062	7,412.70	12,245.77	30.54	0.44	12245.77	763.51	130.33	13,139.61
43	45	2063	7,592.84	12,543.37	31.28	0.45	12543.37	782.06	133.50	13,458.93
44	46	2064	7,777.35	12,848.19	32.04	0.46	12848.19	801.07	136.74	13,786.00
45	47	2065	7,966.36	13,160.42	32.82	0.47	13160.42	820.53	140.06	14,121.02
46	48	2066	8,159.95	13,480.24	33.62	0.48	13480.24	840.48	143.47	14,464.18
47	49	2067	8,358.25	13,807.83	34.44	0.49	13807.83	860.90	146.95	14,815.69
48	50	2068	8,561.37	14,143.38	35.27	0.51	14143.38	881.82	150.53	15,175.73
49	51	2069	8,769.42	14,487.09	36.13	0.52	14487.09	903.25	154.18	15,544.52
50	52	2070	8,982.54	14,839.15	37.01	0.53	14839.15	925.20	157.93	15,922.28
51	53	2071	9,200.83	15,199.76	37.91	0.54	15199.76	947.69	161.77	16,309.22
52	54	2072	9,424.42	15,569.14	38.83	0.56	15569.14	970.72	165.70	16,705.56
53	55	2073	9,653.45	15,947.50	39.77	0.57	15947.50	994.31	169.73	17,111.53
54	56	2074	9,888.04	16,335.05	40.74	0.58	16335.05	1,018.47	173.85	17,527.37

55	57	2075	10,128.34	16,732.01	41.73	0.60	16732.01	1,043.22	178.08	17,953.31
56	58	2076	10,374.47	17,138.63	42.74	0.61	17138.63	1,068.57	182.40	18,389.60
57	59	2077	10,626.59	17,555.12	43.78	0.63	17555.12	1,094.54	186.84	18,836.50
58	60	2078	10,884.83	17,981.74	44.85	0.64	17981.74	1,121.14	191.38	19,294.26
59	61	2079	11,149.35	18,418.73	45.94	0.66	18418.73	1,148.38	196.03	19,763.14
60	62	2080	11,420.30	18,866.33	47.05	0.67	18866.33	1,176.29	200.79	20,243.41
61	63	2081	11,697.83	19,324.81	48.20	0.69	19324.81	1,204.88	205.67	20,735.36
62	64	2082	11,982.10	19,794.44	49.37	0.71	19794.44	1,234.16	210.67	21,239.26
63	65	2083	12,273.29	20,275.47	50.57	0.72	20275.47	1,264.15	215.79	21,755.41
64	66	2084	12,571.55	20,768.20	51.79	0.74	20768.20	1,294.87	221.03	22,284.10
65	67	2085	12,877.06	21,272.90	53.05	0.76	21272.90	1,326.34	226.40	22,825.64
66	68	2086	13,189.99	21,789.86	54.34	0.78	21789.86	1,358.57	231.91	23,380.34
67	69	2087	13,510.53	22,319.39	55.66	0.80	22319.39	1,391.58	237.54	23,948.52
68	70	2088	13,838.86	22,861.79	57.02	0.82	22861.79	1,425.40	243.31	24,530.51
69	71	2089	14,175.16	23,417.37	58.40	0.84	23417.37	1,460.04	249.23	25,126.64
70	72	2090	14,519.64	23,986.45	59.82	0.86	23986.45	1,495.52	255.28	25,737.25
71	73	2091	14,872.49	24,569.36	61.27	0.88	24569.36	1,531.87	261.49	26,362.71
72	74	2092	15,233.92	25,166.43	62.76	0.90	25166.43	1,569.09	267.84	27,003.37
73	75	2093	15,604.12	25,778.01	64.29	0.92	25778.01	1,607.22	274.35	27,659.59
74	76	2094	15,983.33	26,404.46	65.85	0.94	26404.46	1,646.28	281.02	28,331.76
75	77	2095	16,371.75	27,046.13	67.45	0.97	27046.13	1,686.29	287.85	29,020.27
76	78	2096	16,769.61	27,703.39	69.09	0.99	27703.39	1,727.27	294.84	29,725.51

BASELINE GHG EMISSIONS

Table Baseline S1-C
Baseline - Landfill Fires and Fire Extinguishing

Description of Activity:

The existing landfill regularly catches fire, and is either left to "burn out" or emergency services are contracted or called upon to extinguish the fire.

Limited information regarding the number of occurrences, type of material combusted, and efforts to extinguish the fires, available.

The following is the data-set used to quantify the average annual landfill fire emissions:

Three Fire events:

1. 2010/2011 C&D material fire, lasted approximately 27days, was left to "burn itself out"
2. 2014 MSW subsurface fire lasted approximately 4 months, MSW pile approximately the length of a football field and as tall as 17m, had to be dug "bucket by bucket" and doused with water. Fire crews brought in to fight fire, working approximately 17days
3. 2018 small surface fires (two), which were approximately 10m2 or smaller, lasted about 1hr to control and 3-4 hours in total. Fire department called upon to support with extinguishing the fires.

Assumptions for Landfill Fire Emissions

Methodology used will take the total emissions from all fire events and average them over the data period. Emissions included will be all emissions from combusted landfill material. Emissions from additional contracted equipment are not included de to insufficient data (assumed this equipment's fuel usages were not included in the site's total fuel usages).

Methodology followed that suggested from the IPCC, excerpt herein: "*Consistent with the 1996 Guidelines (IPCC, 1997), only CO2 emissions resulting from oxidation, during incineration and open burning of carbon in waste of fossil origin (e.g., plastics, certain textiles, rubber, liquid solvents, and waste oil) are considered net emissions and should be included in the national CO2 emissions estimate. The CO2 emissions from combustion of biomass materials (e.g., paper, food, and wood waste) contained in the waste are biogenic emissions and should not be included in national total emission estimates.* " (From: https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_5_Ch5_IOB.pdf Accessed 28 August 2019)

Assumed volume of waste combusted during the 2010/2011 fire based on the duration of the fire, extrapolating from the size and duration of the fire from 2018 and 2014.

	2010/2011	2014	2018	
Duration of fire (days)	27	122	0.15	49.72
Size of fire	*3165 m3*	15852 m3	15 m3	6,343.92

Total Averaging Period	2010 to 2019
Averaging Years	9 years
Estimated Density (USEPA 2006)	550 lbs/yard
Estimated Density (USEPA 2006)	330 kg/m3
Average amount of waste burned per year	697,017 kg/year

Density obtained from US EPA Volume-to-Weight Conversion Factors U.S. Environmental Protection Agency Office of Resource Conservation and Recovery April

MSW Data - Regional Defaults from 2006 IPCC Guidelines for National GHG Inventories - North America				
	MSW Composition (%)	Dry Matter Content (%)	Total Carbon Content (% of dry weight)	Fossil carbon fraction (% of total carbon)
Food Waste	33.9%	40.0%	38.0%	0.0%
Paper/cardboard	23.2%	90.0%	64.0%	1.0%
Wood	6.2%	85.0%	50.0%	0.0%
Textiles	3.9%	80.0%	50.0%	20.0%
Rubber/leather	1.4%	84.0%	67.0%	20.0%
Plastic	8.5%	100.0%	75.0%	100.0%
Metal	4.6%	100.0%	0.0%	0.0%
Glass	6.5%	100.0%	0.0%	0.0%
Other	9.8%	90.0%	3.0%	100.0%

[1] 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 2 Waste Generation, Composition and Management Data.

Dry matter content (dm)	72%
Total carbon content (CF)	40%
Fraction of fossil carbon in the total carbon (frac	20%
Oxidation factor (OF)	58%

84,948.86

EQUATION 5.1
CO_2 EMISSION ESTIMATE BASED ON THE TOTAL AMOUNT OF WASTE COMBUSTED

$$CO_2\ Emissions = \sum_i \left(SW_i \bullet dm_i \bullet CF_i \bullet FCF_i \bullet OF_i \right) \bullet 44/12$$

Where:

CO_2 Emissions = CO_2 emissions in inventory year, Gg/yr

SW_i = total amount of solid waste of type *i* (wet weight) incinerated or open-burned, Gg/yr

dm_i = dry matter content in the waste (wet weight) incinerated or open-burned, (fraction)

CF_i = fraction of carbon in the dry matter (total carbon content), (fraction)

FCF_i = fraction of fossil carbon in the total carbon, (fraction)

OF_i = oxidation factor, (fraction)

44/12 = conversion factor from C to CO_2

i = type of waste incinerated/open-burned specified as follows:

MSW: municipal solid waste (if not estimated using Equation 5.2), ISW: industrial solid waste, SS: sewage sludge, HW: hazardous waste, CW: clinical waste, others (that must be specified)

If the activity data of wastes are available on a dry matter basis, which is preferable, the same equation can be applied without specifying the dry matter content and the wet weight separately. Also if a country has data on the fraction of fossil carbon in the dry matter, it does not need to provide CF_i and FCF_i separately but instead it should combine them into one component.

Emissions Factor - Open Burning Landfills[1,2]			
Source	Emission Factor		
	CO_2	CH_4	N_2O
Landfill Fire	121.875 kg CO2/tonne fuel	6.500 kg CH4/tonne fuel	0.109 kg N2O/tonne fuel

[1] 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 5 Incineration and Open Burning.

[2] Fire or Emergency services support with extinguishing these fires excluded, Not enough data to quantify at this time

Global Warming Potentials	CO_2	CH_4	N_2O
	1	25	298

2030 Emissions - Biomass Combustion						
Source	Emissions (tonnes)			Emissions (tonnes CO_2e)		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Landfill Fire (Average Annual)	84.95	4.53	0.08	84.95	113.27	22.57
Total in Year 2030	**84.95**	**4.53**	**0.08**	**84.95**	**113.27**	**22.57**
Total Cumulative (2021 to 2030)	**849.49**	**45.31**	**0.76**	**849.49**	**1132.65**	**225.66**

Project Year	Baseline Year	Year	Average Tonnes of MSW Burned (tonnes/yr)[1]	Biomass Boiler Combustion Emissions						Total CO_2e Emissions (tonnes CO2e)
				CO_2 emissions (tonnes)	CH_4 emissions (tonnes)	N_2O emissions (tonnes)	CO_2 emissions (tonnes CO_2e)	CH_4 emissions (tonnes CO_2e)	N_2O emissions (tonnes CO_2e)	
-	1	2019	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
0	2	2020	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
1	3	2021	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
2	4	2022	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
3	5	2023	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
4	6	2024	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
5	7	2025	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
6	8	2026	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
7	9	2027	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
8	10	2028	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
9	11	2029	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
10	12	***2030***	697.02	***84.95***	***4.53***	***0.08***	84.95	113.27	22.57	220.78
11	13	2031	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
12	14	2032	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
13	15	2033	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
14	16	2034	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
15	17	2035	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
16	18	2036	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
17	19	2037	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
18	20	2038	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
19	21	2039	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
20	22	2040	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78

21	23	2041	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
22	24	2042	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
23	25	2043	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
24	26	2044	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
25	27	2045	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
26	28	2046	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
27	29	2047	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
28	30	2048	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
29	31	2049	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
30	32	2050	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
31	33	2051	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
32	34	2052	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
33	35	2053	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
34	36	2054	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
35	37	2055	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
36	38	2056	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
37	39	2057	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
38	40	2058	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
39	41	2059	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
40	42	2060	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
41	43	2061	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
42	44	2062	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
43	45	2063	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
44	46	2064	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
45	47	2065	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
46	48	2066	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
47	49	2067	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
48	50	2068	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
49	51	2069	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
50	52	2070	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
51	53	2071	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
52	54	2072	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
53	55	2073	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
54	56	2074	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
55	57	2075	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
56	58	2076	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
57	59	2077	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
58	60	2078	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
59	61	2079	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
60	62	2080	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
61	63	2081	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
62	64	2082	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
63	65	2083	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
64	66	2084	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
65	67	2085	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
66	68	2086	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
67	69	2087	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
68	70	2088	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
69	71	2089	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
70	72	2090	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
71	73	2091	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
72	74	2092	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
73	75	2093	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
74	76	2094	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
75	77	2095	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78
76	78	2096	697.02	84.95	4.53	0.08	84.95	113.27	22.57	220.78

PROJECT GHG EMISSIONS - CONSTRUCTION EMISSIONS

Method	Description	GHG Emissions (tCO2e)	Rounded (tCO2e)	Low (-50%) (tCO2e)	High (+50%) (tCO2e)
1	Estimate based on manual entry of hours for equipment	3,329	3,330	1665	4995
2	Estimate based on productivity of equipment for specific activities from case studies/references	4,397	4,400	2200	6600
Maximum (take higher as conservative)		**4,397**	**4,400**	**2,200**	**6,600**

PROJECT GHG EMISSIONS - CONSTRUCTION EMISSIONS

Method 1 - Estimate based on manual entry of hours for equipment

Category / Site Area / Activity	Heavy Equipment Sources?	Duration (days)	Daily Equipment Emissions	Total Equipment Emissions	Notes	Bulldozer - Rough Grade				Bulldozer - Stock Pile				Off-Road Truck				Excavator				Grader				All Idling Equipment			
						Number Operating	Hours per Day	% of Duration Used	GHGs	Number Operating	Hours per Day	% of Duration Used	GHGs	Number Operating	Hours per Day	% of Duration Used	GHGs	Number Operating	Hours per Day	% of Duration Used	GHGs	Number Operating	Hours per Day	% of Duration Used	GHGs	Number Operating	Hours per Day	% of Duration Used	GHGs
			[tCO2e]	[tCO2e]		[#]	[hr/day]	[%]	[tCO2e]	[#]	[hr/day]	[%]	[tCO2e]	[#]	[hr/day]	[%]	[tCO2e]	[#]	[hr/day]	[%]	[tCO2e]	[#]	[hr/day]	[%]	[tCO2e]	[#]	[hr/day]	[%]	[tCO2e]
2020 Construction Activities																													
Waste Transfer Station																													
Site Development	Y	28	7.35	205.72		3	12	80%	1.59	3	12	80%	2.40	4	12	95%	1.32	2	8	90%	1.41	1	10	90%	0.51	6	5	60%	0.12
Building and thermosyphon shipped	N	11	---		No heavy equip. for this task	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Installation of thermosyphon	N	28	---		No heavy equip. for this task	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Building slab	Y	28	3.75	104.95		3	5	90%	0.74	3	6	80%	1.20	4	10	80%	0.92	1	8	50%	0.39	1	8	90%	0.41	6	4	50%	0.08
Pre-engineered building erected	Y	56	3.03	169.74		3	8	50%	0.66	3	6	80%	1.20	2	10	50%	0.29	1	8	50%	0.39	1	8	90%	0.41	6	4	50%	0.08
Pre-purchased WTS equipment shipped to Iqaluit	N	67	---		No heavy equip. for this task	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Building interior work	N	84	---		No heavy equip. for this task	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Landfill																													
Site development / environmental protection	Y	28	8.61	241.06		4	12	90%	2.38	4	10	80%	2.67	4	12	95%	1.32	2	10	90%	1.76	1	8	95%	0.43	6	3	40%	0.05
Access roads / ditching	Y	49	7.60	372.20		4	8	90%	1.59	4	10	70%	2.34	4	12	95%	1.32	2	10	95%	1.86	1	8	95%	0.43	6	4	40%	0.06
Cut and fill - landfill & lagoons	Y	70	8.43	589.91		4	10	90%	1.98	4	10	80%	2.67	4	12	95%	1.32	2	12	95%	2.24	1	5	50%	0.14	6	4	50%	0.08
Perimeter & temporary berms - landfill & lagoons	Y	21	5.53	116.21		4	8	80%	1.41	4	8	50%	1.34	4	10	70%	0.81	2	10	95%	1.86	1	2	50%	0.06	6	3	50%	0.06
Grading pad	Y	14	5.67	79.44		4	6	90%	1.19	4	8	60%	1.60	4	10	80%	0.92	2	10	90%	1.76	1	4	50%	0.11	6	4	50%	0.08
2021 Construction Activities																													
North West Aggregate Deposit Road																													
Construction	Y	130	6.23	810.40		3	10	95%	1.57	3	8	90%	1.80	3	10	95%	0.82	2	10	80%	1.57	1	8	95%	0.43	4	3	50%	0.04
Waste Transfer Station																													
Pre-purchased WTS equipment shipped to Iqaluit	N	35	---		No heavy equip. for this task	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Electrical and mechanical	N	56	---		No heavy equip. for this task	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Installation of pre-purchased equipment	Y	70	1.44	100.7524		3	5	80%	0.66	3	2	50%	0.25	2	10	70%	0.40	1	0	0%	0.00	1	2	50%	0.06	4	5	50%	0.07
Installation of exterior elements	Y	49	2.52	123.614456		3	5	80%	0.66	3	6	70%	1.05	2	10	70%	0.40	1	0	0%	0.00	1	6	100%	0.34	4	5	50%	0.07
Commissioning	N	49	---		No heavy equip. for this task	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Landfill																													
Installation of geotextiles and geomembranes	Y	49	2.99	146.34		3	6	95%	0.94	3	8	60%	1.20	2	10	80%	0.46	1	6	50%	0.29	1	4	25%	0.06	3	3	50%	0.03
Installation of leachate collection granular and piping	Y	35	2.93	102.44		3	6	95%	0.94	3	2	50%	0.25	3	10	80%	0.69	2	6	50%	0.59	1	8	95%	0.43	3	3	40%	0.02
Pump station and forcemain	Y	21	2.18	45.82		3	6	50%	0.50	3	2	50%	0.25	2	10	80%	0.46	2	6	50%	0.59	1	8	80%	0.36	3	3	40%	0.02
Wetlands	Y	35	2.11	73.68		3	6	70%	0.69	3	2	50%	0.25	2	10	80%	0.46	2	6	50%	0.59	1	4	40%	0.09	2	3	50%	0.02
Miscellaneous site works	Y	28	1.66	46.48		3	5	50%	0.41	3	4	60%	0.60	2	10	50%	0.29	2	4	25%	0.20	1	5	50%	0.14	2	3	50%	0.02
Commissioning	N	28	---		No heavy equip. for this task	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Subtotal Construction Activities			**72**	**3,329**	**tCO_2e**																								
Mobilization / Staging / Demobilization Factor (15% factor)			**11**	**499**	**tCO_2e**																								
Total Construction Activities			**72**	**3,329**	**tCO_2e**																								

Notes:

A = area
V = volume
L = length

PROJECT GHG EMISSIONS - CONSTRUCTION EMISSIONS

Method 2 - Estimate based on productivity of equipment for specific activities from case studies/references

Category / Site Area / Activity	Heavy Equipment Sources?	Duration (days)	Activity Type	Dim. Type	Dim. Units	Dim. Value	Total Equipment Emissions [tCO2e]	Equipment Included	Usage for Activity: Bulldozer - Rough Grade	Bulldozer - Stock Pile	Off-Road Truck	Excavator	Grader	All Idling Equipment	Number of Vehicle Types within Category for Activity Type (Surface, Road, Excavation, Other): Bulldozer - Rough Grade	Bulldozer - Stock Pile	Off-Road Truck	Excavator	Grader	All Idling Equipment	Number of Hours per day for "Other" Activity Type: Bulldozer - Rough Grade	Bulldozer - Stock Pile	Off-Road Truck	Excavator	Grader	All Idling Equipment	GHG Emissions [tCO2e]: Bulldozer - Rough Grade	Bulldozer - Stock Pile	Off-Road Truck	Excavator	Grader	All Idling Equipment
2020 Construction Activities																																
Waste Transfer Station																																
Site Development	Y	28	Surface	A	m2	23,114	85.46	Dozers, rock truck, exc., grader + roller	Y	Y	Y	Y	Y	N	1	1	1	1	2	0	0	0	0	0	0	0	34.62	0.00	8.86	30.12	11.86	0.00
Building and thermosyphon shipped	N	11	---	---	---	---	---	No heavy equip. for this task	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Installation of thermosyphon	N	28	---	---	---	---	---	No heavy equip. for this task	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Building slab	Y	28	Other	N/A - hours/duration est.			19.38	Cement truck (x2), for duration	N	N	Y	N	N	N	0	0	2	0	0	0	0	0	12	0	0	0	0.00	0.00	19.38	0.00	0.00	0.00
Pre-engineered building erected	Y	56	Other	N/A - hours/duration est.			58.14	Equip. trucks (x2), crane (x1), for duration	N	N	Y	N	N	Y	0	0	2	0	0	1	0	0	12	0	0	12	0.00	0.00	38.76	0.00	0.00	19.38
Pre-purchased WTS equipment shipped to Iqaluit	N	67	---	---	---	---	---	No heavy equip. for this task	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Building interior work	N	84	---	---	---	---	---	No heavy equip. for this task	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Landfill																																
Site development / environmental protection	Y	28	Surface	A	m2	641,222	2,370.79	Dozers, rock truck, exc., grader + roller	Y	Y	Y	Y	Y	N	1	1	1	1	2	0	0	0	0	0	0	0	960.36	0.00	245.80	835.67	328.96	0.00
Access roads / ditching	Y	49	Road	L	m	1,395	25.79	Dozers, rock truck, exc., grader + roller	Y	N	Y	Y	Y	N	1	0	1	1	2	0	0	0	0	0	0	0	10.45	0.00	2.67	9.09	3.58	0.00
Cut and fill - landfill & lagoons	Y	70	Excavation	V	m3	96,320	0.00	Rock truck, excavator	N	N	Y	Y	N	N	0	0	1	1	0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
			Surface	A	m2	225,872	835.12	Dozers, rock truck, exc., grader + roller	Y	N	Y	Y	Y	N	1	0	1	1	2	0	0	0	0	0	0	0	338.29	0.00	86.58	294.37	115.88	0.00
Perimeter & temporary berms - landfill & lagoons	Y	21	Road	L	m	779	6.57	Rock truck, excavator	N	N	Y	Y	N	N	0	0	1	1	0	0	0	0	0	0	0	0	0.00	0.00	1.49	5.08	0.00	0.00
Grading pad	Y	14	Surface	A	m2	39,715	146.84	Dozers, rock truck, exc., grader + roller	Y	N	Y	Y	Y	N	1	0	1	1	2	0	0	0	0	0	0	0	59.48	0.00	15.22	51.76	20.37	0.00
2021 Construction Activities																																
North West Aggregate Deposit Road																																
Construction	Y	130	Road	L	m	970	17.93	Equipment involved for road	Y	N	Y	Y	Y	N	1	0	1	1	2	0	0	0	0	0	0	0	7.26	0.00	1.86	6.32	2.49	0.00
Waste Transfer Station																																
Pre-purchased WTS equipment shipped to Iqaluit	N	35	---	---	---	---	---	No heavy equip. for this task	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Electrical and mechanical	N	56	---	---	---	---	---	No heavy equip. for this task	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Installation of pre-purchased equipment	Y	70	Other	N/A - hours/duration est.			24.23	Equip. trucks (x1) for duration	N	N	Y	N	N	N	0	0	1	0	0	0	0	0	12	0	0	0	0.00	0.00	24.23	0.00	0.00	0.00
Installation of exterior elements	Y	49	Other	N/A - hours/duration est.			16.96	Equip. trucks (x1) for duration	N	N	Y	N	N	N	0	0	1	0	0	0	0	0	12	0	0	0	0.00	0.00	16.96	0.00	0.00	0.00
Commissioning	N	49	---	---	---	---	---	No heavy equip. for this task	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Landfill																																
Installation of geotextiles and geomembranes	Y	49	Surface	A	m2	59,220	111.39	Dozer (backhoe), truck	Y	N	Y	N	N	N	1	0	1	0	0	0	0	0	0	0	0	0	88.69	0.00	22.70	0.00	0.00	0.00
Installation of leachate collection granular and piping	Y	35	Surface	A	m2	above	0.00	Dozer, rock truck, excavator	Y	N	Y	Y	N	N	1	0	1	1	0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
Pump station and forcemain	Y	21	Road	L	m	228	2.97	Excavator (x2)	N	N	N	Y	N	N	0	0	0	2	0	0	0	0	0	0	0	0	0.00	0.00	0.00	2.97	0.00	0.00
Wetlands	Y	35	Surface	A	m2	19,900	63.37	Dozer, rock truck, excavator	Y	N	Y	Y	N	N	1	0	1	1	0	0	0	0	0	0	0	0	29.80	0.00	7.63	25.93	0.00	0.00
Miscellaneous site works	Y	28	Other	N/A - hours/duration est.			38.76	Trucks (x4), for duration	N	N	Y	N	N	N	0	0	4	0	0	0	0	0	12	0	0	0	0.00	0.00	38.76	0.00	0.00	0.00
Commissioning	N	28		---	---	---	---	No heavy equip. for this task	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Subtotal Construction Activities							3823.70																									
Mobilization / Staging / Demobilization Factor (15% factor)							573.55																									
Total Construction Activities							**4397.25**	**tCO_2e**																								

Notes:

A = area
V = volume
L = length

PROJECT GHG EMISSIONS - CONSTRUCTION EMISSIONS

Activity - Excavation - Assumptions

Productivity Estimates

Equipment Type	Duty Cycle	Included?	Productivity Unit	Productivity Value	Note	Reference
Bulldozer	Rough Grade	N	Not included	0		
	Stock Pile	N	Not included	0		
Off-Road Truck	Hauling	Y	m3 of soil / hr	81	See calculation below	
Excavator	Excavating Soil	Y	m3 of soil / hr	120	Doesn't include idle and time to get to excavation from staging	https://steemit.com/engineering/@kharrazi/excavator-and-calculate-its-productivity; https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/timber-pricing/interior-timber-pricing/north_area_ece_productivity_estimating_guide.pdf
Grader	Resurfacing	N	Not included	0		
All Equipment	Idling	N	Not included	0		

Rock Truck Calculations

Parameter	Unit	Value	Reference
Capacity	m3	23	https://www.ritchiespecs.com/model/caterpillar-769d-rock-truck
Haul distance	m	1000	Distance to aggregate area or soil stockpile
Haul speed	m/hr	30,000	30 km/hr average speed assumption
Haul time per load	hr	0.033	
Loading wait time per load	hr	0.17	10 min assumption for excavator to load truck
Unloading time per load	hr	0.08	5 min assumption, queuing at stockpile, etc.
Total time per load	hr	0.28	

PROJECT GHG EMISSIONS - CONSTRUCTION EMISSIONS

Activity - Roads - Assumptions

Productivity Estimates - Road

Equipment Type	Duty Cycle	Included?	Productivity Unit	Productivity Value	Note	Reference
Bulldozer	Rough Grade	Y	m of road / hr	7.36	See calculation below	---
	Stock Pile	N	Not included	0		---
Off-Road Truck	Hauling	Y	m of road / hr	15		---
Excavator	Excavating Soil	Y	m of road / hr	15.05		---
Grader	Resurfacing	Y (x 2 for roller)	m of road / hr	44.04		Divide productivity by 2 for roller (doubles run time)
All Equipment	Idling	N	Not included	0		---

Productivity Estimates - Surface

Equipment Type	Duty Cycle	Included?	Productivity Unit	Productivity Value	Note	Reference
Bulldozer	Rough Grade	Y	m2 of surface / hr	36.81	Multiply road productivity factors by road width	---
	Stock Pile	N	Not included	0		---
Off-Road Truck	Hauling	Y	m2 of surface / hr	75.24		---
Excavator	Excavating Soil	Y	m2 of surface / hr	75.24		---
Grader	Resurfacing	Y (x 2 for roller)	m2 of surface / hr	220.18		Divide productivity by 2 for roller (doubles run time)
All Equipment	Idling	N	Not included	0		---

Equipment Calculations Calculations - CAT Case Study

Parameter	Unit	Value				Reference / Note
		Bulldozer	Off-Road Truck	Excavator	Grader	
Road length	m	80				
Road width	m	5				
Total run time per task						
- Bulk earthmoving	hr	4.67	2.38	2.38		https://construction.trimble.com/sites/default/files/literature-files/2016-07/CAT-Road-Construction-Production-Study-White-Paper-EN.pdf
- Subgrade grading	hr	3.80	2.93	2.93		
- Base course grading	hr	2.40				
- Base course fine grading	hr				1.82	
- Total	hr	10.87	5.32	5.32	1.82	

PROJECT GHG EMISSIONS - CONSTRUCTION EMISSIONS

GHG Emission Factors

Equipment Type	Duty Cycle	Emission Factors				
		HC	CO	NO_x	PM	CO_2
		[g/hr]	*[g/hr]*	*[g/hr]*	*[g/hr]*	*[kg/hr]*
Bulldozer	Rough Grade	130.09	270.01	806.53	5.56	55.13
	Stock Pile	100.53	272.45	962.29	8.78	83.44
Off-Road Truck	Hauling	56.78	128.26	385.64	2.94	28.84
Excavator	Excavating Soil	126.94	341.57	1122.52	10.22	98.05
Grader	Resurfacing	75.52	200.45	655.43	5.86	56.48
All Equipment	Idling	18.34	36	105.96	0.67	6.72

Reference: Anh, C.; W. Pan; S. Lee; F. Pena-Mora. **Enhanced estimation of air emissions from construction operations based on discrete-event simulation.** *Proceedings of the International Conference on Computing in Civil and Building Engineering, n.d.*

ADDITIONAL INFORMATION

City of Iqaluit
Waste Forecasts

Assumptions:

Population Growth Rate	1.42%	Recyclables Growth Rate	1.00%	Density of Baled MSW	750	kg/m^3
Municipal Solid Waste Growth Rate	1.00%	Cardboard Growth Rate	1.00%	Density of baled tires (shredded)	654	kg/m^3
Wood Waste Growth Rate	1.00%	Hazardous Waste Growth Rate	1.00%	Density of baled tires (whole)	462	kg/m^3
Scrap Metal Growth Rate	1.00%	End of Life Vehicle Growth Rate	1.00%	C&D Density	449	kg/m^3
Scrap Tire Growth Rate	1.00%	Mattress Growth Rate	1.00%			

Year		Population	Annual MSW (tonnes)	Cumulative MSW (tonnes)	Cumulative MSW Volume (m^3)	Annual Wood Waste (tonnes)	Scrap Metal (m^3)	Annual Scrap Tires (tonnes)	Annual Hazardous Waste (tonnes)	Annual Cardboard (tonnes)	Non-metallic C&D waste (tonnes)	Non-metallic C&D waste, cumulative (tonnes)	Annual Mattess (each)	Annual Vehicles (each)
0	2020	8,090	8,580	8,580	11,440	7,300	7,714	5.0	10.0	2,704	32	32	312	80
1	2021	8,205	8,789	17,369	23,158	7,477	7,902	5.1	10.2	2,770	33	65	320	82
2	2022	8,318	9,002	26,371	35,161	7,659	8,094	5.2	10.5	2,837	34	99	327	84
3	2023	8,427	9,221	35,591	47,455	7,845	8,290	5.4	10.7	2,906	34	133	335	86
4	2024	8,524	9,445	45,036	60,048	8,036	8,492	5.5	11.0	2,977	35	168	343	88
5	2025	8,615	9,674	54,711	72,948	8,231	8,698	5.6	11.3	3,049	35	203	352	90
6	2026	8,694	9,910	64,620	86,161	8,431	8,910	5.8	11.5	3,123	36	239	360	92
7	2027	8,767	10,150	74,771	99,694	8,636	9,126	5.9	11.8	3,199	36	275	369	95
8	2028	8,859	10,397	85,168	113,557	8,846	9,348	6.1	12.1	3,277	37	312	378	97
9	2029	8,925	10,650	95,818	127,757	9,061	9,575	6.2	12.4	3,356	38	350	387	99
10	2030	8,993	10,909	106,726	142,301	9,281	9,808	6.4	12.7	3,438	38	388	397	102
11	2031	9,062	11,174	117,900	157,200	9,507	10,046	6.5	13.0	3,521	39	427	406	104
12	2032	9,132	11,445	129,345	172,460	9,738	10,290	6.7	13.3	3,607	39	466	416	107
13	2033	9,202	11,723	141,068	188,091	9,974	10,540	6.8	13.7	3,695	40	506	426	109
14	2034	9,265	12,008	153,076	204,102	10,217	10,797	7.0	14.0	3,784	40	547	437	112
15	2035	9,329	12,300	165,376	220,502	10,465	11,059	7.2	14.3	3,876	41	588	447	115
16	2036	9,461	12,599	177,975	237,300	10,719	11,328	7.3	14.7	3,971	42	630	458	117
17	2037	9,595	12,905	190,880	254,507	10,980	11,603	7.5	15.0	4,067	42	672	469	120
18	2038	9,731	13,219	204,099	272,132	11,247	11,885	7.7	15.4	4,166	43	715	481	123
19	2039	9,869	13,540	217,639	290,185	11,520	12,174	7.9	15.8	4,267	43	758	492	126
20	2040	10,009	13,869	231,508	308,677	11,800	12,470	8.1	16.2	4,371	44	802	504	129
21	2041	10,150	14,206	245,714	327,618	12,087	12,773	8.3	16.6	4,477	45	847	517	132
22	2042	10,294	14,551	260,265	347,020	12,380	13,083	8.5	17.0	4,586	45	892	529	136
23	2043	10,440	14,905	275,170	366,893	12,681	13,401	8.7	17.4	4,697	46	938	542	139
24	2044	10,588	15,267	290,437	387,249	12,989	13,727	8.9	17.8	4,811	46	984	555	142
25	2045	10,738	15,638	306,075	408,100	13,305	14,060	9.1	18.2	4,928	47	1,031	569	146
26	2046	10,890	16,018	322,093	429,458	13,628	14,402	9.3	18.7	5,048	48	1,079	582	149
27	2047	11,044	16,407	338,501	451,334	13,960	14,752	9.6	19.1	5,171	48	1,127	597	153
28	2048	11,200	16,806	355,307	473,742	14,299	15,110	9.8	19.6	5,296	49	1,176	611	157
29	2049	11,359	17,215	372,521	496,695	14,646	15,478	10.0	20.1	5,425	49	1,225	626	161
30	2050	11,520	17,633	390,154	520,205	15,002	15,854	10.3	20.6	5,557	50	1,275	641	164
31	2051	11,683	18,061	408,215	544,287	15,367	16,239	10.5	21.1	5,692	50	1,325	657	168
32	2052	11,848	18,500	426,716	568,954	15,740	16,634	10.8	21.6	5,830	51	1,377	673	172
33	2053	12,016	18,950	445,666	594,221	16,123	17,038	11.0	22.1	5,972	52	1,428	689	177
34	2054	12,186	19,410	465,076	620,101	16,515	17,452	11.3	22.6	6,117	52	1,480	706	181
35	2055	12,359	19,882	484,958	646,611	16,916	17,876	11.6	23.2	6,266	53	1,533	723	185
36	2056	12,534	20,365	505,323	673,764	17,327	18,310	11.9	23.7	6,418	53	1,587	741	190
37	2057	12,711	20,860	526,183	701,578	17,748	18,755	12.2	24.3	6,574	54	1,641	759	195
38	2058	12,891	21,367	547,551	730,067	18,179	19,211	12.5	24.9	6,734	55	1,695	777	199
39	2059	13,074	21,886	569,437	759,249	18,621	19,678	12.8	25.5	6,898	55	1,751	796	204
40	2060	13,259	22,418	591,855	789,140	19,074	20,156	13.1	26.1	7,065	56	1,806	815	209
41	2061	13,447	22,963	614,818	819,757	19,537	20,646	13.4	26.8	7,237	56	1,863	835	214
42	2062	13,637	23,521	638,339	851,119	20,012	21,148	13.7	27.4	7,413	57	1,920	855	219
43	2063	13,830	24,093	662,432	883,242	20,498	21,662	14.0	28.1	7,593	58	1,977	876	225
44	2064	14,026	24,678	687,110	916,147	20,997	22,188	14.4	28.8	7,777	58	2,035	897	230
45	2065	14,224	25,278	712,388	949,850	21,507	22,727	14.7	29.5	7,966	59	2,094	919	236
46	2066	14,426	25,892	738,280	984,373	22,029	23,280	15.1	30.2	8,160	59	2,154	942	241
47	2067	14,630	26,521	764,801	1,019,735	22,565	23,845	15.5	30.9	8,358	60	2,213	964	247
48	2068	14,837	27,166	791,967	1,055,956	23,113	24,425	15.8	31.7	8,561	60	2,274	988	253
49	2069	15,047	27,826	819,793	1,093,058	23,675	25,018	16.2	32.4	8,769	61	2,335	1,012	259
50	2070	15,260	28,502	848,296	1,131,061	24,250	25,626	16.6	33.2	8,983	62	2,397	1,036	266
51	2071	15,477	29,195	877,490	1,169,987	24,840	26,249	17.0	34.0	9,201	62	2,459	1,062	272
52	2072	15,696	29,904	907,395	1,209,860	25,443	26,887	17.4	34.9	9,424	63	2,522	1,087	279
53	2073	15,918	30,631	938,026	1,250,701	26,061	27,540	17.9	35.7	9,653	63	2,585	1,114	286
54	2074	16,143	31,376	969,402	1,292,535	26,695	28,210	18.3	36.6	9,888	64	2,649	1,141	293
55	2075	16,372	32,138	1,001,540	1,335,386	27,344	28,895	18.7	37.5	10,128	65	2,714	1,169	300
56	2076	16,604	32,919	1,034,459	1,379,278	28,008	29,598	19.2	38.4	10,374	65	2,779	1,197	307
57	2077	16,839	33,719	1,068,178	1,424,237	28,689	30,317	19.6	39.3	10,627	66	2,845	1,226	314
58	2078	17,077	34,538	1,102,716	1,470,288	29,386	31,054	20.1	40.3	10,885	66	2,911	1,256	322
59	2079	17,319	35,378	1,138,094	1,517,458	30,100	31,808	20.6	41.2	11,149	67	2,978	1,286	330
60	2080	17,564	36,237	1,174,331	1,565,775	30,831	32,581	21.1	42.2	11,420	68	3,046	1,318	338
61	2081	17,813	37,118	1,211,449	1,615,266	31,581	33,373	21.6	43.3	11,698	68	3,114	1,350	346
62	2082	18,065	38,020	1,249,469	1,665,959	32,348	34,184	22.2	44.3	11,982	69	3,183	1,383	355
63	2083	18,321	38,944	1,288,414	1,717,885	33,134	35,015	22.7	45.4	12,273	69	3,252	1,416	363
64	2084	18,581	39,890	1,328,304	1,771,072	33,939	35,866	23.2	46.5	12,572	70	3,322	1,451	372
65	2085	18,844	40,860	1,369,164	1,825,552	34,764	36,737	23.8	47.6	12,877	70	3,392	1,486	381
66	2086	19,110	41,853	1,411,017	1,881,356	35,609	37,630	24.4	48.8	13,190	70	3,462	1,522	390
67	2087	19,381	42,870	1,453,887	1,938,516	36,474	38,544	25.0	50.0	13,511	70	3,532	1,559	400
68	2088	19,656	43,912	1,497,798	1,997,065	37,361	39,481	25.6	51.2	13,839	70	3,602	1,597	409
69	2089	19,934	44,979	1,542,777	2,057,036	38,269	40,441	26.2	52.4	14,175	70	3,672	1,636	419
70	2090	20,216	46,072	1,588,849	2,118,466	39,199	41,423	26.8	53.7	14,520	70	3,742	1,675	430
71	2091	20,502	47,192	1,636,041	2,181,388	40,151	42,430	27.5	55.0	14,872	70	3,812	1,716	440
72	2092	20,793	48,338	1,684,379	2,245,839	41,127	43,461	28.2	56.3	15,234	70	3,882	1,758	451
73	2093	21,087	49,513	1,733,892	2,311,856	42,127	44,517	28.9	57.7	15,604	70	3,952	1,800	462
74	2094	21,386	50,716	1,784,609	2,379,478	43,150	45,599	29.6	59.1	15,983	70	4,022	1,844	473
75	2095	21,688	51,949	1,836,557	2,448,743	44,199	46,707	30.3	60.5	16,372	70	4,092	1,889	484
76	2096	21,996	53,211	1,889,769	2,519,692	45,273	47,842	31.0	62.0	16,770	70	4,162	1,935	496

Table 1–1 IPCC Global Warming Potentials (GWPs)

GHG	Formula	100-Year GWP
Carbon Dioxide	CO2	1
Methane	CH4	25
Nitrous Oxide	N2O	298
Sulphur Hexafluoride	SF6	22,800
Nitrogen Trifluoride	NF3	17,200
Hydrofluorocarbons (HFCs)		
HFC-23	CHF3	14,800
HFC-32	CH2F2	675
HFC-41	CH3F	92
HFC-43-10mee	CF3CHFCHFCF2CF3	1,640
HFC-125	CHF2CF3	3,500
HFC-134	CHF2CHF2	1,100
HFC-134a	CH2FCF3	1,430
HFC-143	CH2FCHF2	353
HFC-143a	CH3CF3	4,470
HFC-152	CH2FCH2F	53
HFC-152a	CH3CHF2	124
HFC-161	CH3CH2F	12
HFC-227ea	CF3CHFCF3	3,220
HFC-236cb	CH2FCF2CF3	1,340
HFC-236ea	CHF2CHFCF3	1,370
HFC-236fa	CF3CH2CF3	9,810
HFC-245ca	CH2FCF2CHF2	693
HFC-245fa	CHF2CH2CF3	1,030
HFC-365mfc	CH3CF2CH2CF3	794
Perfluorocarbons (PFCs)		
Perfluoromethane	CF4	7,390
Perfluoroethane	C2F6	12,200
Perfluoropropane	C3F8	8,830
Perfluorobutane	C4F10	8,860
Perfluorocyclobutane	c-C4F8	10,300
Perfluoropentane	C5F12	9,160
Perfluorohexane	C6F14	9,300
Perfluorodecalin	C10F18	7,500
Perfluorocyclopropane	c-C3F6	17,340
*Atmospheric Lifetime data excluded		

National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada

Canada—National Inventory Report 1990–2017—Part 2

Appendix B

Additional Equipment Information

Equipment Operations

Activity	Source ID	Description	Equipment Description	Vehicle Numbers (#/hour)	Total Peak Time for all Pieces of Equipment Combined in a Given Hour (minutes/hour)	Representative Average Hours per Day for Each Piece of Equipment	Operating Frequency
Working face operation	WF	Waste/ADC trucks haulage	Info to be provided by Transportation discipline	20			Year-round
		Lift waste trailer to unload waste/ADC	Landfill tipper	1	10	10	Year-round
		Push and spread waste	CAT D8T Dozer	3	135	10	Year-round
		Compact waste	CAT 836K Landfill Compactor	3	135	10	Year-round
Public waste drop-off area	--	Public drop off waste materials at bins located near the existing Maintenance Building. Vehicles would be scaled and would not cross the landfill.	Light vehicles/pick-up trucks	3	10	10	Year-round
Future public recycling facility	--	The public would access through the Recycling Facility Entrace on Erieau Road to avoid crossing the landfill. Outbound haulage would be completed by commercial tri-axle trucks that would cross the landfill to use the outbound scale and leave the site through the main gate.	Tri-axle truck	2	9	10	Year-round
Wood chipping	WC	Wood grinder. Occurs seasonally using contractor with mobile unit.	Information to be provided by WCC	1	60	6	Once a year, 5 days per event
		Moving material within lay down area/feeding the grinder	John Deere 644K Front End Loader	1	60	10	Once a year, 5 days per event
Concrete crushing	CC	Concrete waste haul - Scenarios 1 and 2	Tri-axle truck	0.5	8	10	Twice a year, 5 days per event
		Concrete waste haul - Scenario 3	Tri-axle truck	0.5	12	10	Twice a year, 5 days per event
		Feed the crusher	Cat 336 Hydraulic Excavator	1	60	6	Twice a year, 5 days per event
		Push the material	Cat D8T Dozer	1	60	6	Twice a year, 5 days per event
		Create stockpiles	Conveyor	1	60	10	Twice a year, 5 days per event
		Crusher. Occurs seasonally using contractor with mobile unit	Information to be provided by WCC	1	60	10	Twice a year, 5 days per event
Stockpile excavation - Scenario 1	ST	Soil excavation/truck loading at stockpile	CAT 345 Hydraulic Excavator	1	45	5	Year-round
		Hauling soil	Articulated dump truck (i.e. rock truck) Volvo A30	2	90	5	Year-round
Cell excavation and hauling - Scenario 2	CE - Scenario 2	Soil excavation/truck loading at stockpile	CAT 336 Hydraulic Excavator	1	60	10	Year-round
		Soil excavation/truck loading at stockpile	CAT 345 Hydraulic Excavator	1	60	9	Year-round
		Hauling soil	Articulated dump truck (i.e. rock truck) Volvo A30	2	2	9	Year-round
Cell excavation and hauling - Scenario 3	CE - Scenario 3	Soil excavation/truck loading at stockpile	CAT 345 Hydraulic Excavator	1	60	9	Year-round
		Hauling soil	Articulated dump truck (i.e. rock truck) Volvo A30	2	2	9	Year-round
Watering roads for dust control	--	Frim the site entrace to the working face.	CAT 735 Water Wagon	1	30	4	Spring, summer and fall (9 months per year)
Site maintenance	SM	Ditch cleaning, road maintennce, general maintenance	CAT 430 Backhoe-loader with sweeper attachment and forks	2	60	6	Year-round
Leachate collection system construction (clear stone trucks) - Scenario 2	LCS - Scenario 2	Unloading clear stone for leachate collection system construction	Tri-axle truck	5	8	8	July and August
Leachate collection system construction (clear stone trucks) - Scenario 3	LCS - Scenario 3	Unloading clear stone for leachate collection system construction	Tri-axle truck	5	9	8	July and August
Leachate collection system construction (clear stone trucks) - Scenarios 2 and 3	LCS - Scenarios 2 and 3	Unloading clear stone for leachate collection system construction	CAT D6 Dozer	1	60	8	July and August

Landfill Information

Type of Equipment	Worst Case Operating Hours per Day	Average Operating Hours per Day	# in Operation	Weight Information	Engine Size Information
Landfill Operations					
Sterling LT 8500 roll-off	7 hrs	4 hrs	1	60000 lb / 80000 lb	300 hp engine (diesel)
CAT 826 Compactor	7 hrs	6 hrs	1	82000 lb	341 hp engine (diesel)
CAT D-6 Bulldozer	7 hrs	4 hrs	1	36000 lb	189 hp engine (diesel)
Terex TA 27 Rock Truck	7 hrs	4 hrs	1	49000 lb / 104000 lb	365 hp engine (diesel)
Case 821 Front End Loader	7 hrs	5 hrs	1	31000 lb	186 hp engine (diesel)
Trackless MT-5	4 hrs	5 hrs per week	1		Negligible
Kubota 1100 RTV UTV	3 hrs	6 hrs per month	1		Negligible
MadVac litter vacuum	6 hrs	5 hrs	1		Negligible
Composting Operations					
Sittler compost turner	6 hrs	5 hrs every third day	1		Pulled by tractor
RotoScreen Compost Screener	6.5 hrs	5 hrs	1		225 hp engine (diesel)
Odour turbine	9 hrs	7.5 hrs	1		
John Deere Farm Tractor 5420	6 hrs	5 hrs every third day	1	7000 lb	81 hp engine (diesel)
Sterling STE flow truck/sander	7 hrs	5 hrs as needed	1	60000 lb / 80000 lb	300 hp engine (diesel)
Various front end loaders	7 hrs	5 hrs as needed	1		
Various water trucks	6 hrs	5 hrs as needed	1		
Cell Construction Operations					
Tri-axl dump truck (gravel)	9 hrs	5 trips per hour	1	60000 lb / 80000 lb	300 hp engine (diesel)
CAT D-7 Bulldozer	9 hrs	9 hrs	1	45000 lb	200 hp engine (diesel)
Cell Mining Operations					
McCloskey MCB 733 Trommel Screeners	60 min/hr	9 hrs	2	Stationary	225 hp engine (diesel)
McCloskey Stacker	60 min/hr	9 hrs	1	Stationary	90 hp engine (diesel)
Mobark 1100 Tub Grinder	60 min/hr	9 hrs	1	Stationary	600 hp engine (diesel)
CAT 345 Excavator	60 min/hr	9 hrs	2	100000 lb	345 hp engine (diesel)
CAT D-7 Bulldozer	60 min/hr	9 hrs	1	45000 lb	200 hp engine (diesel)
CAT 735 Articulating Truck	run 30 min in hour	9 hrs	2	67000 lb / 140000 lb	413 hp engine (diesel)

Appendix C

Operating Information Memo

AECOM Imagine it. Delivered.

AECOM Canada Ltd.
101-18817 Stony Plain Road NW
Edmonton, AB T5S 0C2
Canada

T: 780.486.7000
F: 780.486.7070
aecom.com

May 10, 2019

Our Reference
60571501

Erik Marko P. Eng, PMP
Project Manager
Colliers Project Leaders
Suite 700, 150 Isabella Street
Ottawa, ON K1S 1V7

Dillon Consulting Questions

Dear Erik

Following are the answers to address the information requested by Dillon in their e-mail dated May 6, 2019.

- Business as usual - fires at landfill
  - Frequency of fires:
    - The landfall experienced a C&D material fire in 2010/2011 that lasted about 27 days. This fire was allowed to burn itself out.
    - In 2014 an MSW fire occurred that lasted months.
    - In 2018 the landfill had 2 small surface fires.
  - Size of fires:
    - 2010/2011: C& D stockpile size unknown.
    - 2014: Size unknown, was a subsurface fire.
    - 2018 fires: approximately $10m^2$ or smaller.
  - Length of burn before fire is extinguished:
    - 2010/2011: 27 days.
    - 2014: months.
    - 2018 fires: about 1 hour to control, approximately 3 to 4 hours on site.
  - Firefighting equipment used:
    - 2010/2011: left to burn out.
    - 2014: fire department equipment as well as contracted fire specialist, fuel usage not known.
    - 2018 fires: fire department equipment, diesel fuel type, fuel usage unknown.
- Anticipated compost generation
  - The landfill is not composting. The anticipated composting generation and volumes will be a function of the new waste management center and needs to be addressed by that design.
- Landfill Equipment
  - Cat 816F Landfill Compactor: 2010 Model F11, fuel type diesel, (S/N BZB00298)
  - From June 2018 to May 7, 2019 the machine operated 1,132 hours for an average of 3.9 hrs per operating day
  - Cat 950G Loader: 1012, fuel type diesel, (S/N AXX00981)

        - From June 2018 to May 7, 2019 the machine operated 1,122 hours for an average of 3.9 hrs per operating day
    - John Deere Skid Steer: 2013, fuel type diesel (S/N 1T0318EKJEJ269023)
    - From June 2018 to May 7, 2019 the machine operated 182 hours for an average of 0.63 hrs per operating day.
- Pick-up Trucks
    - Unit 101: 2011 Ford F-250, fuel gas
    - Unit 110: 2011 Ford F-250, fuel gas
- Fuel Consumption
    - In 2018 the landfill consumed the following amounts of fuel.
        - Diesel: 26,289 liters
        - Gas: 10,651 liters
        - If fuel efficiency for each piece of equipment is required this information will have to be provided by the equipment manufacturer.
- Transfer station
    - Boiler type, fuel type, operating time: Answer by Dillion
    - Electricity requirements, source of electrical power: Answer by Dillon Combustion of cardboard
- The landfill on an intermittent basis combusts cardboard. This activity is done on a very varied frequency as use of the facility is tied to wind speed. In 2018 the burned was only used times and in 2019 to date has not been used.
    - Mass of cardboard burned: when used the burner combusted approximately 20 to 25 cubic meters per day.
    - In 2018 the burner operated from March to August and averaged approximately 10 days per month. It operated from October 23 to November 23 and burned for 14 days during that period.
    - Accelerant used: diesel at a rate of 9.46 liters per hour (2.5 US gal/hr). Note the amount for diesel consumed in 2018 is included in the amount of diesel provided under landfill equipment.

Yours sincerely,

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