SECTION D. Application of a monitoring methodology and plan

D.1. Name and reference of approved monitoring methodology applied to the project activity:

The approved monitoring methodology applied to this project activity is the ACM0001 ver.4 – Consolidated Monitoring Methodology for Landfill Gas Project Activities.

D.2. Justification of the choice of the methodology and why it is applicable to the project activity:

ACM0001 ver. 4 was developed as a consolidated document that incorporates all previously-approved methodologies applicable to landfill gas activities where the baseline scenario is the partial or total atmospheric release of landfill gas. Scenarios contemplated by the methodology ACM0001 ver. 4 include the case where the management of the LFG collected at the Site includes direct flaring for emission reductions, which forms the basis of the project activity.

This monitoring methodology is based on the direct measurement of the quantity of LFG captured, collected and destroyed by the LFG management system. The actual tonnage of methane emissions reduced by the project is calculated based on flow rate of the landfill gas, methane concentration, and destruction/conversion efficiency of the combustion equipment. The monitoring plan proposed by CRA provides for the continuous measurement of both LFG quantity and quality using a continuous flow meter and on-line LFG analyzer. The methane emissions reduced by the flares are determined based on the operating hours measured by a run-time meter. The destruction efficiency of the flare is directly correlated to the internal combustion temperature and the retention time in the unit.

D.2. 1. Option 1: Monitoring of the emissions in the project scenario and the baseline scenario

The section was left blank on purpose. Option 2 was selected.

D.2.1.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

D.2.1.2. Description of formulae used to estimate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

The section was left blank on purpose. Option 2 was selected.

D.2.1.3. Relevant data necessary for determining the baseline of anthropogenic emissions by sources of GHGs within the project boundary and how such data will be collected and archived :

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

The section was left blank on purpose. Option 2 was selected.

D.2.1.4. Description of formulae used to estimate baseline emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

The section was left blank on purpose. Option 2 was selected.

D. 2.2. Option 2: Direct monitoring of emission reductions from the project activity (values should be consistent with those in section E).

D.2.2.1. Data to be collected in order to monitor emissions from the project activity, and how this data will be archived:

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment
1. $LFG_{total,y}$	Total amount of landfill gas captured and flared	On-Line LFG flow meter (thermo mass)	Nm^3	m	Continuous	100%	Daily: electronic Monthly: paper	Measured by a flow meter which is calibrated periodically according to manufacture's specifications by an officially accredited entity. The Thermo mass flow meter is capable to provide the volume in normalized cubic meters
~~2. $LFG_{flare,y}$~~	~~Total amount of landfill gas flared~~	~~On-Line LFG flow meter~~	~~m^3~~	~~m~~	~~Continuous~~	~~100%~~	~~Daily: electronic Monthly: paper~~	~~Measured by a flow meter or calculated using flare efficiency from 1.~~
2. FE	Flare/combustion efficiency determined	Thermistors, Samples	%	m/c	(1) continuously; (2) Enclosed flares shall be	100%	Daily: electronic Monthly: Paper	(1) The flare operation shall be continuously monitored by continuous measurement of operation time of flare using a run time meter connected to a

	by the operation hours (1) and the methane content in the exhaust gas (2)				monitored yearly, with the first measurement to be made at the time of installation			flame detector or a flame continuous temperature controller, irrespective of whether the flare efficiency is monitored. (2) The enclosed flares shall be operated and maintained as per the specification prescribed by the manufacturer.
3. $w_{CH4,y}$	Methane fraction in the landfill gas	On-Line LFG analyzer	m^3 CH_4/ m^3 LFG	m	Continuous	100%	Daily: electronic Monthly: Paper	Measured by continuous gas quality analyser
4.	Total amount of electricity import to meet project requirements	Electricity meter	MWh	m	Continuous	100%	Daily: electronic Monthly: paper	Required to determine CO_2 emissions from use of electricity
5.	CO_2 emission intensity of the electricity and/or other energy carriers in ID4	Calculated	tCO_2/ MWh	c	Annually	100%	Daily: electronic Monthly: paper	Required to determine CO_2 emissions from use of electricity
6.	Regulatory requirements relating to landfill gas projects	Test	Test	n/a	Annually	100%	Periodically	

It is noted that items related to electricity or thermal energy output in approved consolidated monitoring methodology ACM0001 ver.4 are not components of the proposed project activity. Additionally, all data will be archived during the crediting period and for two years after.

D.2.2.2. Description of formulae used to calculate project emissions (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.):

Landfill gas not captured by the landfill gas collection and flaring systems at each Site cannot be monitored, as this emission is diffused over the landfill. The amount of landfill gas collected and destroyed by combustion can be monitored at a centralised location using a flow meter. Project emissions are thus comprised of the quantity of methane collected and not flared due to flaring inefficiency, and this amount is subtracted from the measured amount of collected methane. The overall flaring efficiency for an enclosed flare is upwards of 99.99%.

The total amount of methane destroyed by the flare in a given hour is calculated as:

$MD_{project} = [LFG_{flare}$ (1.) x w_{CH4} (3.) x DCF_{CH4} x FE (2.)]

Where:

$MD_{project,y}$ = methane destroyed during a specified monitoring period (tonnes of CH_4)
LFG_{flare} = average flow of LFG collected during specified monitoring period in m^3/t
w_{CH4}= percentage by volume of CH_4 in LFG (m^3 CH_4/m^3 LFG)
DCF_{CH4} =methane density at standard pressure (1 atm) and temperature (0°C) conditions, 0.0007168 tonnes/m^3, as per consolidated methodology ACM0001
FE = destruction efficiency of the flare (%)

D.2.3. Treatment of leakage in the monitoring plan

D.2.3.1. If applicable, please describe the data and information that will be collected in order to monitor leakage effects of the project activity

ID number *(Please use numbers to ease cross-referencing to table D.3)*	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data to be monitored	How will the data be archived? (electronic/ paper)	Comment

No leakage effects need to be accounted under methodology ACM0001 ver 4.

D.2.3.2. Description of formulae used to estimate leakage (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

No leakage effects need to be accounted under methodology ACM0001 ver. 4.

D.2.4. Description of formulae used to estimate emission reductions for the project activity (for each gas, source, formulae/algorithm, emissions units of CO_2 equ.)

The following formulae will be used to estimate emission reductions for the project activity.

$$ER_y = (MD_{project,y} - MD_{reg,y}) * GWP_{CH4} + EG_y * CEF_{electricity,y} + ET * CEF_{thermal,y}$$

Where:

- ER_y are the emission reductions, measured in tCO_2e;
- $MD_{project,y}$ is the amount of methane actually destroyed/combusted during the year, measured in tCH_4;
- $MD_{reg,y}$ is the amount of methane that would have been destroyed/combusted during time period t in the absence of the project activity, measured in tCH_4;
- GWP_{CH4} is the approved Global Warming Potential value for methane, 21 tCO_2e/tCH_4;
- EG_y is net quantity of electricity displaced during a given period t, measured in MWh;
- EL_y is net quantity of electricity displaced during a given period t, measured in MWh
- $CEF_{electricity,y}$ is the CO_2 emissions intensity of the electricity displaced, measured in tCO2e/MWh;
- ET is the quantity of thermal energy displaced, measured in TeraJoules (TJ);
- $CEF_{thermal,y}$ is the CO_2 emissions intensity of the thermal energy displaced, measured in tCO2e/TJ.

It is noted that while the terms for electricity and thermal energy have been included to be consistent with the overall formulation stated in ACM0001 ver. 4, energy displacement is not a component of the proposed project activity. As a result, the above equation reduces to the following form for the project activity:

$ER_y = (MD_{project,y} - MD_{reg,y}) * GWP_{CH4}$

Considering that there is no regulatory or contractual requirement determining MD_{reg}, an adjustment factor (AF) is used:

$MD_{reg} = MD_{project} * AF$

The methane destroyed by the project activity during a given time period can be determined by the following: monitoring the quantity of methane actually flared and LFG used to generate electricity and to produce thermal energy, and is given by:

$MD_{project} = MD_{flared} + MD_{electricity} + MD_{thermal}$

For the proposed project activity, $MD_{electricity} = MD_{thermal} = 0$, as there is no energy displacement component of the project. As a result, the total actual quantity of methane captured and destroyed will be metered *ex post* once the project activity is operational, and:

$MD_{project} = MD_{flared}$

And,

$MD_{flared,y} = LFG_{flare,y} * w_{CH4,y} * D_{CH4} * FE$

Where:

- $MD_{flared,y}$ is the quantity of methane destroyed by flaring in a given time period t, measured in tCH_4;
- LFG_{flare} is the quantity of landfill gas flared during the time period t, measured in cubic meters (m^3);
- w_{CH4} is the average methane fraction of the landfill gas as measured during the given time period t and expressed as a fraction of CH_4 volume per LFG volume ($m^3 CH_4 / m^3$ of LFG);
- FE is the flare efficiency (the fraction of the methane destroyed);
- D_{CH4} is the methane density, expressed in tonnes of methane per cubic meter of methane (tCH_4/m^3CH_4), and measured at STP (0 degree Celsius and 1.013 bar), which is 0.0007168 tCH_4/m^3CH_4 (as per consolidated methodology ACM0001).

D.3. Quality control (QC) and quality assurance (QA) procedures are being undertaken for data monitored		
Data *(Indicate table and ID number e.g. 3.-1.; 3.2.)*	Uncertainty level of data (High/Medium/Low)	Explain QA/QC procedures planned for these data, or why such procedures are not necessary.
1. (Table D.2.2.1)	Low	Calibration of equipment as per manufacturer specifications to ensure validity of data measured.
2.(Table D 2.2.1)	Medium	Regular maintenance to ensure optimal operation of controlled combustion environment.
3. (Table D2.2.1)	Low	Calibration of equipment as per manufacturer specifications to ensure validity of data measured.
4. (Table D2.2.1)	Low	Calibration of equipment as per manufacturer specifications to ensure validity of data measured.
5. (Table D2.2.1)	Low	Calculated value following from ID4.
6. (Table D2.2.1)	Low	Not applicable.

D.4 Please describe the operational and management structure that the project operator will implement in order to monitor emission reductions and any leakage effects, generated by the project activity

All continuously measured parameters (LFG flow, CH_4 concentration, flare temperature, and flare operating hours), will be recorded electronically via a datalogger, which will have the capability to aggregate and print the collected data at the frequencies as specified above.

Before commencement of the O&M phase, a training and quality control program will be enacted to ensure that good management practices are ensured and implemented by all project operating personnel in terms of record-keeping, equipment calibration, overall maintenance, and procedures for corrective action. An operations manual will be developed for the operating personnel. The procedures for filing data and calculations to be performed by the LFG management operator will be included in a daily log to be placed in the main control room.

D.5 Name of person/entity determining the monitoring methodology:

The monitoring methodology for the project is determined by Conestoga-Rovers & Associates Limited. The details of the monitoring plan are provided in Annex 4 and contact information is presented below:

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