Landfill Project Protocol

Landfill Methane Treatment or Destruction

Protocol Version

[Effective Date]

Notes on the draft protocol: This protocol adaptation is based on the Quebec compliance offset protocol. The QC protocol has been reformatted, with proposed revisions implemented. These revisions have already undergone review by a Technical Task Team, including staff from MOECC and MDDELCC. Redlining indicates content that has changed from the previous Stakeholder draft.

Table of Contents

List of Tables

List of Figures

List of Equations

Abbreviations and Acronyms

CH_4	Methane
CO_2	Carbon dioxide
GHG	Greenhouse gas
GJ/h	Gigajoule per hour
K	Kelvin
Kg	Kilogram
kPa	Kilopascal
L	Litres
Landfill Site	Place where residual materials is permanently disposed of above or below ground
LFG	Landfill Gas
LFGE	Landfill gas-to-energy
LNG	Liquid Natural Gas
Mg	Mega gram (1,000,000 grams or one tonne, or “t”)
MDDELCC	Ministère du Développment durable, de l’Environnement et de la Lutte contre les changements climatiques du Québec (Quebec Ministry of Sustainable Development, Environment, and Fight Against Climate Change)
MOECC	Ontario Ministry of Environment and Climate Change
MSW	Municipal Solid Waste
m^3	Cubic meters
N_2O	Nitrous oxide
NG	Natural gas
SSR	Source, sink, and reservoir
t	Metric ton (or tonne)
USEPA	United States Environmental Protection Agency
WIP	Waste in place

1 Introduction

The purpose of the landfill protocol is to quantify greenhouse gas (GHG) emissions reductions associated with any project designed to reduce GHG emissions by destroying (or treating so as to permanently avoid the emission of) the CH_4 captured at a landfill site.

Project Developers that install landfill gas capture and destruction technologies use this document to register GHG emission reductions with either the Ontario Cap and Trade Program[1] or the Quebec Cap and Trade System.[2] This protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information. This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with a landfill project.[3] If there are multiple versions of this protocol, Project Developers shall refer to the Regulation to determine the appropriate version for their landfill project.

For the purposes of this protocol, the term “Regulation” is used to refer to the following:

1. For projects to be registered with the Ontario Cap and Trade Program, the term “Regulation” shall refer to the Ontario Regulation concerning The Cap and Trade Program, made under the Climate Change Mitigation and Low-Carbon Economy Act;
2. For projects to be registered with the Quebec Cap and Trade Program, the term “Regulation” shall refer to the Quebec Regulation respecting a cap-and-trade system for greenhouse gas emission allowances, made under the Environment Quality Act.

For the purposes of this protocol, the term “Ministry” is used to refer to the following:

1. For projects to be registered with the Ontario Cap and Trade Program, the term “Ministry” shall refer to the Ontario Ministry of Environment and Climate Change (MOECC);
2. For projects to be registered with the Quebec Cap and Trade Program, the term “Ministry” shall refer to the Quebec Ministry of Sustainable Development, Environment, and Fight Against Climate Change (MDDELCC).

For the purposes of this protocol, the term “project” is equivalent to the term “offset initiative” in the Ontario Regulation.

For the purposes of this protocol, the term “Project Developer” is used to refer to the following:
1. For projects to be registered with the Ontario Cap and Trade Program, the equivalent term is “Offset Initiative Operator”;[4]
2. For projects to be registered with the Quebec Cap and Trade Program, the equivalent term is “Project Promoter.”

[1] As created by the Climate Change Mitigation and Low-Carbon Economy Act, 2016, Ontario Regulation 144/16, “The Cap and Trade Program.”
[2] As created by the Environmental Quality Act, Chapter Q-2, r. 46.1, “Regulation Respecting a Cap and Trade System for Greenhouse Gas Emission Allowances.”
[3] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.
[4] In certain circumstances, the Ontario Regulation may allow for an Offset Initiative Sponsor to fulfill duties that this protocol assigns to the Project Developer.

2 The GHG Reduction Project

2.1 Project Definition

For the purposes of this protocol, the GHG reduction project is defined as the use of an eligible device to treat or destroy CH_4 captured at an eligible landfill site in Canada, above and beyond any historical or legally mandated CH_4 management. This offset credit protocol covers any project designed to reduce GHG emissions by treating or destroying the CH_4 captured in a landfill site in Canada.

Eligible treatment or destruction devices are enclosed flares, open flares (where permitted), combustion engines, boilers, turbines, CH_4 liquefaction units, fuel cells, microturbines, and natural gas pipeline injection.[5] Devices not listed here may be used, contingent upon approval by Ministry staff for the offsets program with which the project is registered. The CH_4 may be treated or destroyed on the landfill site or transported and treated or destroyed off-site.

An eligible landfill is one that:

1. Is not subject to regulations or other legal requirements requiring the destruction of methane gas; and
2. Is not an anaerobic bioreactor, defined as: "a MSW landfill or portion of a MSW landfill where any liquid other than leachate (leachate includes landfill gas condensate) is added in a controlled fashion into the waste mass (often in combination with recirculating leachate) to reach a minimum average moisture content of at least 40 percent by weight to accelerate or enhance the anaerobic (without oxygen) biodegradation of the waste"; and
3. Does not add any liquid other than leachate into the waste mass in a controlled manner;[6] and
4. Is not an aerobic bioreactor, whereby oxygen is actively introduced into the waste mass through a system of wells, pipes, or channels in order to maintain an aerobic environment and avoid methane generation.

For the purposes of this protocol,

1. "Landfill gas" (LFG) means any gas resulting from the decomposition of residual materials disposed of at a landfill site;

2. "Landfill site" means a place where residual materials is permanently disposed of above or below ground.

The provisions of the first numbered item of this Section and those of Section 3.4.1 do not apply to a landfill site of a pulp and paper mill, a sawmill or an oriented strandboard manufacturing plant.

[5] Where the project destruction device(s) are located off-site, connected to the project collection system through a dedicated pipeline, the project shall not be classified as "natural gas pipeline injection."
[6] Landfills may recirculate leachate collected on site.

2.1.1 Project Activities

Project activities are those activities that are necessary for the collection and treatment or destruction of CH_4 produced by the degradation of organic waste in a landfill. This includes the operation of the LFG wellfield, extraction and conveyance of LFG, gas treatment, metering, and operation of the destruction device(s).

2.2 The Project Developer

The definition and responsibilities of the Project Developer can be found in the Regulation.

3 Eligibility Rules

Projects must fully satisfy the following eligibility rules in order to register offset credits. The criteria only apply to projects that meet the definition of a GHG reduction project (Section 2.1).

Eligibility Rule I:	Location	⟶	*Canadian provinces and territories*
Eligibility Rule II:	Project Start Date	⟶	*Per the guidance in the Regulation*
Eligibility Rule III:	Additionality	⟶	*Meet the performance standard test and the legal requirement test*

3.1 Location

The project must be carried out at a landfill site located in Canada.

3.2 Project Start Date

The project start date of a landfill project is defined as the date of commencement of CH_4 destruction following the completion of a start-up and/or testing period, which is not to exceed six (6) months.[7] A landfill project may be operational regardless of whether sufficient monitoring data are available to report emission reductions. Project Developers shall refer to the Regulation to determine the eligibility of their start date, including deadlines related to submittal of applications to the Ministry.

3.3 Project Crediting Period

Project Developers shall refer to the Regulation for guidance regarding the definition, length, and rules related to project crediting periods.

3.4 Additionality

The project is considered to go beyond current practice when it meets the conditions of this document. Reductions in GHG emissions must be additional and result from a project that is voluntary, that is that it is not being carried out, at the time of registration or renewal, in response to a legislative or regulatory provision, a permit or other type of authorization, an order made under an Act or regulation, or a court decision. The requirements of additionality are assessed through this Section.

Projects must satisfy the following tests to be considered additional:

1. Size Threshold
   a. Operating Landfills
   b. Closed Landfills
2. The Performance Standard Test
3. The Legal Requirement Test

[7] The start-up period begins on the first day of LFG destruction in the project system.

3.4.1 Size Threshold

Landfill projects are only eligible at landfill sites which meet certain conditions for size, including annual waste acceptance rate, permitted capacity, and heat capacity of captured CH_4. These conditions vary depending on whether the landfill site is open (operational) or closed.

3.4.1.1 Operational Landfills

An operational landfill project is required to meet the following conditions at the time of registration:

1. On the date of application for registration with the Ministry and for the entire duration of the project, if the site is in operation, it receives less than 50,000 metric tonnes of residual materials annually[8] and has a total capacity of less than 1.5 million cubic meters;

2. On the date of registration with the Ministry, in every case, the site has less than 450,000 metric tonnes of residual materials in place,[9] or the CH_4 captured from the LFG has a heat capacity of less than 3 GJ/h, as determined below:

    a. When a site has over 450,000 tonnes of residual materials in place, the Project Developer must assess the heat capacity of the CH_4 captured, in gigajoules per hour, using the following method:
        i. By calculating the quantity of CH_4 emitted each hour;
            (1) By determining the quantity of CH_4 generated using the Landgem software of the U.S. Environmental Protection Agency (USEPA), available at http://www.epa.gov/ttncatc1/products.html#software
            (2) By determining the quantity of residual materials disposed of annually using the data available since the opening of the landfill site[9]
            (3) By using, for the parameters "k" and "L_0" of the software referred to in paragraph 1, the most recent parameters from the national inventory report on GHG emissions prepared by Environment Canada
            (4) By using a percentage of 50% as the percentage of CH_4 in LFG
            (5) By using the appropriate value for the density of CH_4 from Table A.2, according to the standard temperature applied to all project gas measurement data
        ii. By determining the quantity of CH_4 captured each hour by multiplying the quantity of CH_4 generated each hour by, obtained above, 0.75;
        iii. By determining the heat capacity by multiplying the quantity of CH_4 captured each hour, obtained above, by 0.0359 GJ/m^3, the high heat value of the CH_4 portion of the LFG as set out in Table 20-1 of Appendix 10 of ON.20, the guidance for quantification method for General Stationary Combustion under the Ontario Guideline for Greenhouse Gas Emissions Reporting.[10]

[8] The calculation of annual receipt of residual materials includes all materials received, with the exception of clean soils, manufactured products, and all non-organic materials used as daily, intermediate, and final cover.
[9] The quantity of WIP may be determined either by: 1) the filled volume of the landfill (in m^3) at the time of project registration, multiplied by the density (0.75 t/m^3) and the decomposable fraction (0.70); or 2) the annual receipt of residual materials since the landfill opened. If records are not available for either method, WIP may be determined by assessment of the population served and operating years of the landfill, subject to Ministry approval.
[10] Quebec landfill projects shall use a value of 0.03982 GJ/m^3, as set out in Table 1-1 of QC.1.7 in Schedule A.2 to the Regulation respecting mandatory reporting of certain emissions of contaminants into the atmosphere (chapter Q-2, r. 15).

3.4.1.2 Closed Landfills

In the case of a landfill site that is closed on the date of application for registration, the following conditions will apply:

1. If the site opened or was extended between 2006 and 2008 inclusively, it should have received less than 50,000 tonnes of residual materials annually and should have had a maximum capacity of less than 1,500,000 cubic meters; and
2. If the site was in operation in 2009 or a subsequent year, the site should have received less than 50,000 metric tonnes of residual materials annually and should have had a maximum capacity of less than 1,500,000 cubic meters.
3. On the date of registration with the Ministry, in every case, the site has less than 450,000 metric tonnes of residual materials in place, or the CH_4 captured from the LFG has a heat capacity of less than 3 GJ/h, as determined above.

3.4.2 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a performance threshold, i.e., a standard of performance applicable to all landfill projects, established by this protocol. The Performance Standard Test is applied as of the project start date.

This protocol employs a technology-specific threshold (or “practice-based” threshold), which serves as a “best practice standard” for managing landfill gas fugitive emissions. A project passes the Performance Standard Test if it involves one of the following activities:

1. Installation of a landfill gas collection system and a new, eligible destruction device at an eligible landfill where landfill gas has never been collected and destroyed prior to the project start date.

2. Installation of a new, eligible destruction device at an eligible landfill where landfill gas is currently collected and vented, but has never been destroyed in any manner prior to the project start date.

3. Installation of a new, eligible destruction device at an eligible landfill where landfill gas was collected and destroyed at any time prior to the project start date using an ineligible destruction device (e.g., a passive flare[11], or a device which was installed too early to be considered an eligible project);

4. Installation of a landfill gas collection system at an eligible landfill where landfill gas has never been collected and destroyed prior to the project start date, and connection of this collection system to an existing destruction system at another landfill. Such projects are subject to the conditions of Section 2.1.2.

The practice threshold is applied as of the project start date, and is evaluated at the project’s initial verification.

Under the scenarios above, expanding a well-field (either in conjunction with, or subsequent to, installing a new destruction device) constitutes a system expansion rather than a separate project.

[11] A “passive flare” is a destruction system where LFG is collected only through the passive pressure within the waste mass and sent to a device which automatically sparks to initiate combustion (operation is typically not monitored).

Destruction devices that were installed temporarily and utilized only for pilot or testing purposes specifically in anticipation of the GHG project shall not be considered in determining project eligibility or quantification. Devices may only be excluded under this provision if they were installed as a direct precursor to the project activity in order to gather information or determine project viability. Verifiable evidence of this intent must be presented.

Changes in landfill ownership, or in the ownership of destruction devices, are not considered in determining prior landfill gas management practices. If landfill gas was previously collected and destroyed by a party other than the Project Developer, it still qualifies as “prior” collection and destruction.

3.4.3 The Legal Requirement Test

All projects are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state, or local regulations, or other legally binding mandates. At the initial application for registration, the Project Developer must attest that the above is true. In addition, the project’s Surveillance plan (Section 6) must include procedures that the Project Developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test.

3.4.3.1 Federal Regulations

Landfill methane emissions are not subject to regulation at the federal level in Canada.

3.4.3.2 Provincial, Territorial, and State Regulations

Canadian provinces and territories, as well as US states with which they may link their cap-and-trade programs, have individual regulations related to the control of methane emissions at landfills. Those regulations which have been identified as relevant to this protocol are described below for each jurisdiction. Projects located in other jurisdictions are subject to legal requirements of their particular jurisdiction, in addition to the eligibility rules of this protocol.

Ontario

Ontario Environmental Protection Act, Regulation 232/98[12] requires that any new landfill (or expansion) with a designed capacity of greater than 1.5 M m^3 must prepare a plan for the collection and burning or use of LFG generated during site operation and following closure. Regulation 347 requires the same for sites not subject to Regulation 232/98.

Quebec

Landfill methane emissions are regulated under the Quebec Environmental Quality Act, Q-2, r. 19.[13] Under this regulation, all landfills must have a system (active or passive) for collecting biogas and conveying either to the environment or to treatment/destruction. Open landfills with a capacity greater than 1.5 M m^3, or which receive greater than 50,000 tons of residual materials per year, must have active collection and either treatment or destruction, so long as CH_4 concentration is greater than 25%. The timing of this regulation depends on the rate at which waste is received at the landfill. Active collection may be ceased after 5 years of measured CH_4 concentration in the collected gas of less than 25%.

[12] https://www.ontario.ca/laws/regulation/980232
[13] http://legisquebec.gouv.qc.ca/en/ShowDoc/cr/Q-2,%20r.%2019

California

On June 17, 2010, the California Air Resources Board (CARB) approved a discrete early action measure to reduce methane emissions from landfills. The control measure applies to landfills with greater than 450,000 t waste in place (WIP). The regulation reduces methane emissions from landfills by requiring gas collection and control systems where these systems were not previously required, and establishes statewide performance standards to maximize methane capture efficiencies.[14]

3.5 Regulatory Compliance

As a final eligibility requirement, Project Developers must attest that project activities do not cause material violations of applicable laws (e.g., air, water quality, safety, etc.). Project Developers are required to disclose in writing to the verifier any and all instances of legal violations – material or otherwise – caused by the project activities.

A violation should be considered to be "caused" by project activities if it can be reasonably argued that the violation would not have occurred in the absence of the project activities. If there is any question of causality, the Project Developer shall disclose the violation to the verifier.

If a verifier finds that project activities have caused a material violation, then credits will not be issued for GHG reductions that occurred during the period(s) when the violation occurred. Individual violations due to administrative or reporting issues, or due to "acts of nature," are not considered material and will not affect crediting. However, recurrent administrative violations directly related to project activities may affect crediting. Verifiers must determine if recurrent violations rise to the level of materiality. If the verifier is unable to assess the materiality of the violation, then the verifier shall consult with the Ministry.

[14] California Air Resources Board, Landfill Methane Control Measure webpage: http://www.arb.ca.gov/cc/landfills/landfills.htm (accessed Oct 30, 2016).

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that must be assessed by Project Developers in order to determine the net change in emissions caused by a landfill project.[15]

This protocol does not account for carbon dioxide emission reductions associated with displacing grid-delivered electricity or fossil fuel use.

CO_2 emissions associated with the generation and destruction of landfill gas are considered biogenic emissions[16] (as opposed to anthropogenic) and are not be included in the GHG Assessment Boundary. This is consistent with the Intergovernmental Panel on Climate Change's (IPCC) guidelines for captured landfill gas.[17]

Figure 4.1 illustrates all relevant GHG SSRs associated with landfill project activities and delineates the GHG Assessment Boundary.

Table 4.1 provides greater detail on each SSR and justification for the inclusion or exclusion of certain SSRs and gases from the GHG Assessment Boundary.

[15] The definition and assessment of SSRs is consistent with ISO 14064-2 guidance.
[16] The rationale is that carbon dioxide emitted during combustion represents the carbon dioxide that would have been emitted during natural decomposition of the solid waste. Emissions from the landfill gas control system do not yield a net increase in atmospheric carbon dioxide because they are theoretically equivalent to the carbon dioxide absorbed during plant growth.
[17] *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*; p.5.10, ftnt.

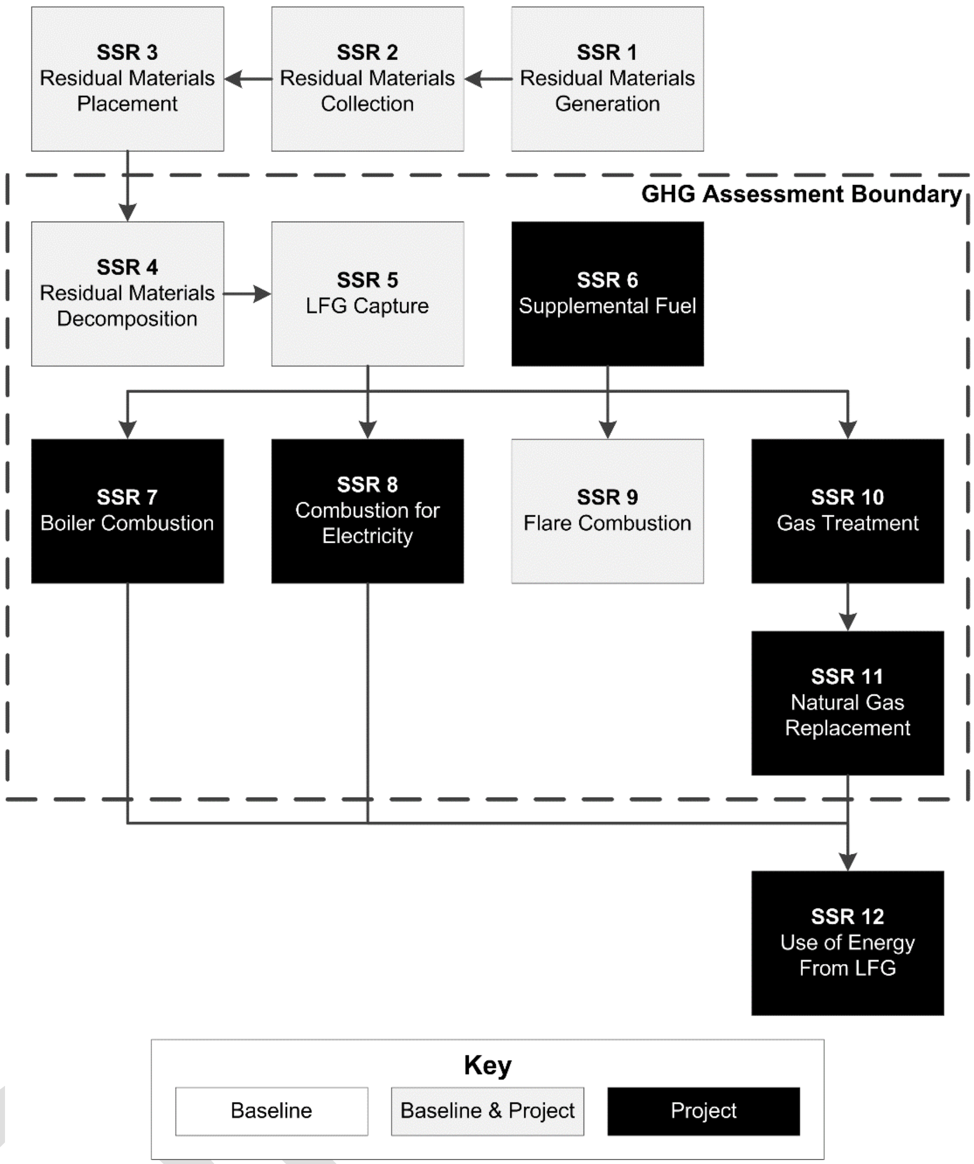


Figure 4.1. General Illustration of the GHG Assessment Boundary

Table 4.1. Description of All Sources, Sinks, and Reservoirs

SSR	Source Description	Gas	Relevant to Baseline (B) or Project (P)	Included or Excluded	Justification/Explanation
1	Residual Materials Generation	N/A	B, P	Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios
2	Residual Materials Collection	CO_2	B, P	Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios
		CH_4		Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios
		N_2O		Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios
3	Residual Materials Placement	CO_2	B, P	Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios
		CH_4		Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios
		N_2O		Excluded	This emission source is assumed to be equal in the baseline and project scenarios
4	Decomposition of Residual Materials in Landfill	CO_2	B, P	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Primary source of GHG emissions in baseline. Calculated based on destruction in baseline and project destruction devices
5	LFG Capture System	CO_2	B,P	Included	Landfill projects result in CO_2 emissions associated with the energy used for collection and processing of landfill gas
		CH_4		Excluded	Fugitive CH_4 released prior to reaching the flow meter is assumed to have been released in the baseline.
		N_2O		Excluded	This emission source is assumed to be very small
6	Supplemental Fuel	CO_2	B,P	Included	Landfill projects may require use of supplemental fossil fuel, resulting in significant new GHG emissions. Baseline use is excluded.
		CH_4		Included	Calculated based on destruction efficiency of destruction device. Baseline use is excluded.

SSR	Source Description	Gas	Relevant to Baseline (B) or Project (P)	Included or Excluded	Justification/Explanation
		N_2O		Excluded	This emission source is assumed to be very small
7	LFG Boiler Destruction	CO_2	B,P	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
8	LFG Combustion for Electricity (combustion engine, turbine, micro turbine)	CO_2	B,P	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
9	LFG Flare Combustion	CO_2	B,P	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
10	LFG Treatment and Upgrade	CO_2	B,P	Included	Landfill projects may result in GHG emissions from additional energy used to upgrade landfill gas
		CH_4		Excluded	This emission source is assumed to be very small
		N_2O		Excluded	This emission source is assumed to be very small
11	Natural Gas Replacement End Use (direct use boiler, NG transmission pipeline, vehicle fuel, CH_4 liquefaction)	CO_2	B,P	Excluded	Biogenic emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	Assumed to be very small
12	Use of Energy from LFG to Displace Fossil Energy	CO_2	B,P	Excluded	This protocol does not credit for displacement of GHG emissions from grid-connected electricity or fossil fuels

5 Calculation of Emission Reductions

GHG emission reductions from a landfill project are quantified by comparing actual project emissions to the calculated baseline emissions (Equation 5.1).

Equation 5.1. Calculating GHG Emission Reductions

$$ER = BE - PE$$

Where,			Units
ER	=	GHG emission reductions attributable to the project during the project reporting period	tCO_2e
BE	=	Baseline scenario emissions during the project reporting period, calculated using Equation 5.3	tCO_2e
PE	=	Project emissions during the project reporting period, calculated using Equation 5.9	tCO_2e

When the flow meter does not correct for the temperature and pressure of the LFG at standard conditions, the Project Developer must measure LFG pressure and temperature separately and correct the flow values using Equation 5.2. The Project Developer must use the corrected flow values in all the equations of this protocol. The reference pressure shall be 1 atm (101.325 kPa), but the reference temperature may be chosen by the Project Developer from Table A.2, based on the prevailing standard of the relevant jurisdiction.

Equation 5.2. Adjusting the Landfill Gas Flow for Temperature and Pressure

$$LFG_{i,t} = LFG_{uncorrected} \times \frac{T_{ref}}{T_m} \times \frac{P_m}{101.325}$$

Where,			Units
$LFG_{i,t}$	=	Corrected volume of LFG sent to destruction device *i*, in time interval *t*	m^3
$LFG_{uncorrected}$	=	Uncorrected volume of LFG captured for the given interval	m^3
P_m	=	Measured pressure of the LFG for the given time interval	kPa
T_{ref}	=	Reference temperature of the LFG for the project	K
T_m	=	Measured temperature of LFG for the given time period, in Kelvin (°C + 273.15)	K

5.1 Calculation of Baseline Emissions

Total baseline emissions for the reporting period are estimated by calculating and summing the emissions from all relevant baseline SSRs that are included in the GHG Assessment Boundary (as indicated in Table 4.1). With the exception of the deductions outlined below, baseline emissions are equal to the sum of all methane destroyed by eligible destruction devices.

Baseline oxidation of CH_4 in landfills should be accounted in the following manner:

1. For landfill sites with a geomembrane covering the entire landfill area, use a CH_4 oxidation rate of zero (0%). In this case, the Project Developer must show in the first project report that the landfill site has a geomembrane that meets the requirements of Ontario Regulation

232/98 respecting landfilling sites or the Quebec Environmental Quality Act, Chapter Q-2 r.19, as appropriate; and

2. For landfill sites with gas collection from multiple cells, some with a geomembrane meeting the requirements described above, and some without, and engineered such that gas may not migrate between cells, it is allowable to pro-rate the CH_4 oxidation factor based on the expected volumes of gas to be collected from each cell. For example, for a landfill with one closed cell, expected to produce 70% of the LFG, and one open cell, expected to produce 30% of the LFG, the value of OX would be (0x0.7)+(0.1x0.3)=0.03, or 3%. The verifier will confirm the appropriateness of the assumptions used to calculate the pro-rated value.

3. For all other landfill sites, use a CH_4 oxidation factor of 10%.

Equation 5.3. Calculating Baseline Emissions

$$BE = (CH_4DEST_{PR}) \times GWP \times (1 - OX) \times (1 - DF) - Dest_{base} \times (1 - OX)$$

Where,			Units
BE	=	Baseline scenario emissions during the project reporting period	tCO_2e
CH_4Dest_{PR}	=	Total quantity of CH_4 treated or destroyed by all LFG treatment and destruction devices during the project reporting period	tCH_4
GWP	=	Global Warming Potential factor of CH_4, as set out in Ontario and Quebec regulations concerning the reporting of GHG emissions.	tCO_2e/tCH_4
OX	=	Factor for the oxidation of CH_4 by soil bacteria, as determined according to the guidance above.	
DF	=	Discount factor to account for uncertainties associated with the monitoring equipment for CH_4 content in the LFG, namely a factor of 0 when the CH_4 content in the LFG is measured continuously, and 0.1 in other cases, with measurements made at least weekly	
$Dest_{base}$	=	Adjustment to account for baseline LFG destruction (see Equation 5.7). Equal to 0 if no LFG destruction system is in place prior to project implementation.	tCO_2e

Equation 5.4. Total Methane Emissions Destroyed

$$CH_4Dest_{PR} = \sum_{i}^{n} (CH_4Dest_i) \times (\rho_{CH_4} \times 0.001)$$

Where,			Units
CH_4Dest_{PR}	=	Total quantity of CH_4 treated or destroyed by all LFG treatment or destruction devices during the project reporting period	tCH_4
n	=	Number of treatment or destruction devices	
i	=	Treatment or destruction device	
CH_4Dest_i	=	Net quantity of CH_4 treated or destroyed by device *i* during the project reporting period, calculated using Equation 5.5	m^3 CH_4
ρ_{CH4}	=	Density of CH_4 (Table A.2)	$kgCH_4/m^3$
0.001	=	Conversion factor, kilograms to metric tonnes	$tCH_4/kgCH_4$

Equation 5.5. Total Methane Emissions by Device During the Reporting Period

$$CH_4Dest_i = Q_i \times DE_i$$

Where,

			Units
CH_4Dest_i	=	Net quantity of CH_4 treated or destroyed by device *i* during the project reporting period	m^3CH_4
Q_i	=	Total quantity of CH_4 sent to device *i*	m^3CH_4
i	=	Treatment or destruction device	
DE_i	=	CH_4 treatment or destruction efficiency of device *i*, determined in accordance with Appendix A	fraction

Equation 5.6. Total Quantity of CH_4 Sent to Treatment or Destruction Device

$$Q_i = \sum_{t=1}^{n} \left(LFG_{i,t} \times PR_{CH4,t} \right)$$

Where,

			Units
Q_i	=	Total quantity of CH_4 sent to device *i* during the project reporting period	m^3CH_4
n	=	Number of time intervals during the project reporting period	
t	=	Time interval shown in the Table 6.1 for which LFG CH_4 flow and content measurements are aggregated	
$LFG_{i,t}$	=	Corrected volume of LFG sent to device *i* during time interval *t*	m^3
$PR_{CH4,t}$	=	Average CH_4 fraction of the LFG in time interval *t*	m^3CH_4/m^3LFG

For projects where methane was destroyed in the baseline, Equation 5.7 must be applied. The time period over which the value of $Dest_{base}$ is to be aggregated may be chosen by the Project Developer, but cannot be less than weekly, and must be consistent throughout the reporting period.

Equation 5.7. Baseline Adjustment for Destruction in the Baseline Scenario

$$Dest_{base} = BD_{discount} \times \rho_{CH_4} \times 0.001 \times GWP$$

Where,

			Units
$Dest_{base}$	=	Adjustment to account for the baseline methane destruction associated with a baseline destruction device. Equal to zero if there is no baseline installation	tCO_2e
$BDBD_{discount}$	=	Adjustment to account for the methane that would have been destroyed in the baseline, ineligible destruction device. Equal to zero if there is no ineligible destruction device.	m^3 CH_4
ρ_{CH4}	=	Density of CH_4 (Table A.2)	$kgCH_4/m^3$
0.001	=	Conversion factor, kilograms to metric tonnes	$tCH_4/kgCH_4$
GWP	=	Global Warming Potential factor of CH_4, as set out in Ontario and Quebec regulations concerning the reporting of GHG emissions.	tCO_2e/tCH_4

$BD_{discount}$, may be determined using either of the following options.

1. $BD_{discount}$ shall be equal to the measured quantity of methane recovered through an active gas collection system installed into the corresponding cell or waste mass of the landfill in which the baseline devices operated. The landfill gas flow from these active wells shall be determined using Equation 5.4 above for a minimum of one month.[18]

2. $BD_{discount}$ shall be monitored and calculated per Equation 5.8 and Appendix C.

Equation 5.8. Calculating Baseline Adjustment for Non-Qualifying Devices

$$BD_{discount} = LFG_{B2} \times B_{CH_4NQ}$$

Where,			Units
$BD_{discount}$	=	Adjustment to account for the methane that would have been combusted in the baseline, ineligible destruction device. Equal to zero if there is no ineligible destruction device	m^3 CH_4
LFG_{B2}	=	Landfill gas that would have been destroyed by the original, ineligible destruction system during the reporting period. See Appendix C for guidance on calculating LFG_{B2}	m^3
$B_{CH4,BD}$	=	Methane fraction of landfill gas destroyed by ineligible destruction devices in the baseline. Equal to average methane concentration over the reporting period if maximum capacity is used for LFG_{B2}. See Appendix C for further guidance on calculating $B_{CH4,BD}$	m^3 CH_4/m^3 LFG

5.2 Calculation of Project Emissions

Project emissions are actual GHG emissions that occur within the GHG Assessment Boundary as a result of the project activity. Project emissions must be quantified every reporting period on an *ex post* basis. The Project Developer must calculate the GHG project emissions using Equation 5.9 to Equation 5.12. For any fossil fuel or electricity usage which cannot be directly monitored in order to satisfy the data requirements of this section, the Project Developer may apply to the Ministry for the use of an alternative, conservative estimation methodology, subject to verifier review and approval. This option is only available if the project emissions from these sources can be reasonably estimated to be less than 5% of the total baseline emissions for the reporting period.

[18] For the purpose of using Equation 5.4 to determine $BD_{discount}$, the quantity of landfill gas would be only that which is being metered from the corresponding cell or waste mass in which the baseline devices had operated, and not necessarily all of the landfill gas being destroyed by the destruction system.

Equation 5.9. Calculating Project Emissions

$$PE = FF_{CO2} + EL_{CO2} + NG_{emissions}$$

Where,			Units
PE	=	Project emissions during the project reporting period	tCO_2e
FF_{CO2}	=	Total CO_2 emissions attributable to the use of fossil fuels during the project reporting period, calculated using Equation 5.10	tCO_2e
EL_{CO2}	=	Total CO_2 emissions attributable to the consumption of electricity during the project reporting period, calculated using Equation 5.11	tCO_2e
$NG_{emissions}$	=	Total quantity of CH_4 and CO_2 emissions attributable to supplemental natural gas during the project reporting period, calculated using Equation 5.12	tCO_2e

Any emissions related to the use of natural gas to supplement operation of any of the project destruction devices shall be quantified using Equation 5.12. Otherwise, all fossil fuel consumption related to project activities (not regular landfill operations) shall be quantified using Equation 5.10.

Equation 5.10. Calculating Project Emissions from Fossil Fuel Use

$$FF_{C02} = \frac{\sum_{j}^{n}(FF_{PR,j} \times EF_{CF,j})}{1000}$$

Where,			Units
FF_{CO2}	=	Total CO_2 emissions attributable to the use of fossil fuels (other than supplemental natural gas) during the project reporting period	tCO_2e
n	=	Number of types of fossil fuel	tCO_2e
j	=	Type of fossil fuel	
$FF_{PR,j}$	=	Annual quantity of fossil fuel *j* consumed in the operation of equipment within the SSRs in the baseline scenario	volume fossil fuel
$EF_{CF,j}$	=	CO_2 emission factor for fossil fuel *j* specified in the relevant Ontario and Quebec regulations concerning the reporting of GHG emissions	$kgCO_2$/volume fossil fuel
1000	=	Conversion factor, kilograms to tonnes	$kgCO_2/tCO_2$

Equation 5.11. Calculating Project Emissions from Electricity Use

$$EL_{C02} = \frac{EL_{PR} \times EL_{EL}}{1000}$$

Where,			Units
EL_{CO2}	=	Total CO_2 emissions attributable to the consumption of grid electricity during the project reporting period	tCO_2
EL_{PR}	=	Total grid electricity consumed by the project LFG capture and treatment or destruction system during the project reporting period, in megawatt-hours;	MWh
EL_{EL}	=	CO_2 emission factor for the consumption of electricity from the local province, according to the most recent National Inventory Report: Greenhouse Gas Sources and Sinks in Canada, Part 3, published by Environment Canada	$kgCO_2$/MWh
1000	=	Conversion factor, metric tonnes to kilograms	$kgCO_2/tCO_2$

Equation 5.12. Calculating Project Emissions from the Use of Supplemental Natural Gas

$$NG_{emissions} = \sum_{i}^{n}\left[NG_i \times NG_{CH4} \times \rho_{CH_4} \times 0.001\left[\left((1 - DE_i) \times GWP\right) + \left(DE_i \times \frac{12}{16} \times \frac{44}{12}\right]\right]\right.$$

Where,			Units
$NG_{emissions}$	=	Total CH_4 and CO_2 emissions attributable to supplemental natural gas during the project reporting period	tCO_2e
n	=	Number of treatment or destruction devices	
i	=	Treatment or destruction device	
NG_i	=	Total quantity of supplemental natural gas sent to treatment or destruction device *i* during the project reporting period	m^3
NG_{CH4}	=	Average CH_4 fraction of the supplemental natural gas, according to the supplier's specifications	m^3 CH_4 / m^3 NG
ρ_{CH4}	=	Density of CH_4 (Table A.2)	$kgCH_4$ / m^3 CH_4
0.001	=	Conversion factor, kilograms to metric tonnes	$kgCH_4/tCH_4$
DE_i	=	Default CH_4 efficiency of device *i*, determined in accordance with Appendix A	Appendix A
GWP	=	Global Warming Potential factor of CH_4, as set out in Ontario and Quebec regulations concerning the reporting of GHG emissions.	tCO_2e/tCH_4
12/16	=	Molecular mass ratio, carbon to CH_4	C/CH_4
44/12	=	Molecular mass ratio, CO_2 to carbon	CO_2/C

6 Data Management and Project Surveillance

6.1 Data Collection and Validation

The Project Developer is responsible for collecting the information required for project monitoring. The Project Developer must show that the data collected are actual and that rigorous supervision and record-keeping procedures are applied at the project site.

The Project Developer must institute a transparent, verifiable methodology for the validation of all project data to ensure that any erroneous or unusual data are identified, subject to verifier review and approval. Any data which are determined to be invalid shall be replaced using the Missing Data procedures in Appendix B.

6.2 Surveillance Plan

At a minimum, the surveillance plan must include the following:

1. Methods used to collect and record the data required for all the relevant parameters in Table 6.1;

2. Frequency of data acquisition;

3. Record keeping plan (see Section 7.1 for minimum record keeping requirements)

4. Frequency of instrument cleaning, inspection and calibration activities, and of the verification of instrument calibration accuracy; and

5. The role and qualifications of the person responsible for each surveillance activity, as well as the quality assurance and quality control measures taken to ensure that data acquisition and instrument calibration are carried out consistently and with precision; and

6. A detailed diagram of the LFG capture and treatment or destruction system, including the placement of all measurement instrument and equipment that affect included SSRs; and

7. Procedures which will be followed to ascertain and demonstrate that the project at all times passes the Legal Requirement Test (Section 3.4.3).

6.3 Surveillance Requirements

Project Developers are responsible for monitoring the performance of the project and ensuring that the operation of all project-related equipment is consistent with the manufacturer's recommendations. Methane emission reductions from landfill gas capture and control systems must be monitored with measurement equipment that directly meters:

1. The flow of landfill gas delivered to each destruction device[19], measured continuously and recorded every 15 minutes or totalized and recorded at least daily, adjusted for temperature and pressure

---

[19] A single meter may be used for multiple, identical destruction devices. In this instance, CH_4 destruction in these units will be eligible only if both units are monitored to be operational, unless evidence is available to document that the design of the device is such that CH_4 may not pass through when it is not operational.

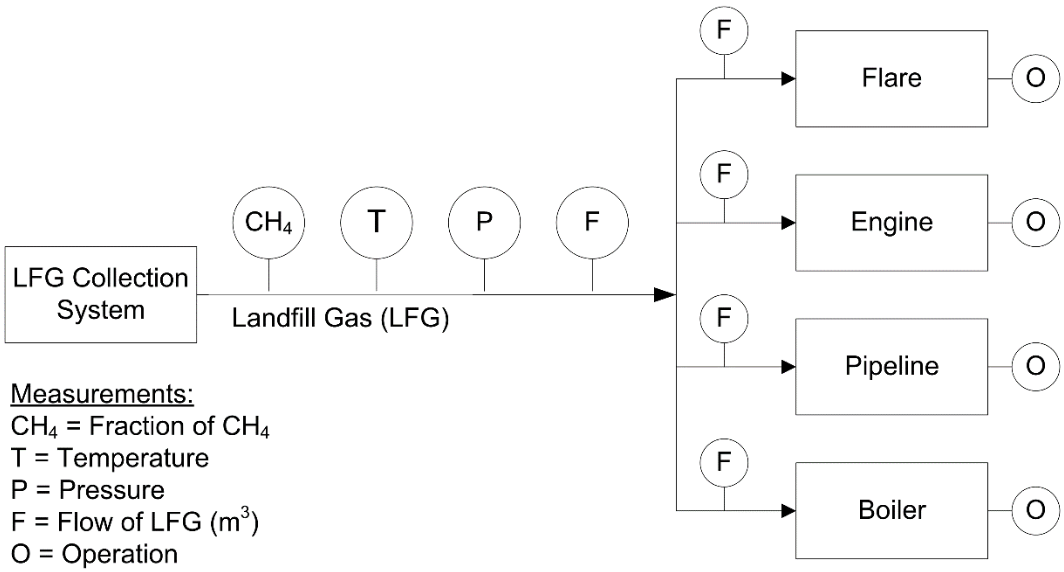
2. The fraction of methane in the landfill gas delivered to the destruction device, measured continuously and recorded every 15 minutes and averaged at least daily (measurements taken at a frequency that is between daily and weekly may be used with the application of a 10% discount in Equation 5.3)

All flow data collected must be corrected for temperature and pressure. Pressure correction is to 1 atm, but temperature correction may be chosen according to one of the values listed in Table A.2 and applied to all gas measurement data for the project. The appropriate value for the density of CH_4 is based on the chosen reference temperature. The temperature and pressure of the landfill gas must be measured continuously. No separate monitoring of temperature and pressure is necessary when using flow meters that automatically correct for temperature and pressure, expressing LFG volumes in normalized cubic meters.

The continuous methane analyzer is the preferred option for monitoring methane concentrations. When using an alternative approach of up to weekly methane concentration measurement, Project Developers must account for the uncertainty associated with these measurements by applying a 10% discount factor to the total quantity of methane collected and destroyed in Equation 5.3. Non-continuous methane measurement may occur through the use of a calibrated, portable methane analyzer, or a device which collects gas samples into a common container which is then analyzed by an off-site laboratory, providing an average methane content for the period. In the latter case, the device must collect samples at least weekly, and the gas analysis must be carried out at least monthly.

Methane fraction of the landfill gas to be measured on a wet/dry basis (must be measured on same basis as flow, temperature, and pressure). The methane analyzer and flow meter should be installed in the same relative placement to any moisture-removing components of the landfill gas system (there should not be a moisture-removing component separating the measurement of flow and methane fraction). An acceptable variation to this arrangement would be in the case where the flow meter is placed after a moisture-removing component (dry basis), while the methane analyzer is placed before this component (wet basis). The opposite arrangement is not permissible.

Figure 6.1 represents the suggested arrangement of destruction system metering equipment.



Note: The number and arrangement of flow meters must be sufficient to track the flow to each combustion device. The above scenario includes one more flow meter than would be necessary to achieve this objective.

Figure 6.1. Suggested Arrangement of LFG Metering Equipment

The operational activity of the landfill gas collection system and the destruction devices shall be monitored and documented at least hourly to ensure actual landfill gas destruction. GHG reductions will not be accounted for during periods which the destruction device was not operational. For flares, operation is defined according to the regulatory standard for the relevant jurisdiction. For all other destruction devices, the means of demonstration shall be determined by the Project Developer, according to applicable regulatory standards, should they exist, and otherwise according to manufacturer guidance, and subject to verifier review.

If the Project Developer can demonstrate that the engineering design of the destruction system is such that gas may not be released when the device is not operational, and that such design elements are functioning properly, it is not required to monitor operational status on an hourly basis.

6.4 Instrument Quality Assurance and Quality Control (QA/QC)

The Project Developer must ensure that all LFG flow meters and CH_4 analyzers are:

1. Documented to be in calibration at the time of installation at the project; and

2. Cleaned and inspected as specified in the project's surveillance plan and at the minimum cleaning and inspection frequency specified by the manufacturer, with all cleaning and inspection activities documented by landfill site personnel; and

3. Not more than 2 months before or after the project reporting period end date, either

   a. Checked for accuracy by a qualified and independent person, either using a portable instrument, such as a pitot tube, or manufacturer's specifications, and ensure that the percentage drift is recorded; or
   b. Calibrated by the manufacturer, or by a third person certified for that purpose by the manufacturer; and

4. Calibrated by the manufacturer, or by a third-party certified for that purpose by the manufacturer, according to the manufacturer's specifications or every 5 years, whichever is more frequent.

A calibration certificate or a verification report on calibration accuracy, from either the manufacturer or a qualified third-party service provider, must be produced and included in the project report.

Flow meters and/or methane analyzers which are installed temporarily (not portable devices) must be documented to be in calibration at the time of installation.

Flow meter calibrations must be documented to show that the meter was calibrated to a range of flow rates corresponding to the flow rates expected at the landfill site. CH_4 analyzer calibrations must be documented to show that the calibration was carried out to a range of temperature and pressure conditions corresponding to the range of conditions measured at the landfill site.

The verification of flow meter and analyzer calibration accuracy must show that the instrument provides a reading of volumetric flow or CH_4 content that is within a ± 5% accuracy threshold.

When either a calibration or a field check of a device shows a shift outside the ± 5% accuracy threshold, but the manufacturer specifies a cleaning procedure for accuracy checks, the device may be cleaned and rechecked. If the device is still out of the allowable threshold, the device must be calibrated by the manufacturer or by a third party certified for that purpose by the manufacturer. In addition, for the entire period from the last calibration or field check that confirmed accuracy within the ± 5% threshold until such time as the piece of equipment is correctly calibrated, all the data from the piece of equipment must be corrected according to the following procedure:

1. When the calibration indicates an under-reporting of flow rates or CH_4 content, the Project Developer must use the measured values without correction;

2. When the calibration indicates an over-reporting of flow rates or CH_4 content, the Project Developer must apply to the measured values the greatest calibration drift recorded at the time of calibration.

For devices which are cleaned and rechecked, with the second check showing a return to calibration accuracy, the device does not need further calibration, but the data must be adjusted per the procedure outlined above.

If the Project Developer uses a portable CH_4 analyzer, it must be maintained and calibrated according to the manufacturer's specifications, and calibrated at least annually by the manufacturer, by a laboratory certified by the manufacturer, or by an ISO 17025 accredited laboratory. The portable analyzer also must be calibrated per the manufacturer's guidance prior to each use.

No offset credit may be issued for a project reporting period when the calibration or verification of the calibration accuracy of the required instruments has not been correctly carried out and documented.

6.5 Missing Data

In situations where the flow rate or methane concentration monitoring equipment is missing data, the Project Developer shall apply the data substitution methodology provided in Appendix B. If for any reason the destruction device monitoring equipment is inoperable (for example, the thermal coupler on the flare), then no emission reductions can be registered for that device for the period of inoperability.

6.6 Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.1.

Table 6.1. Landfill Project Surveillance Plan

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
	Capacity and annual residual material tonnage	N/A	metric tonne	o	Annual or at each project reporting period, in accordance with the second paragraph of Section 1	Must be monitored and determined for each reporting period. The amount of waste in place shall be documented as of the beginning of the reporting period to assess whether the landfill continues to satisfy the performance standard test (Section 3.4.1).
	Operating status of destruction devices	N/A	Unit determined per destruction device	m	Hourly	Required for each destruction device.
Equation 5.2 **Equation 5.6**	Corrected volume of LFG sent to destruction device i, in time interval t	$LFG_{i,t}$	Cubic meter at standard conditions	m/c	Continuous and recorded at least every 15 minutes or totalized and recorded at least daily and adjusted for temperature and pressure	Measured continuously by a flow meter and recorded at least once every 15 minutes. Data to be aggregated by time interval t (this parameter is calculated in cases where the metered flow must be corrected for temperature and pressure)

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.2	Uncorrected volume of LFG captured for the given interval	$LFG_{uncorrected}$	Cubic meter	m	Only when flow data are not adjusted at standard conditions	Used only in cases where the flow meter does not automatically correct to standard conditions
Equation 5.2	Measured pressure of the LFG for the given time interval	P_m	kPa	m	Continuous	
Equation 5.2	Reference temperature of the LFG for the project	T_{ref}	K	m		
Equation 5.2	Measured temperature of LFG for the given time period	T_m	K	m		
Equation 5.3.	Total quantity of CH_4 treated or destroyed by all LFG treatment and destruction devices during the project reporting period	CH_4Dest_{PR}	tCH_4	c		
Equation 5.3 Equation 5.7 Equation 5.12	Global Warming Potential factor of CH_4	GWP	N/A	r	At each reporting period	As set out in Ontario and Quebec regulations concerning the reporting of GHG emissions
Equation 5.3	Factor for the oxidation of CH_4 by soil bacteria	OX	N/A	r	At each reporting period	Value determined based on use and extent of geomembrane final landfill cover

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.3	Discount factor to account for uncertainties associated with monitoring equipment for CH_4 content in the LFG	DF	0 when the CH_4 content is continuously monitored, or 0.1 in other cases	N/A	At each reporting period	Equal to zero if using continuous methane monitor
Equation 5.3.	Adjustment to account for baseline LFG destruction	$Dest_{base}$	N/A	c	At each reporting period	Equal to 0 if no LFG destruction system is in place prior to project implementation (see Equation 5.7)
Equation 5.4	Number of treatment or destruction devices	n	N/A	r		
Equation 5.4 Equation 5.5	Treatment or destruction device	*i*	N/A	r		
Equation 5.4	Net quantity of CH4 treated or destroyed by device	CH_4Dest_i	m^3 CH_4	c		
Equation 5.4 Equation 5.7	Density of CH_4	ρ_{CH4}	$kgCH_4/m^3$	r	Once	See 42
Equation 5.5 Equation 5.6	Total quantity of CH_4 sent to destruction device *i* during the project reporting period	Q_i	Cubic meter of CH_4 at standard conditions	c	Daily when the CH_4 is continuously monitored, or weekly if CH_4 is monitored weekly	Calculated daily if methane is continuously metered or weekly if methane is measured weekly
Equation 5.5	Default CH_4 treatment or destruction efficiency of device *i*	DE_i	N/A	r/m	Once	Determined in accordance with Appendix A

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.6	Number of time intervals during the project reporting period	n	N/A	r	Continuous/ Daily/ Weekly	Projects employing continuous methane concentration monitoring may use the interval of their data acquisition system. Otherwise, this parameter is equal to one day for continuously monitored methane concentration and one week for weekly monitored methane concentration.
Equation 5.6	Time interval for which LFG CH_4 flow and content measurements are aggregated	t	Week, day, hour, or minute	m	Continuous, daily, or weekly	Projects with a continuous CH_4 concentration monitoring system may use the interval used by their data acquisition system, provided it is not more than 1 day for the continuous monitoring of CH_4 content and 1 week for the weekly monitoring of CH_4 content
Equation 5.6.	Corrected volume of LFG sent to device *I* during time interval *t*	$LFG_{i,t}$	m^3		Measured continuously	
Equation 5.6	Average CH_4 fraction of the LFG in time interval t	$PR_{CH4,t}$	Cubic meter of CH_4 at standard conditions per cubic meter of LFG at standard conditions	m	Measured continuously or weekly	Measured continuously or by portable analyzer

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.7	Adjustment to account for the methane that would have been combusted in the baseline	$NQ_{discount}$	m^3 CH_4	c	Yearly	Non-qualifying combustion device. Equal to zero if there is no non-qualifying combustion device.
Equation 5.9	Total CO_2 emissions attributable to the use of fossil fuels during the project reporting period	FF_{CO2}	tCO_2e	c	At each reporting period	Calculated using Equation 5.10
Equation 5.9	Total CO_2 emissions attributable to the consumption of electricity during the project reporting period	EL_{CO2}	tCO_2e	c	At each reporting period	Calculated using Equation 5.11
Equation 5.9 Equation 5.12.	Total quantity of CH_4 and CO_2 emissions attributable to supplemental natural gas during the project reporting period	$NG_{emissions}$	tCO_2e	c	At each reporting period	Calculated using Equation 5.12
Equation 5.10	Number of types of fossil fuel	n	tCO_2e	c	At each reporting period	
Equation 5.10	Type of fossil fuel	*j*	tCO_2e	c	At each reporting period	
Equation 5.8	Landfill gas that would have been destroyed by the original, non-qualifying destruction system during the reporting period	LFG_{B2}	m^3	c	Yearly	See Appendix C for guidance on calculating LFG_{B2}

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.8	Methane fraction of landfill gas destroyed by non-qualifying devices in the baseline	$B_{CH4,NQ}$	m^3 CH_4/m^3 LFG	m	Continuously/ Weekly	Equal to average methane concentration over the reporting period if maximum capacity is used for LFG_{B2}. See Appendix C for further guidance on calculating $B_{CH4,NQ}$
Equation 5.10	Total fossil fuels consumed by the capture and destruction system during the project reporting period, by type of fuel *j*	$FF_{PR,j}$	Kilogram (solid) Cubic meter at standard conditions (gas) Litre (liquid)	r	Calculated using fossil fuels purchasing register	Calculated from monthly record of fossil fuel purchased and consumed
Equation 5.10	Annual quantity of fossil fuel *j* consumed in the operation of equipment within the SSRs in the baseline scenario	$EF_{CF,j}$	Kilogram (solid) Cubic meter at standard conditions (gas) Litre (liquid)	r	Calculated using fossil fuels purchasing register	Volume fossil fuel
Equation 5.11	Total electricity consumed by the LFG capture and destruction system during the project reporting period	EL_{PR}	Megawatt-Hour	r	Measured by onsite meter or based on electricity purchasing record	Obtained from either onsite metering or utility purchase records. Required to determine CO_2 emissions from use of electricity to operate the project activity
Equation 5.11.	CO_2 emission factor for the consumption of electricity	EL_{EL}	$kgCO_2/MWh$	r	At each reporting period	Determined based on the most recent National Inventory Report: Greenhouse Gas Sources and Sinks in Canada, Part 3, published by Environment Canada

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.12	Total quantity of supplemental natural gas sent to the destruction device during the project reporting period	NG_i	Cubic meter at standard conditions	m/r	Measured before being sent to the destruction device	Metered prior to delivery to destruction device
Equation 5.12	Average CH_4 fraction of the supplemental natural gas, according to the supplier's specifications	NG_{CH4}	Cubic meter of CH_4 at standard conditions per cubic meter of natural gas at standard conditions	m/r	At each project reporting period	Based on purchasing register
Equation 5.12.	Default CH_4 efficiency of device *i*	DE_i	Appendix A	r	At each project reporting period	Determined in accordance with Appendix A
Equation 5.2	LFG temperature	T	K	m	continuous	No separate monitoring of temperature is necessary when using flow meters that automatically adjust flow volumes for temperature and pressure, expressing LFG volumes in normalized m^3
	LFG pressure	P	kPa	m	continuous	No separate monitoring of pressure is necessary when using flow meters that automatically measure adjust flow volumes for temperature and pressure, expressing LFG volumes in normalized m^3

Eq. #	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation C.1	Landfill gas that would have been destroyed by the original, non-qualifying destruction system during the reporting period	LFG_{B2}	scf LFG	c	Yearly	
Equation C.1	90% upper confidence limit of the average flow rate in the metered period (must be >3 months)	$90\%UCL(LFG_{scfm})$	scfm LFG	c	Once	
Equation C.1	Methane concentration for baseline calculations	$B_{CH4,NQ,t}$	scf CH_4/ scf LFG	c	Once	
Equation C.1	The 90% t-value coefficient for data set with degrees of freedom	t_{value}	N/A	c	Once	use Excel feature: =T.INV.2T(0.1,df)
Equation C.1	Standard deviation of the sample	SD	N/A	c	Once	
Equation C.1	Sample size	n	N/A	r	Once	
Equation C.1	Degrees of freedom (= n-1)	*df*	N/A	c	Once	

7 Reporting

This section provides requirements and guidance on reporting rules and procedures. A priority of the Ministry is to facilitate consistent and transparent information disclosure among Project Developers. Project Developers shall conduct regular project reporting according the guidance in the Regulation.

7.1 Record Keeping

For purposes of independent verification and historical documentation, Project Developers are required to keep all information outlined in this protocol for the period of time defined by the Regulation. Information on data procedures and data monitoring must be managed in a way that guarantees the integrity, exhaustiveness, accuracy and validity of the data.

The Project Developer must keep the following documents and information:

1. The information and data required under the surveillance plan, including all GHG calculations and their related data inputs;
2. Information on each flow meter, CH_4 analyzer and destruction device used, including type, model number, serial number and manufacturer's maintenance and calibration procedures;
3. For a portable analyzer, the date, time and place where measurements are taken and, for each measurement, the CH_4 content in the LFG;
4. The calibration date, time and results for CH_4 analyzers and flow meters, and the corrective measures applied if a piece of equipment fails to meet the requirements of this Regulation;
5. The maintenance records for capture, destruction and monitoring systems;
6. Operating records showing the quantity of residual material disposed of;
7. All documentation related to permits related to the landfill facility (e.g., air quality, water quality, solid waste, land use, system construction, etc.), as well as documentation related to any regulatory compliance inquiries, warnings, or violations.

7.2 Reporting Period and Verification Cycle

Project Developers must report GHG reductions resulting from project activities during each reporting period. Reporting periods shall be 12 months in length. Guidance regarding the deadlines for verification of each reporting period can be found in the Regulation.

Except for the initial reporting period, projects which generate fewer than 25,000 tonnes of emission reductions in a calendar year may delay verification for up to a year. These projects may verify two 12-month reporting periods at the same time.

8 Verification Guidance

Only accredited verification bodies, as defined in the Regulation, are eligible to verify landfill project reports.

8.1 Standard of Verification

The Ministry's standard of verification for landfill projects is the Landfill Project Protocol (this document) and the Regulation. To verify a landfill project report, verification bodies apply the guidance in the Regulation and this section of the protocol to the standards described in Sections 2 through 7 of this protocol. In cases where the Regulation differs from the guidance in this protocol, the Regulation takes precedent.

Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Ministry's verification process and professional judgment, please see the Regulation.

8.2 Surveillance Plan

Verification bodies shall confirm that the surveillance plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.1 are collected and recorded.

8.3 Verifying Project Eligibility

Verification bodies must affirm a landfill project's eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for a landfill project. This table does not represent all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.2.

Table 8.1. Summary of Eligibility Criteria

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	Per guidance in the Regulation	Once during first verification
Location	Canada	Once during first verification
Size threshold	Ensure that operating and closed landfills meet the appropriate thresholds in Section 3.4.1	Once during first verification
Performance Standard: Practice Threshold	Installation of an eligible destruction device where not required by law (see Section 3.4.2 for other requirements)	Once during first verification
Legal Requirement Test	Specific to each province (see Section 3.4.3 for more information)	Every verification
Regulatory Compliance Test	Disclosure of all non-compliance events to verifier; project must be in material compliance with all applicable laws	Every verification
Exclusions	▪ Bioreactors ▪ Landfills which re-circulate a liquid other than leachate in a controlled manner ▪ Indirect emissions from the displacement of grid electricity or natural gas	Every verification

8.4 Core Verification Activities

The Regulation describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of a landfill project, but verification bodies must also follow the general guidance in the Regulation.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emission sources, sinks, and reservoirs (SSRs)
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs
The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project, such as, *inter alia*, landfill methane emissions, system energy use, fuel consumption, combustion and destruction from various eligible and ineligible destruction devices, and soil oxidation.

Reviewing GHG management systems and estimation methodologies
The verification body reviews and assesses the appropriateness of the methodologies and management systems that the landfill Project Developer uses to gather data and calculate baseline and project emissions.

Verifying emission reduction estimates
The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project facility (or facilities if the project includes multiple facilities) to

ensure the systems on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body recalculates a representative sample of the performance or emissions data for comparison with data reported by the Project Developer in order to double-check the calculations of GHG emission reductions.

8.5 Landfill Project Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a landfill project. The tables include references to the section in the protocol where requirements are further described. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to landfill projects that must be addressed during verification.

8.5.1 Project Eligibility and Credit Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and credit issuance for landfill projects. These requirements determine if a project is eligible to register credits for the reporting period. If any one requirement is not met, either the project may be determined ineligible or the GHG reductions from the reporting period (or sub-set of the reporting period) may be ineligible for issuance of credits, as specified in Sections 2, 3, and 6.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
3.4.2	Verify that the project meets the appropriate Performance Standard Tests for the project type per Section 3.4.2	No
3.4.3	Verify that the project activities comply with applicable laws by reviewing any instances of non-compliance provided by the Project Developer and performing a risk-based assessment	Yes
4	Confirm all baseline destruction devices have been properly accounted for within project's GHG Assessment Boundary	No
6	Verify that monitoring meets the requirements of the protocol	No
6	Verify that the project surveillance plan contains procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test at all times	Yes
6	Verify that the landfill gas control system operated in a manner consistent with the design specifications	Yes
6	Verify that there is an individual responsible for managing and reporting GHG emissions, and that individual properly trained and qualified to perform this function	Yes
6.2	Verify that all gas flow meters and methane analyzers adhered to the inspection, cleaning, and calibration schedule specified in the protocol. If they do not, verify whether any non-conformances should be considered material.	Yes
6.2	If any piece of equipment failed a calibration check, verify that data from that equipment was scaled according to the failed calibration procedure for the appropriate time period	No
6.3	If used, verify that data substitution methodology was properly applied	No
7	Verify that appropriate documents are created to support and/or substantiate activities related to GHG emission reporting activities, and that such documentation is retained appropriately	Yes

8.5.2 Quantification of GHG Emission Reductions

Table 8.3 lists the items that verification bodies shall include in their risk assessment and re-calculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before credits are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that SSRs included in the GHG Assessment Boundary correspond to those required by the protocol and those represented in the project	No
5	Verify that the Project Developer correctly accounted for baseline methane destruction in the baseline scenario	No
5	Verify that the Project Developer correctly monitored, quantified and aggregated the amount of methane collected from the landfill and destroyed by the project landfill gas control system	No
5	Verify that the Project Developer correctly quantified and aggregated electricity use	Yes
5	Verify that the Project Developer correctly quantified and aggregated fossil fuel use	Yes
5	Verify that the Project Developer applied the correct emission factors for fossil fuel combustion and grid-delivered electricity	No
5	Verify that the Project Developer applied the correct methane destruction efficiencies	No
Appendix A	If the Project Developer used source test data in place of the default destruction efficiencies (Appendix A), verify accuracy and appropriateness of data and calculations	Yes
Appendix B	If data substitution was employed, verify that it meets the guidance in Appendix B	No

8.5.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
8.2	Verify that the surveillance plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6.3, 6.6	Verify that appropriate monitoring equipment is in place to meet the requirements of the protocol	No
6.4	Verify that equipment calibrations have been carried out to satisfy the requirements of the protocol	No
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6	Verify that appropriate training was provided to personnel assigned to greenhouse gas reporting duties	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the Project Developer. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
6.4	Verify that the methane destruction equipment was operated and maintained according to manufacturer specifications	Yes

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
7.1	Verify that all required records have been retained by the Project Developer	No

8.6 Completing Verification

The Regulation provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Opinion, submitting the necessary documents to the Ministry, and notifying the Ministry of the project's verified status.

9 Glossary of Terms

Additionality	Project activities that are above and beyond "business as usual" operation, exceed the baseline characterization, and are not mandated by regulation.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e., fossil fuel destruction, de-forestation, etc.).
Biogenic CO_2 emissions	CO_2 emissions resulting from the destruction and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the Carbon Cycle, as opposed to anthropogenic emissions.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
Closed Landfill	A landfill that has ceased waste acceptance, and has submitted a closure report.
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Direct emissions	GHG emissions from sources that are owned or controlled by the reporting entity.
Effective Date	The date of adoption of this protocol by the MOECC or the MDDELCC.
Eligible landfill	A landfill that meets the performance standard evaluation and uses an eligible device to treat or destroy METHANE captured at a landfill site.
Emission factor (EF)	A unique value for determining an amount of a GHG emitted for a given quantity of activity data (e.g., metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
Emission reduction	1 metric tonne CO_2 equivalent reduced, as compared to a baseline level of emissions
Environment and Climate Change Canada	Governmental organization responsible for accurate and transparent monitoring, reporting and verification of Canada's greenhouse gas emissions and removals.
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).

GHG reservoir	A physical unit or component of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.
GHG sink	A physical unit or process that removes GHG from the atmosphere.
GHG source	A physical unit or process that releases GHG into the atmosphere.
Global Warming Potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Reductions in GHG emissions that occur at a location other than where the reduction activity is implemented, and/or at sources not owned or controlled by project participants.
Landfill gas (LFG)	Gas resulting from the decomposition of wastes placed in a landfill. Typically, landfill gas contains methane, carbon dioxide and other trace organic and inert gases.
Landfill gas project	Installation of infrastructure that in operating causes a decrease in GHG emissions through destruction of the methane component of landfill gas.
Landfill gas-to-energy (LFGE)	A LFGE project is one where the LFG destruction involves a destruction device that generates saleable energy (engine, turbine, microturbine, fuel cell, boiler, upgrade to pipeline, upgrade to CNG/LNG, etc.). This does not include small-scale, non-commercial applications, such as leachate drying.
Landfill site	A place where residual materials is permanently disposed of above or below ground.
Metric ton (t, tonne)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.623 pounds or 1.1 short tons.
Methane (CH_4)	A potent GHG with a high global warming potential, consisting of a single carbon atom and four hydrogen atoms.
Ministry	Ontario Ministry of the Environment and Climate Change (MOECC) or Quebec Ministry of Sustainable Development, Environment, and Fight Against Climate Change (MDDELC)
Mobile combustion	Emissions from the transportation of employees, materials, products, and waste resulting from the combustion of fuels in company owned or controlled mobile combustion sources (e.g., cars, trucks, tractors, dozers, etc.).
Non-beneficial destruction device	A device which destroys methane (CH_4) from LFG without producing an additional, beneficial output, such as fuel, usable heat, or electricity.

Project baseline	A “business as usual” GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project Developer	An entity that undertakes a GHG project, as identified in Section 2.1 of this protocol.
Qualifying destruction device	Eligible treatment or destruction devices include enclosed flares, open flares, combustion engines, boilers, turbines, microturbines, natural gas pipeline injection, fuel cells, and CH_4 liquefaction units. Additional types of devices may be approved by the Ministry.
Reporting period	Specific time period of project operation for which the Project Developer has calculated and reported emission reductions and is seeking verification and issuance of credits. The reporting period must be no longer than 12 months.
Residual materials	Material received at the landfill site for permanent disposal through placement in the waste mass. For the purposes of this protocol, the weight of residual materials does not include clean soil or manufactured products.
Verification	The process used to ensure that a given Project Developer’s GHG emissions or emission reductions have met the minimum quality standard and complied with the respect to Québec’s procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification organization	An organization that is accredited under ISO 14065 by a member of the International Accreditation Forum in Canada or the United States according to an ISO 17011 program.
Waste in place	The cumulative amount of solid waste, measured in metric tons, that has been permanently placed into the landfill.

Appendix A Parameters for Quantification

A.1 Methane Destruction

Equation 5.5 requires the use of a value for the destruction efficiency for each individual destruction device for which methane destruction is to be quantified. Where available, site-specific source-testing data should be used to determine the appropriate value for DE_i. Such source testing results are valid for use by the offset project so long as they are valid for use in relevant regulatory reporting applications. Otherwise, projects shall select the appropriate default destruction efficiency from Table A.1, below.

If a device not listed in table A.1 is approved for use by the Ministry, the destruction efficiency shall be determined through on-site emissions testing or monitoring, unless otherwise directed by the Ministry.

Table A.1. Destruction Efficiencies for Destruction Devices

Treatment or Destruction Device	Efficiency
Open Flare	0.96
Enclosed Flare	0.995
Internal Combustion Engine	0.936
Boiler	0.98
Microturbine or Large Gas Turbine	0.995
Boiler Following Upgrade and Injection into a Pipeline	0.96
CH_4 Liquefaction Unit	0.95
Injection into natural gas transmission pipeline	0.98
Direct use pipeline (to end use other than boiler)	*Per the appropriate end use device*

A.2 Methane Density

Table A.2. Density of Methane at Reference Conditions

Reference Pressure (atm)	Reference Temperature (°C)		Density of CH_4 (kg/m^3) [20,21]
	°C	K	
1	0	273.15	0.717
1	5	278.15	0.704
1	10	283.15	0.692
1	15	288.15	0.680
1	20	293.15	0.668
1	25	298.15	0.657

[20] Lemmon, E.W., Huber, M.L., McLinden, M.O. NIST Standard Reference Database 23: Reference Fluid Thermodynamic and Transport Properties-REFPROP, Version 9.1, National Institute of Standards and Technology, Standard Reference Data Program, Gaithersburg, 2013.

[21] Setzmann, U. and Wagner, W., "A New Equation of State and Tables of Thermodynamic Properties for Methane Covering the Range from the Melting Line to 625 K at Pressures up to 1000 MPa," J. Phys. Chem. Ref. Data, 20(6):1061-1151, 1991.

Appendix B Missing Data – Substitution Methods

The substitution methods below may be used only:

1. For CH_4 content or LFG flow rate parameters;
2. For missing data on gas flow rates that are discrete, non-chronic and due to unforeseen circumstances;
3. When the proper functioning of the treatment or destruction device can be demonstrated in accordance with the requirements of Section 6.3;
4. When data on LFG flow rate only, or CH_4 content only, are missing (except as described below for electric generators);
5. To replace data on LFG flow rates when a continuous analyzer is used to measure CH_4 content and when it is shown that CH_4 content was consistent with normal operations for the time when the data are missing; and
6. To replace data on CH_4 content when it is shown that the LFG flow rate was consistent with normal operations for the time when the data are missing.

No offset credit may be issued for periods when the substitution methods cannot be used.

For projects which destroy LFG in a device which generates electricity, missing data for periods greater than 7 days may be replaced through the use of Equation B.1, below. This approach may be used to replace missing flow and CH_4 concentration data simultaneously. The electrical output must be continuously monitored, and totalized at a frequency no greater than monthly.

Equation B.1 Alternative Method of Estimating the Volume of CH_4 Destroyed

$$CH_{4,dest,i,alt} = \frac{kWh \times HR}{HHV_{CH_4}}$$

Where,

			Units
$CH_{4,dest,i,alt}$	=	Net quantity of CH_4 treated or destroyed by device *i* during the period of missing data, calculated using the alternative method	m^3
kWh	=	Total electrical output of device *i* during the period of missing data	kWh
HR	=	Heat rate of destruction device *i*, as determined through the most recent source testing event. If no source test data are available, the heat rate specified by the manufacturer shall be used.	GJ/kWh
HHV_{CH4}	=	The high heat value of the CH_4 portion of the LFG, 0.0359, as set out in Table 20-1 of Appendix 10 of ON.20, the guidance for quantification method for General Stationary Combustion under the Ontario Guideline for Greenhouse Gas Emissions Reporting.[22]	GJ/m^3

For devices other than electric generators, or for missing data gaps of less than 7 days, the substitution methods in Table B.1 shall be employed.

[22] Quebec landfill projects shall use a value of 0.03982 GJ/m^3, as set out in Table 1-1 of QC.1.7 in Schedule A.2 to the Regulation respecting mandatory reporting of certain emissions of contaminants into the atmosphere (chapter Q-2, r. 15).

Table B.1. Missing Data – Substitution Methods

Missing Data Period	Substitution Method
Less than 6 hours	Use the average of the 4 hours immediately before and following the missing data period
6 to less than 24 hours	Use the 90% upper or lower confidence limit of the 72 hours prior to and after the missing data period, whichever results in greater conservativeness
1 to 7 days	Use the 95% upper or lower confidence limit of the 72 hours prior to and after the missing data period, whichever results in greater conservativeness
More than 7 days	No data may be replaced and no reduction may be credited, except for projects which destroy LFG in a device which generates electricity, as described above.

Appendix C Baseline Monitoring and Calculation of LFG_{B1}, LFG_{B2}, and B_{CH4}

This appendix shall be used to calculate LFG_{B2} and $B_{CH4,BD}$ for use in Equation 5.7. Much of the discussion here is concerned with accommodating the added complexity of monitoring passive flares and other ineligible destruction devices. However, the methodology described is also applicable for measuring and documenting LFG_{B1} and $B_{CH4,closed}$ for calculating $Closed_{discount}$ in Equation 5.8.

C.1 Baseline Monitoring

Passive flares and other ineligible destructiondevices are often installed at landfills for purposes other than CH_4 destruction, and therefore are not amenable to simple monitoring. For example, flares installed for odor control may be used intermittently and without any instrumentation tracking gas flow and CH_4 concentration. This makes assessing baseline CH_4 destruction from passive flares extremely difficult to quantify. Quantification is further exacerbated by the fact that passive flares are not necessarily designed to accommodate metering equipment; for example, in many cases passive flares do not have sufficient straight pipe length to control for turbulence. These limitations, combined with the low flow rates generally seen at passive flares greatly limit the number and type of metering equipment that can be used. Monitoring destruction of landfill gas from baseline landfill gas wells at closed landfill flares will face fewer obstacles.

The Ministry recognizes that the constraints on monitoring landfill gas from passive flares are unique to each landfill. We have attempted to make this methodology as flexible as possible to make it widely applicable. Any deviations from this methodology will require a formal request for variance. If the baseline destruction system is no longer installed and able to be operated to satisfy the monitoring requirements of this Appendix, and it is not possible to meter the active collection of LFG from the cell or waste mass where the baseline system was installed, the Project Developer may apply to the Ministry for the use of an alternative methodology to estimate the volume of CH_4 destroyed by the baseline system, subject to verifier review and approval.

C.2 Monitoring

Ineligible destruction devices (e.g., passive flares) must be monitored for a period of at least three months. This period must occur prior to the project start date to ensure that the measured gas flow is not decreased by the addition of project wells or pressure changes that result from the project activity. CH_4 destruction from the chosen period must be extrapolated to one year based on the 90% upper confidence limit of the CH_4 destruction identified in this period. Therefore, monitoring for more than three months, or with greater than weekly frequency, may lessen statistical uncertainty and reduce the required $BD_{discount}$.

Gas flow must be measured weekly at a minimum, and must be normalized to maximum flow capacity (scfm). If gas flow falls below the measurable range for the chosen metering device, the minimum flow value of the chosen metering device must be applied to that time interval. CH_4 concentration must also be measured at least weekly.

One measurement should be entered on each day for which readings were taken. If continuous measurements were taken, these should be averaged. If a single measurement was taken, then this value should be used. Therefore, if a daily monitoring plan is chosen for the three-month period, a total of 90 data points will be available (one per day). However, if weekly measurements are taken, then only 13 data points will be available for the analysis (one per week). Alternatively, irregular measurement intervals (for example, if someone is on-site three consecutive days) or bi-weekly measurements can be used as well, allowing for anywhere between 13 and 90 data points for any 90-day period. However, no more than one data point per calendar day may be applied and all collected data must be used.

All metering equipment used in baseline monitoring is subject to the same maintenance, calibration, and QA/QC requirements outlined previously for project metering equipment.

C.3 Non-Beneficial Device Configuration

As the configuration of non-beneficial destruction devices will be unique to each landfill, it is not possible to dictate a single monitoring methodology. Rather, the following options have been devised as acceptable configurations.

1. Each device will be monitored individually for both flow and CH_4 concentration according to the schedule outlined in Section C.2.
2. Wells from two or more devices may be connected to a device with a single set of meters for both flow and CH_4 concentration. Additional engineering may be required to ensure that the altered pressure characteristics of the system do not decrease total gas flow. The flow characteristics of this system will require substantiation from engineering documents and calculations and will be assessed by the verification body.
3. Wells from two or more devices may be connected with the active collection system and monitored separately from the new project wells while under vacuum from the blower.

C.4 Calculation

Equation C.1. Calculation of Baseline Discount for a Non-Qualifying Device

$$LFG_{B2} = 525{,}600 \times 90\%UCL(LFG_{scfm})$$

Where,			Units
LFG_{B2}	=	Landfill gas that would have been destroyed by the original, ineligible destruction system during the reporting period	scf LFG
$90\%UCL(LFG_{scfm})$	=	90% upper confidence limit of the average flow rate in the metered period (must be >3 months)	scfm LFG
525,600	=	Minutes in one year	min/yr

$$B_{CH_4,NQ} = 90\%UCL\left(B_{CH_4,NQ,t}\right)$$

Where,			Units
$B_{CH4,BD,t}$	=	CH_4 concentration for baseline calculations	scf CH_4/ scf LFG
$90\%UCL(B_{CH4,BD,t})$	=	90% upper confidence limit of the average CH_4 concentration in the metered period (must be >3 months)	scf CH_4/ scf LFG

$$90\%UCL = mean + t_{value} \times \left(\frac{SD}{\sqrt{n}}\right)$$

Where,			Units
mean	=	Sample mean (of $B_{CH4,BD,t}$ or LFG_{scfm})	scf or %
t_{value}	=	The 90% t-value coefficient for data set with degrees of freedom *df* (use Excel feature: =T.INV.2T(0.1,df)	

SD	=	Standard deviation of the sample (of $B_{CH4,BD,t}$ or LFG_{scfm})	scf or %
n	=	Sample size	
df	=	Degrees of freedom (= n-1)	

C.5 Example

The following example (Table C.1) demonstrates the necessary calculation for calculation of $BD_{discount}$. The calculations outlined above in Section C.4 are represented by the first three columns of data. The final conversions to tCO_2e/yr are done using Equation 5.7.

Note that although the measurements had average values yielding a deduction of 5,961 tCO_2e/yr, due to the limited data and variability of the measurements, the appropriate deduction is 7,830 tCO_2e/yr. If, instead of weekly data there was daily data over this three-month period that yielded the exact same mean and standard deviation, the additional data alone would have lowered the deduction to only 6,807 tCO_2/yr. Alternately, if the data had been more consistent and showed a standard deviation for the flow data of only 6 with the same mean, then the deduction with 14 samples would have been only 6,689 tCO_2/yr. Therefore, the added uncertainty deduction of this method is directly related to the level of variability in the data and the number of samples.

Table C.1. Example Dataset and Calculation of $BD_{discount}$

	Calculating According to Equations C.1 and C.2				**Calculated According to Equation 5.7**	
	CH_4 (%)	**Flow (scfm)**	**Flow CH_4 (scfm)**	**CH_4/year (scf/yr)**	**CH_4/year (t/yr)**	**tCO_2e/year**
6/1/2016	56.7	48	27	14,304,703	274	5,760
6/8/2016	55.3	75	41	21,799,260	418	8,778
6/15/2016	58.1	21	12	6,412,846	123	2,582
6/22/2016	54.0	90	49	25,544,160	490	10,286
6/29/2016	55.6	47	26	13,734,979	263	5,531
7/6/2016	56.3	23	13	6,805,994	131	2,741
7/13/2016	57.2	70	40	21,045,024	404	8,475
7/20/2016	58.0	15	9	4,572,720	88	1,841
7/27/2016	52.3	89	47	24,465,103	469	9,852
8/3/2016	55.7	42	23	12,295,886	236	4,951
8/10/2016	54.8	51	28	14,689,469	282	5,915
8/17/2016	62.1	19	12	6,201,554	119	2,497
8/24/2016	59.3	66	39	20,570,933	394	8,284
8/31/2016	57.6	70	40	21,192,192	406	8,534
Mean	**56.6**	**51.86**	**28**	**14,803,281**	**284**	**5,961**
SD	0.02	25.70				
n	14	14				
df	13	13				
90% t-value	1.77	1.77				
UCL at 90%	**57.8**	**64.02**	**37**	**19,443,275**	**373**	**7,830**