VANCOUVER LANDFILL GAS CAPTURE OPTIMIZATION, CITY OF VANCOUVER – DELTA

GHG PROJECT PLAN

PREPARED ACCORDING TO THE REQUIREMENTS OF THE BC EMISSION OFFSETS REGULATION USING THE PACIFIC CARBON TRUST TEMPLATE

PREPARED ON BEHALF OF:
THE CITY OF VANCOUVER

PREPARED BY:
CH2M HILL CANADA LIMITED

DATE:

Final Version 1 – November 2012

Final Version 2 – December 2012

Final Version 3 – April 1, 2013

Final Version 4 – April 8, 2013

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ASL	above sea level
BC	Province of British Columbia
BTU	British thermal unit
˚C	degrees centigrade
CDM	Clean Development Mechanism
CO_2e	carbon dioxide equivalent
COV	City of Vancouver
CRA	Conestoga-Rovers & Associates
DLC	demolition, land clearing, and construction
EIA	environmental impact assessment
EOR	Emission Offsets Regulation
GD	Gardner Denver
GGRTA	Greenhouse Gas Reduction Targets Act
GHG	greenhouse gas
GWP	global warming potential
h	hour
ha	hectare
HMI	human-machine interface
hp	horsepower
IPCC SAR	Intergovernmental Panel on Climate Change Second Assessment Report
ISO	International Organization for Standardization
KO	knockout
LFG	landfill gas
LFGCS	LFG collection system
Maxim	Maxim Power Corporation
m	metre

m^3	cubic metre
mm	millimeter
MOE	Ministry of the Environment [British Columbia]
MOLO	Manager of Landfill Operations
MSW	municipal solid waste
NMOC	non-methane organic carbon
NPV	net present value
OC	Operational Certificate
O&M	operations and maintenance
P&ID	process and instrumentation diagram
PCT	Pacific Carbon Trust
PLC	programmable logic controller
QA	quality assurance
QC	quality control
scfm	standard cubic feet per minute
SSR	sources, sinks, and reservoirs
STP	standard pressure and temperature
SWANA	Solid Waste Association of North America
SWDS	solid waste disposal site
The Charter	Climate Action Charter
UBCM	Union of BC Municipalities
WC	water column

2.0 GENERAL REQUIREMENTS

Please note: to facilitate validation/verification, reference to clauses within the BC Emission Offsets Regulation and International Organization for Standardization (ISO) 14064-2 are made throughout this greenhouse gas (GHG) project plan to indicate where specific requirements of the Regulation/ISO 14064-2 are met.

2.1 PROJECT ELIGIBILITY CRITERIA

(BC-Reg: Section 3, subsection 2 k & o)

The following two general eligibility requirements under the BC Emission Offsets Regulation are satisfied by the project:

Location: 5400 72nd Street, Delta, BC V4K 3N2

Start date: Construction started August 2011 (Stage 1 started and fully complete February 2012)
Crediting period starts January 2012 (at start of Stage 1 implementation)

2.2 RELEVANT PROTOCOLS

(BC-Reg: Section 3, subsection 2h)

The baseline assessment and additionality will be determined using the Pacific Carbon Trust (PCT) "Guide to Determining Project Additionality."

The Clean Development Mechanism (CDM) "Approved consolidated baseline and monitoring methodology ACM0001 Version 13.0.0, Flaring or use of landfill gas" will be used for identification of relevant sources and sinks, and to quantify project and baseline emissions. Additionally, the addendum "Methodology Addendum – CDM ACM001 Use Under BC Emissions Offset Regulation" was reviewed and is attached in Appendix 1 for the readers' reference.

3.0 PROJECT DESCRIPTION

3.1 PROJECT TITLE

(ISO-14064-2: clause 5.2 a, BC-Reg: Section 3, subsection 2a)

Vancouver Landfill Gas Capture Optimization – City of Vancouver – Delta

3.2 PURPOSES AND OBJECTIVES

(ISO-14064-2: clause 5.2 a, BC-Reg: Section 3, subsection 2a)

The purpose of the Vancouver Landfill Gas Capture Optimization Project is to increase landfill gas (LFG) capture efficiency at the City of Vancouver Landfill from approximately 33 percent in 2011 to 75 percent by 2014, further reducing GHG emissions and the landfill carbon footprint. This will be achieved 2 years in advance of the British

Columbia Landfill Gas Management Regulation requiring the installation of a LFG collection system with a collection efficiency design objective of 75 percent.

3.3 TYPE OF GHG PROJECT

(ISO-14064-2: clause 5.2 b,f)

The project is a LFG emission destruction project. Recovered LFG will be thermally destroyed within an enclosed flare system, LFG-fueled cogeneration facility, or future other beneficial end-use applications. The project crediting period is from January 26, 2012, through December 31, 2015.

Note to reader: Please see Section 3.7 for further project details.

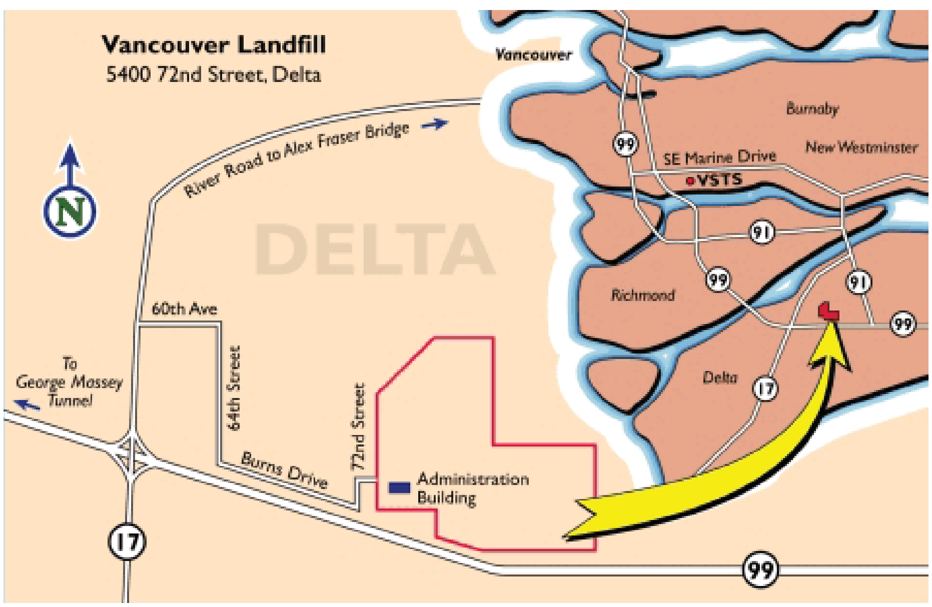
3.4 PROJECT LOCATION

(ISO-14064-2: clause 5.2 c, BC-Reg: Section 3, subsection 2f)

The Vancouver Landfill site is located in the Corporation of Delta in the southwest corner of Burns Bog (Figure 1). Site address is 5400 72nd St., Delta, BC V4K 3N2.

Legal description: Parcel Identifier: 008-452-989, Lot 9, Sections 5 and 6, Township 4, New Westminster District, Plan 38013.

Figure 1: Location Map



Access to the landfill site is from HWY 99 South and HWY 17 to River Road North. From River Road, turn right onto 60th Avenue, then south on 64th Street to Burns Drive to 72nd Street, then to the landfill entrance as shown in Figure 1.

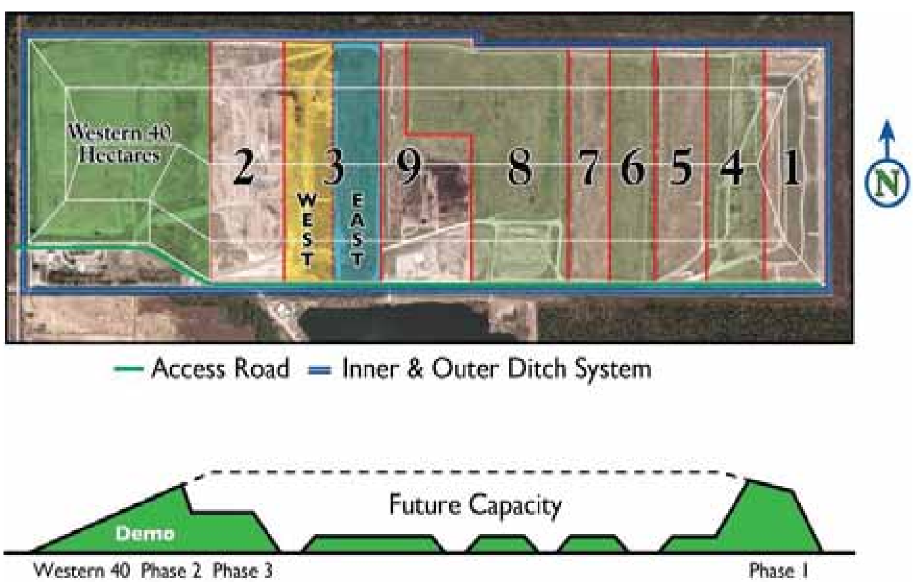
An aerial view of the Vancouver landfill facility is shown in Figure 2, which shows the current site boundary and landfill area with Burns Bog (dark area) located to the north of the landfill site and HWY 99 running south through

Delta. The photo also shows the location of the blower/flare station onsite, as well as the Village Farms greenhouse operations south of HWY 99 where LFG is beneficially used in a cogeneration facility owned by Maxim Power Corporation.

Figure 2: Landfill Aerial View

The landfill property includes approximately 420 hectares of permitted area approved for landfill development. Figure 3 shows the Vancouver Landfill current operational boundary and approved filling plan. LFG has been actively collected at the site since 1991. The project includes LFG recovered within Phases 1, 2, and 3 based on new LFG control infrastructure installed in 2011 and 2012.

Figure 3: Vancouver Landfill Current Filling Plan



3.5 CONDITIONS PRIOR TO PROJECT INITIATION

(ISO-14064-2: clause 5.2 d, BC-Reg: Section 3, subsection 2j (i) & (ii))

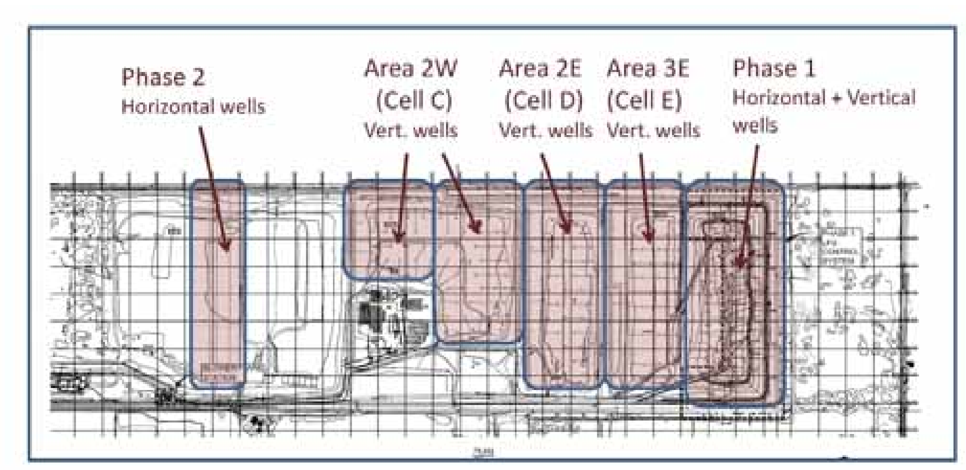
The Vancouver Landfill, located in Delta, BC, is owned and operated by the City of Vancouver (COV). Landfilling at the site commenced in 1966. The facility property is approximately 420 hectares in size with a current landfill footprint of approximately 225 hectares. Under an agreement between COV, the Corporation of Delta, and Metro Vancouver, the landfill is currently operated as part of the regional municipal solid waste management system. The total amount of municipal solid waste (MSW) in place at the end of 2012 was approximately 22.3 million tonnes (including demo and demolition/hog waste).

The Vancouver Landfill's lifespan has been projected to last approximately 45 years or more from 2012, although the legal agreement for landfilling operations between COV, Metro Vancouver, and the Corporation of Delta expires in 2037.

The City has captured LFG voluntarily from the landfill site since 1991. LFG controls were originally installed within the Western 40 hectares. This LFG collection system in the Western 40 hectares was decommissioned in 2000 based on reduced LFG recovery as a result of age of waste and landfill settlement. Since that time, there have been numerous landfill cell expansions within the permitted boundary and phased developments, as well as progressive closure of cells at the site.

In 2000, the LFG collection system (LFGCS) was expanded to include an additional 150 vertical wells in Areas A-2W, A-2E, and A-3, including an upgraded blower/flare station, as shown in Figure 4. The LFGCS had a design capacity of 3,000 standard cubic feet per minute (scfm). The COV's blower/flare station incorporated two Hoffman multistage centrifugal blowers rated for 1,500 scfm (2,550 m^3/h) each and two Callidus enclosed ground flare units each with a capacity of 1,500 scfm (2,550 m^3/h)

Figure 4: LFGCS Layout



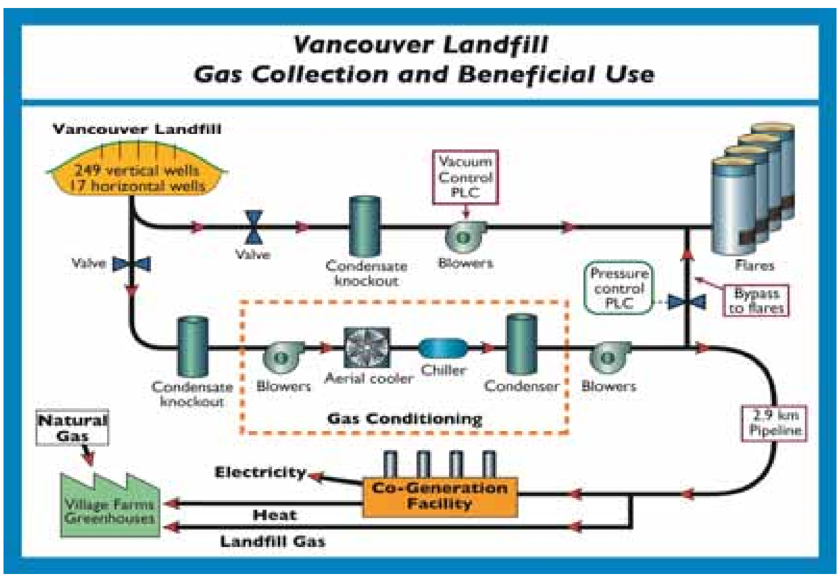
From 2004 to 2006, the LFGCS was expanded to include LFG recovery from Phase 1 with the installation of 10 horizontal collectors and over 20 vertical gas wells installed along the west, north, and south sides and along the top crest of the waste cell. Three horizontal LFG recovery wells were installed in the Phase 2 cell area during the same period.

In 2009, the LFGCS was further expanded as part of the Phase I cell closure project and included the installation of both a horizontal collection system and vertical wells. The LFGCS upgrades incorporated within the closure of Phase 1 also included installation of additional condensate traps, three new knockout (KO) tanks, and upgrades to the COV blower/flare station to increase the LFG control system capacity to 6,000 scfm. This included replacing the existing LFG blowers with 3 new 3,000 scfm (5,100 m^3/h) GD multistage centrifugal blowers and adding 2 new John Zink enclosed ground flares each with a capacity of 1,500 scfm (2,550 m^3/h). The layout of the LFGCS (current to 2010) is also shown in Figure 4.

Maxim Power Corporation (Maxim) has been operating a LFG utilization system since 2003 that recovers, processes, and supplies LFG from the COV landfill to Maxim's powerhouse at Village Farms via a dedicated pipeline. Maxim delivers the processed gas to a cogeneration facility that produces power that is then sold to BC Hydro. Recovered heat is sold to the greenhouse operations.

A schematic of diagram showing the existing conditions for LFG recovery and beneficial use is shown in Figure 5.

Figure 5: Vancouver LFG and Beneficial Use



Landfill gas captured is metered at the following points: 1) COV flare header line, 2) the Maxim pipeline leading to the cogeneration facility, and 3) the bypass flow line from Maxim to the COV flares (upstream of the Maxim LFG meter). The total gas captured is the combined total volume (at standard pressure and temperature) of the LFG metered at the COV flare header line and the Maxim pipeline leading to the cogeneration facility. Locations of the flow monitoring and gas analyzing equipment are shown in Section 5, Figures 8 and 9.

3.5.1 LANDFILL COVER SYSTEM

The landfill is typically filled in 5 metre (m) lifts, and will reach a final maximum design elevation of 39 m above sea level (ASL) based on the approved filling plan. Landfilling activities occur 7 days per week. To reduce onsite fill/soil material consumption, the COV uses an alternate cover system comprised of tarps for daily cover, as well as bottom ash from the Burnaby Waste to Energy Facility and use soil for daily cover material only as required. The final cover for Phase 1 through Phase 9 will be a flexible membrane liner system (comprised of a linear low density polyethylene [LLDPE]) to prevent moisture infiltration. The west, north, and south sections of Phase 1 are closed and have a final cover system that was installed in 2009.

3.5.2 LEACHATE CONTROL

Leachate at the site is controlled using an inner ditch around the perimeter of the site. Surface water (clean) run-on is diverted using an outer ditch that runs parallel to the inner leachate ditch. The leachate is collected and pumped offsite to a wastewater treatment plant. The clean outer ditch water is discharged to adjacent lands.

3.5.3 LFG COLLECTION SYSTEM

Under the existing project, 249 vertical LFG recovery wells and a total of 17 LFG horizontal collectors are located in the Areas A-2W, A-2E, and A-3, Phase 1 and Phase 2 Landfill waste cells as shown in Figure 4.

LFG is collected and routed to a 400-millimeter- (mm) diameter main header system that runs along the perimeter road of the landfill and ties in lateral lines from collection wells and horizontal collectors from Phase 1 in the east to Phase 2 in the west portion of the site. LFG is routed to the blower/flare station where it is thermally destroyed using enclosed flares, or processed and routed via a dedicated pipeline to an offsite cogeneration facility and the engineering/administration building on site.

3.5.4 BLOWERS

Currently, three 3,000 scfm (5,100 m^3/h) Gardner Denver (GD) centrifugal blowers are installed at the blower/flare station. The parallel configuration provides up to 6,000 scfm (10,200 m^3/h) of installed capacity, with 3,000 scfm (5,100 m^3/h) standby capacity and allowance for future expansion.

3.5.5 ENCLOSED FLARES

There are currently four 1,500 (2,550 m^3/h) scfm enclosed ground flares at the landfill. Two flares (#1 and #2) are 4.44 m diameter x 12.2 m high supplied by Callidus in 2001, and two flares (#3 and #4), installed during the Phase 1 LFG expansion in 2010 are 2.74 m diameter x 12.2 m high John Zink enclosed ZTOF biogas flares.

The flow range for flares #1 and #2 is 638 m^3/h to 2550 m^3/h, with an operating temperature of 871 ˚C to 1093 ˚C. Maximum observed operating temperature is 1,037 ˚C, with a minimum destruction efficiency of 98 percent. Maximum heat release is 48,000,000 BTU/h.

The Callidus flares #1 and #2 were re-lined with new refractory material in 2009 prior to the installation of flares #3 and #4.

The flow range for flares #3 and #4 is 255 m^3/h to 2,550 m^3/h, with a design operating temperature of 760 ˚C to 982 ˚C, minimum destruction efficiency of 98 percent, and a retention time of 0.7-second at 982 ˚C. Maximum rated temperature is 1,093 ˚C. Maximum heat release is 50,770,000 BTU/h.

All four enclosed flares operate with a continuous purge system, which significantly shortens the start-up time required for each flare when called upon to be placed into service. This provides instantaneous start-up of all flares without the wait time for a full flare purge cycle.

LFG captured and thermally destroyed annually from 2010 through 2011, as measured from data supplied by the COV from continuous online flow meters and LFG continuous analyzing equipment, is represented in Table 1. The average of these 2 years will be used in calculating the historical baseline prior to the project activity, as 2009 Phase 1 closure and LFG recovery wells were completed in 2009 and represented the last system expansion prior to the LFG upgrades associated with the project activity in Stage 1.

The captured LFG represents the combined totalized volume of LFG as measured using a calibrated thermal mass continuous flow meter located in the flare line, and a calibrated continuous measure differential pressure (array tube) flow meter located at the outlet of the Maxim LFG treatment and delivery system. Both meters represent LFG volumetric flow rate and total volume at standard pressure and temperature conditions. The volume of captured LFG represents the annual LFG recovered by the installed collection and recovery system. Locations of the flow monitoring and gas analyzing equipment are shown in Section 5, Figures 8 and 9.

Table 1: LFG Recovery and CO_2e Reduction

Year	LFG Capture (scf)	Methane (annual ave. % by Vol.)	Methane Capture (SCM)	Methane Capture (t/yr)	Methane Capture (t CO_2e / yr)	Methane Destruction (t CO_2e / yr)
2010	1,444,772,060	51.66	21,134,152	13,858	291,011	285,191
2011	1,144,969,277	51.19	16,596,371	10,882	228,527	223,957
2 year avg.	**1,294,870,669**	**51.43**	**18,865,262**	**12,370**	**259,769**	**254,574**

Notes:

LFG capture based on COV and Maxim LFG meter totalized volumetric readings at (101.325 kPa and 25C).

Methane capture based on totalized LFG volume converted to standard cubic meters and average methane concentration as read by online LFG analyzer (as per COV reports)

Methane capture in tonnes per year based on methane density of 0.6557 kg/m3.

Methane capture in t CO2e/yr based on Global Warming Potential (GWP) of 21.

Methane Destruction based on 98% methane destruction efficiency for flares, engines, boilers

3.6 GHG EMISSIONS REDUCTION STRATEGY

(ISO-14064-2: clause 5.2 e, BC-Reg: Section 3, subsection 2e)

LFG is typically characterized as being comprised of approximately 50 percent methane and 50 percent carbon dioxide. Methane is a GHG with a 100-year Global Warming Potential (GWP) of 21 according to the Intergovernmental Panel on Climate Change Second Assessment Report (IPCC SAR) 1995 values and endorsed by Environment Canada and British Columbia. The average composition of LFG recovered for flaring or beneficial use at the Vancouver Landfill site is approximately 52 percent methane, 40 percent carbon dioxide, 9.8 percent nitrogen and 0.2 percent oxygen on a volumetric basis.

Since LFG contains methane, it can be used as an alternative fuel source to generate power or provide heat, or alternatively it can be thermally destroyed by flaring to reduce GHG emission impacts and prevent site odours.

This project reduces GHG emissions by reducing the amount of methane emitted to the atmosphere by collecting and combusting LFG when compared to the identified baseline scenario. Under both the baseline scenario and project scenario, the functionally equivalent activity is the operation of the landfill for the disposal of solid waste. In the business-as-usual case, the landfill operation results in landfill methane emissions to the atmosphere that is not being captured through the existing LFG collection system. The proposed project will increase LFG collection system efficiency and result in a net reduction in landfill methane emissions by increasing the capture of LFG at the landfill site. The LFG captured in the project scenario will be thermally destroyed through the existing flare system (or beneficially used), and converted to carbon dioxide.

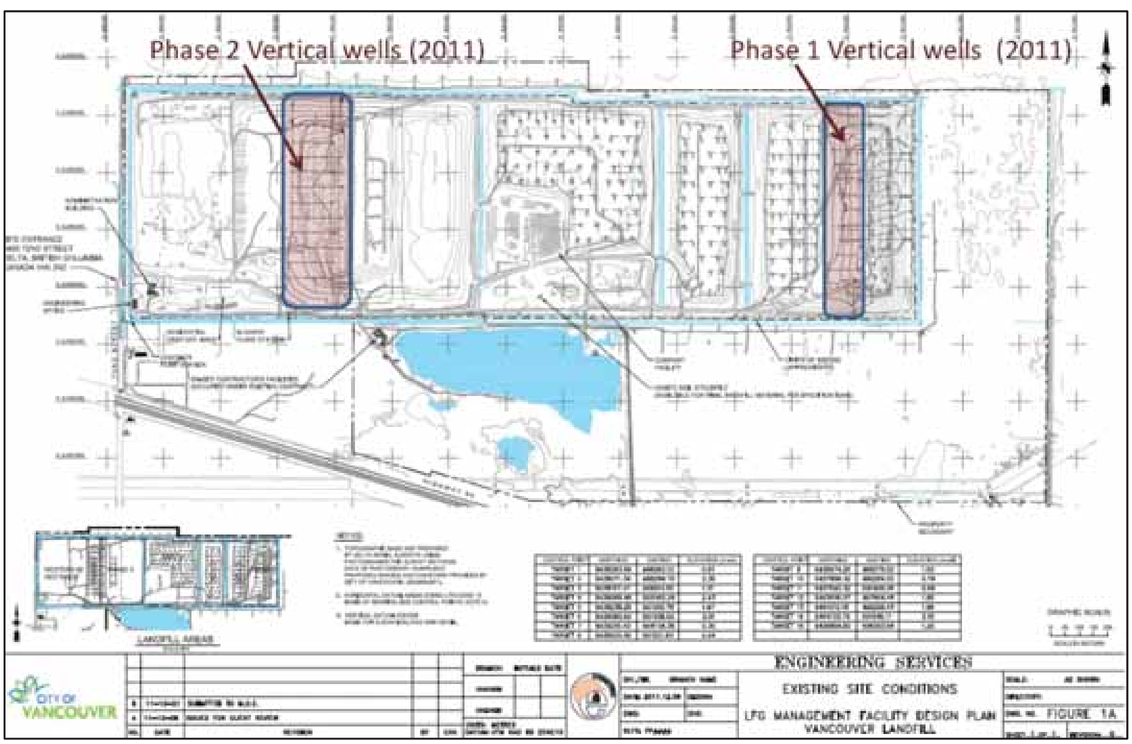
3.7 DETAILED PROJECT DESCRIPTION

(ISO-14064-2: clause 5.2 f, BC-Reg: Section 3, subsection 2e.)

The new project consists of optimizing the LFG collection system to have an efficiency of 75 percent or greater in advance of 2016. This will be accomplished in two distinct stages.

Stage 1 includes the installation of new and the replacement of wells completed in 2011 in Phase 1 and Phase 2 but not fully operational until early 2012. New vertical LFG recovery wells were installed along the west slope of Phase 1 and also within the completed area of Phase 2 as shown in Figure 6.

Figure 6: Stage 1 LFG collection system infrastructure



Stage 2 consists of the following proposed infrastructure work designed to significantly increase LFG capture:

For 2012:

- Adding/replacing gas extraction wells in the closed area of Phase 1
- Installation of horizontal gas wells in active areas of filling (Phase 3 west / east)
- Replacement of condensate drain traps with new traps that can handle higher vacuum

For 2012/2013:

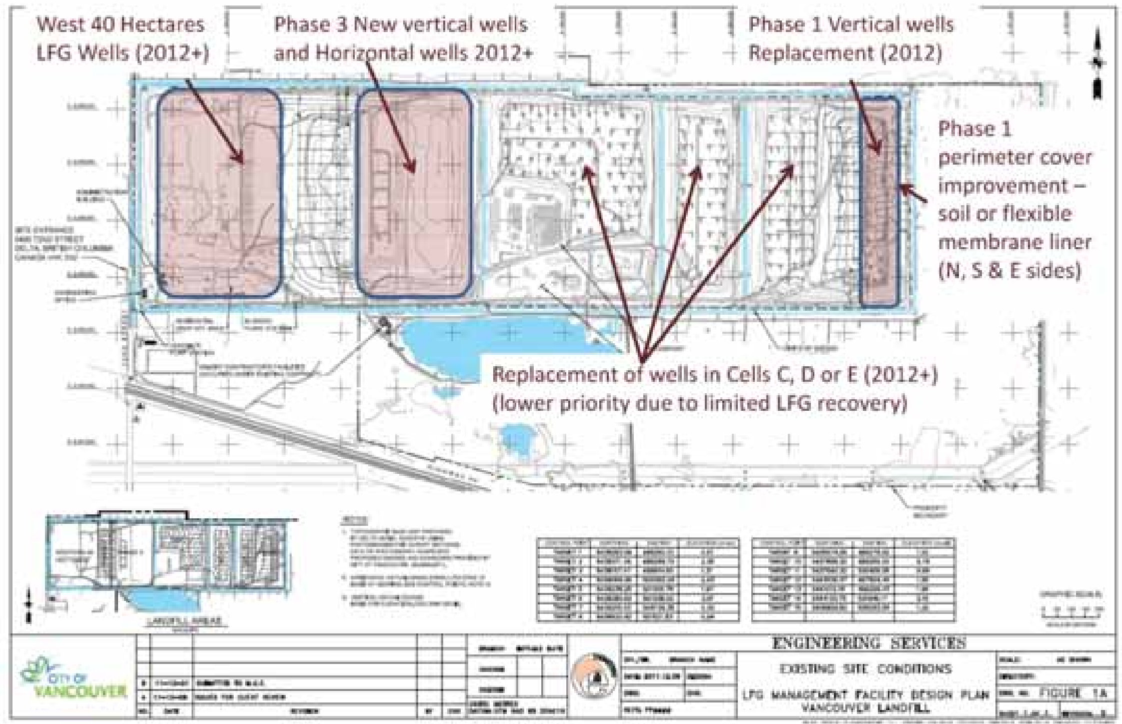
- Improvements to the existing cover system on the north, east, and south sides of Phase 1 (perimeter road to toe of slope) to minimize the potential for air intrusion into the demolition, land clearing, and construction (DLC) mattress layer, with the addition of clay or a flexible membrane liner (timing related to weather conditions)
- Installation of gas wells in the Western 40-hectare (ha) area
- Closure of 19 Hectares (Phase 2) with a flexible membrane cover system

Planned for 2013:

- Replacement of gas extraction wells in Cells C, D, or E - between Phase 1 and Phase 2
- Replacement of well head control assemblies - throughout the network
- Installation of vertical recovery wells
- Re-sloping portions of header and lateral pipes to alleviate condensate blockage and vacuum/flow surging (To-Be-Confirmed in 2013)

Figure 7 shows the areas within the landfill site where Stage 2 infrastructure work is to be implemented.

Figure 7: Stage 2 LFG collection system improvement locations/details



3.8 ESTIMATED GHG EMISSION REDUCTIONS AND REMOVAL ENHANCEMENTS

(ISO-14064-2: clause 5.2 g, BC-Reg: Section 3, subsection 2p)

The project benefit is the reduction of GHG emissions resulting from the project activity, and is equal to the emissions in the project activity minus the baseline emissions.

The crediting period for this project is January 26, 2012, to December 31, 2015. The project has the potential to result in a total emission reduction of up to 708,216 tonnes of carbon dioxide equivalent (CO_2e). Table 2 is a summary of the estimated annual emission reductions for each year based on the LFG generation forecasts (as found in Appendix 2) resulting from increases in LFG collection efficiencies that would be realized through the project activity.

Table 2: Estimated Annual Emission Reductions

Year	Modelled Methane Generation[1] (t CH4)	Baseline Methane Destruction (t CH4)	Estimated LFG Collection System Efficiency (%)	Project Methane Destruction (t CH4)	Net Benefit from (Project activity – Baseline) (t CH4)	Estimated Potential GHG Emission Reduction Credits Generated (t of CO_2e)
2012	30,374	12,343	53	15,750	3,067	64,397
2013	30,434	12,368	72	21,541	8,256	173,368
2014	30,366	12,340	83	24,799	11,213	235,471
2015	30,302	12,314	83	24,747	11,189	234,979
Total Estimated Project emission reductions					**33,725**	**708,216**

Notes:

1. The Landfill Gas Generation Assessment Procedure Guidance Report and the Landfill Gas Generation Estimation Tool LFG model used for landfill site LFG and methane generation estimation. Data adjusted to reflect revised Conestoga-Rovers & Associates (CRA) LFG emissions modeling conducted in July 2012 to include demo and demolition/hog waste not originally accounted for in 2011 LFG assessment. (See Appendix 2)
2. Methane mass emission in the model calculated using methane gas density of 0.6557 kg./m^3 at 1 atm. and 25 ˚C. (see Appendix 2)
3. GWP of 21 used in calculation of t of CO2e (as noted Section 3.6 and used in Appendix 2 GHG calculations)
4. Net benefit and potential GHG emission reductions include a methane oxidation factor of 10%
5. LFG collection system efficiency has been calculated with methane oxidation factor included. LFG efficiency under BC Regulation does not include the methane oxidation factor and will result in lower efficiency when applied to Table 12. LFG collection system efficiency in 2014 and 2015 is equivalent to 75% without the methane oxidation factor included

Because Stage 1 LFG collection system wells were installed in 2011, but not fully operational until 2012, potential GHG emission credits for 2011 during system testing, commissioning, and start-up of the LFG recovery areas in Phase 1 and Phase 2 prior to December 31, 2011, have not been included.

3.9 RISK ASSESSMENT

(ISO-14064-2: clause 5.2 h)

Technical, financial, and other risks that may cause the project to not perform as planned and/or that may substantially affect the GHG emission reductions or removal enhancements achieved by the project were considered and are documented in Table 3.

Table 3: Project Risks

Risk Identification	Level of Risk	Mitigation/Management Strategy
Technical Risks		
LFG blower flare station may fault	Low - moderate	Fully automated programmable logic controller (PLC) system with alarms and call-out system. After hours on-call staff notified of system alarm immediately. If flare alarm results in flare shut-down, backup flare (lag flare) will come online in sequence.
Operation of COV blower/flare system and Maxim blower system simultaneously at high flow rates, causing each system to not operate smoothly.	Moderate - high	Ongoing work with PLC and blower/flare system programming to provide smooth/seamless operation of system controls for both Maxim and COV blower/ flare system operation.
Implementation of Stage 1 or Stage 2 does not provide projected LFG capture rates and collection system efficiency	Low - moderate	Assess each step associated with LFG flow rate increase and LFG composition in each stage. Evaluate performance (increase in LFG capture) following each stage.
Financial Risks		
Project activity funding is not available because of change in economic conditions	Low	Ongoing communication with financial stakeholders
Other		
Change in waste stream composition and tonnage landfilled at the site. Reduction in organic fraction of waste based on diversion programs and changes in waste management practices, thereby reducing LFG generation potential.	Low - moderate	Potentially adjust filling plan and implementation of project activity in highest potential yield areas. Focus on system improvements to increase capture efficiency.

3.10 CONTACT INFORMATION

(ISO-14064-2: clause 5.2 i, BC-Reg: Section 3, subsection 2 b, c, d)

Project Stakeholders

Organization

Project Proponent: Primary Contact

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Project Proponent: Secondary Contact

Contact Name and Title:	Lynn Belanger
Company:	City of Vancouver
Roles and Responsibilities:	Manager, Transfer and Landfill Operations, Engineering Services
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Project Stakeholders:

City of Vancouver

The City of Vancouver is a coastal city on the lower mainland of British Columbia. The City is home to approximately 603,000 residents and is also the eighth largest city in Canada. The City is nestled within the Metro Vancouver area and is densely populated, with over 5,000 people per square kilometre.

City Council is made up of the Mayor and ten Councillors who are elected at large for a 3-year term. The City of Vancouver is governed by the Vancouver Charter and has the power to:

- Pass bylaws regulating such things as businesses, building, noise and land use
- Buy and sell property
- Collect property taxes and other taxes
- Approve major spending for all parts of City government
- Take on debt
- Allocate funds for special activities, such as arts and community services
- Set up departments and offices for City services
- Hire staff for City departments and offices

Under the City Council is the Office of the City Manager, which oversees the City Clerk's Department, Community Services, Engineering Services, Corporate Communications, Fire and Rescue Services, Financial Services, Legal Services, Human Resources, Real Estate, and Facilities Management.

In accordance with Metro Vancouver's 2010 Regional Integrated Solid Waste and Resource Management Plan, the City of Vancouver owns and operates a MSW landfill located in Delta. The landfill is permitted under an Operational Certificate issued by the BC Ministry of Environment (MOE) and has approval to accept up to 750,000 tonnes per year of MSW from jurisdictions within the Metro Vancouver area. The City not only disposes of MSW at the site, it also operates a number of waste diversion and recycling programs at the landfill, including leaf and yard waste composting, metals, and white goods recycling, to name a few.

The Vancouver – Delta Agreement (1999) sets the remaining waste disposal capacity of the landfill at 20 million tonnes as of October 1, 1997. This agreement and the Tripartite Agreement (1989) between Metro Vancouver, Delta, and Vancouver both expire in 2037. Although current projections indicate the landfill will reach capacity well after 2037, the current closure date is envisioned as 2037 to coincide with the expiration of the landfill's legal agreements.

The City of Vancouver has taken voluntary action since 1991 to either capture or destroy LFG, or beneficially use the gas for progressive energy saving projects at the site and within the community. The City currently operates the active LFG recovery system at the site, either supplying captured LFG for beneficial use, or thermally destroying the gas on site. The ownership of solid waste disposed of at the site is split between the City of Vancouver and its partners; therefore, the environmental emission reduction offsets associated with the capture of LFG from the Vancouver Landfill would also be split between the City and its partners.

Corporation of Delta

The Corporation of Delta (Delta) is a municipal government serving the communities of Ladner, North Delta, and Tsawwassen. Delta is located in British Columbia's lower mainland and is home to approximately 100,000 residents. In addition to residential, commercial and industrial areas, it also includes a thriving agricultural land base.

Delta is governed by a City Council made up of the Mayor and six Councillors. Delta provides public works and engineering services, legal and finance services, health care services, educational facilities, police and fire services, parks, recreation and culture programs and services, and climate change and environmental programs and services to communities within its municipal boundaries.

Delta's mission statement is "to provide a healthy workplace and foster a safe, vibrant, sustainable community through excellence in municipal services honouring culture, heritage, and the environment."

Delta's involvement and interest in the Vancouver Landfill and the LFG project is both from an operational standpoint based on the 1999 agreement for operation of the site, and from a successful climate change and environmental perspective. The increased LFG collection system efficiency will result in GHG emission reductions that contribute to Delta's community GHG reduction goals set out in its Official Community Plan and also reduce potential community odour impacts resulting from fugitive LFG emissions.

Metro Vancouver

Metro Vancouver is a political body and corporate entity operating under Provincial legislation as a 'regional district' and 'greater boards' that deliver regional services, policy, and political leadership on behalf of 24 local authorities. Metro Vancouver comprises 22 municipalities, one electoral area, and one treaty First Nation.

The 2012 Board consists of 37 Directors who are members of the Municipal or First Nation councils and who have been appointed to the Board by their respective councils on a "representation by population" basis.

Metro Vancouver is responsible for managing the waste produced by 2.3 million residents and businesses in the region. The region currently generates about 3 million tonnes of waste every year, about 55 percent of which is kept out of the landfill through recycling and reuse. Metro Vancouver's goal is to reduce the amount of waste going to the landfill by 70 percent by 2015. Six transfer stations, a waste-to-energy facility (where waste is incinerated), Cache Creek Landfill and Vancouver Landfill are the main components of the disposal portion of Metro Vancouver's Integrated Solid Waste and Resource Management Plan.

Metro Vancouver's involvement and interest in the landfill and LFG project is based on the 1998 agreement. The City of Vancouver is a member of Metro Vancouver, and in accordance with Metro Vancouver's 2010 Regional Integrated Solid Waste and Resource Management Plan, the City of Vancouver owns and operates the Vancouver Landfill in Delta.

CH2M HILL Canada Limited

CH2M HILL Canada Limited is an environmental consulting services company retained by the City of Vancouver to prepare the GHG Project Plan.

3.11 RELEVANT POLICIES, SCHEMES, AND/OR LEGISLATION

(ISO-14064-2: clause 5.2 j, BC-Reg: Section 3, subsection 2 b,d)

Relevant policies, schemes, and/or legislation applicable for this project are listed below as identified in the Protocol and drawing on project-specific details:

- Greenhouse Gas Reduction Targets Act, Emission Offsets Regulation

The Emission Offsets Regulation (EOR) of the Greenhouse Gas Reduction Targets Act (GGRTA) was enacted on December 9, 2008. This regulation sets out requirements/criteria for greenhouse gas reductions and removals from projects to be eligible for emission offsets for the purposes of the GGRTA.

The EOR was recently amended on December 6, 2010. This new amendment redefines the definitions of validation body and verification body. The amended EOR requires that a validation body or verification body must be accredited by a member of the International Accreditation Forum, in accordance with ISO 14065 and through a program developed under ISO 17011.

- Greenhouse Gas Reduction (Cap and Trade Act)

The Greenhouse Gas Reduction (Cap and Trade) Act was passed in May 2008. This legislation made British Columbia the first Canadian province to authorize hard caps on GHG emissions. The Act creates the statutory basis for setting up a market-based cap and trade framework to reduce GHG emissions from large facilities operating in the province. The Act enables BC to implement a cap and trade system. Under cap and trade, limits are set on GHG emissions of regulated facilities. If a regulated facility is able to lower its emissions below the set limit, it can either save its offset for future use, or sell it to another facility that exceeded its maximum allowable limit.

In order to facilitate the Act, the BC government introduced the Reporting Regulation in November 2009. Any facility that emits 10,000 tonnes of CO_2e or more per year must file an annual report on their emissions beginning on January 1, 2010. Those facilities emitting 25,000 tonnes or more of CO_2e per year would require third party verification for their report.

- Landfill Gas Management Regulation

The Landfill Gas Management Regulation was developed under the Greenhouse Gas Reduction (Emission Standards) Statutes Amendments Act and was brought into force in January 2009. It establishes LFG capture criteria for all MSW landfills in BC. The regulation requires that regulated landfills (landfills with 100,000 tonnes or more of MSW in place or with an annual waste acceptance rate exceeding 10,000 tonnes) undertake an assessment of LFG generation and to submit the results to the MOE in a report by January 1, 2011.

- Landfill Gas Generation Assessment Procedure Guidelines

This Guideline was developed to provide a procedure and report format for the assessment of LFG generation at regulated MSW landfills in BC, and to provide guidelines for landfill owners and operators to comply with the British Columbia Landfill Gas Management Regulation, approved and ordered on December 8, 2008.

- Landfill Gas Management Facility Design Guidelines

Landfill Gas Management Facility Design Guidelines provide guidance for the design, installation, and operation of efficient LFG management systems at MSW landfills in BC that generate more than 1,000 tonnes of methane per year. This Guideline must be followed by landfill owners, operators, and qualified professionals in the preparation of LFG facilities design in accordance with the Landfill Gas Management Regulation. Based on the Landfill Gas Management Regulation, regulated landfills must submit a LFG management facilities design plan to the BC MOE no later than January 1, 2012. The LFG management plan must be implemented by January 1, 2016 and shall follow the design standards and performance objectives/performance standards outlined in the guidelines.

- Landfill Criteria For Municipal Solid Waste

These Criteria were revised in June 1993 and apply to all new landfills and both lateral and vertical expansions of existing landfills subsequently designed and constructed for the disposal of MSW. The document outlines the criteria for performance, siting, design, operation, and closure and post-closure. It indicates that if the emission of non-methane organic carbon (NMOC) exceeds or is expected to exceed 150 tonnes/year, the installation and operation of LFG recovery and management systems are mandatory. The criteria are currently being updated and revised for 2012 by the BC MOE.

At the time the Operational Certificate (OC) for the Vancouver Landfill was written, the OC was specifically structured by the BC MOE so that the LFG collection and combustion measures undertaken by the City of Vancouver were voluntary. As stated in the OC (Section 2.13), "If, at any time, the progress attained and maintained by the operation certificate holder's implementation of its voluntary measures are not considered adequate by the Regional Waste Manager, he or she may at such time prescribe a statutory requirement to install and implement additional landfill gas collection, flaring or energy recovery."

- Guidelines for Environmental Monitoring at Municipal Solid Waste Landfills

The Guideline was last reviewed on January 1996. The Guideline provides landfill owners and operators the information on regulatory requirements to develop and implement an environmental monitoring program, as specified in section 7.15 of the Landfill Criteria for Municipal Solid Waste. Section 6 of the Guidelines provides detailed requirements, including acceptable methane levels, monitoring locations, and frequency of landfill gas monitoring.

- Climate Action Charter

Climate Action Charter (The Charter) recognizes the importance of climate change and the need to reduce GHG emissions. The Charter states that the local government commitment toward reducing GHG emissions does not include solid waste facilities that are regulated under the Environmental Management Act. The Province and the Union of BC Municipalities (UBCM) have agreed that the commitment to carbon neutrality is intended to capture only those activities for which the local government exercises direct control (e.g., emissions relating to vehicles and buildings owned by the local government).

An incentive program (Climate Action Revenue Incentive Program) was introduced by the Province on September 24, 2008, to offset the carbon tax for local governments that are one of the signing parties. To be eligible for the program, local governments are required to report annually on the steps they are taking – and progress they have made – to become carbon neutral by 2012.
The Charter is not legally binding.

3.12 ENVIRONMENTAL IMPACTS

(ISO-14064-2: clause 5.2 k, BC-Reg: Section 3, subsection 2 u)

An environmental impact assessment (EIA) is not required for this project under Provincial or federal regulations.

Besides the reduction in landfill methane emissions to the atmosphere, there will be a reduction in potential offsite LFG migration as well as reduced onsite subsurface LFG migration potential into onsite subsurface structures such as gas monitoring valve and control valve chambers that have been installed below grade.

Based on the nature of the site, the geological setting, and the hydrogeology, the risk of subsurface LFG migration offsite is relatively low. The high groundwater table combined with the inner leachate control ditch, as well as the outer perimeter run-on water control ditch, contribute to being effective barriers for offsite lateral migration. The impact would be seen more in the potential for onsite LFG subsurface migration.

The effectiveness of the project activity can be measured not only in the LFG capture volume, but also through periodic surface emission monitoring and monitoring of below grade structures and foundations.

3.13 STAKEHOLDER CONSULTATIONS

(ISO-14064-2: clause 5.2 l, BC-Reg: Section 3, subsection 2 v)

The City has consulted extensively with municipal partners Metro Vancouver and the Corporation of Delta.

3.14 PROJECT ACTIVITIES AND TIMELINES

(ISO-14064-2: clause 5.2 m, BC-Reg: Section 3, subsection 2 g)

The key project activities and milestones are summarized in Table 4.

Table 4: Project Timeline

TASK	Stage 1 START	Stage 1 END	Stage 2 START	Stage 2 END
Planning/Feasibility	2010 TBC	2010 TBC	Mar 2011	Estimated Dec 2012
Design	2010/11	2010/11	Sep 2011	Estimated Jun 2013
Final Approval for Expenditure	May 2011	May 2011	May 2011	TBC
Construction	Aug 2011	Jan 2012	June 2012	Estimated Oct 2013
Testing	Aug 2011	Jan 2012	Aug 2012	Estimated Nov 2013
Commissioning	Jan 2012	Feb 2012	Aug 2012	Estimated Dec 2013
Commercial Operations	Feb 2012	Ongoing – TBC	TBC	TBC
Prepare and complete final project plan	In progress – TBC	TBC	TBC	TBC

4.0 IDENTIFICATION OF "RELEVANT" GHG SOURCES, SINKS, AND RESERVOIRS

4.1 IDENTIFICATION OF PROJECT SSRS

(ISO-14064-2: Clause 5.3; BC_Reg: Section 3, subsection 2m)

Project sources, sinks, and reservoirs (SSRs) were identified using the approved consolidated baseline and monitoring methodology in ACM001, "Flaring or use of landfill gas" Version 13.0.0, which is the most relevant and current good practice guidance for this project.

The project boundary includes the landfill, gas collection systems, flares and combustion equipment.

The potential GHG offsets associated with generation of electricity or displacement of natural gas use for heating have been explicitly excluded from the project to enable the potential creation of future beneficial use offset project(s). The combustion of landfill gas in devices other than the flares is included in the project plan in terms of methane destruction only, and explicitly excluded in terms of the offsetting of other GHG emissions associated with grid electricity or heating from natural gas combustion, or supply of LFG to a natural gas distribution network.

Also for the purposes of the Province of BC, all electricity generated for use on BC Hydro's centralized electrical grid is considered carbon neutral (PCT Guidance Document to the B.C. Emissions Offset Regulation (v2.0).

The above will also allow for conservatism in the baseline and project emissions.

Based on this methodology, it was confirmed that the list of potentially relevant SSRs identified in the CDM methodology was an appropriate starting point for determining project-specific relevant SSRs, and the above-noted SSRs have been excluded.

Potentially relevant project SSRs are summarized in Table 5 and described in Section 4.1.1 (taken directly from the methodology).

4.1.1 DESCRIPTION OF THE PROJECT SSRS

Description of projects SSRs is provided as shown in Table 5, taken directly from the methodology. There are no sinks or reservoirs associated with the project.

The summary of greenhouse gases and sources included in and excluded from the project boundary are also shown in Table 5.

Table 5: Summary of GHG Sources, Sinks, and Reservoirs Descriptions

	Source	Gas	Included?	Justification/Explanation
Baseline	Emissions from decomposition of waste at the solid waste disposal site	CH4	Yes	The major source of emissions in the baseline
		N2O	No	N2O emissions are small compared to CH4 emissions from SWDS. This is conservative
		CO2	No	CO2 emissions from decomposition of organic waste are not accounted for since the CO2 is also released under the project activity
	Emissions from electricity generation	CO2	No	Major emission source if power generation is included in the project activity; however, has been excluded based on the carbon neutral BC electrical grid. It has also been excluded from the project to enable the potential creation of future beneficial use offset project
		CH4	No	Excluded for simplification and based on above
		N2O	No	Excluded for simplification and based on above.
	Emissions from heat generation	CO2	No	Excluded from the project to enable the potential creation of future beneficial use offset project
		CH4	No	Excluded for simplification.
		N2O	No	Excluded for simplification.
	Emissions from the use of natural gas	CO2	No	Excluded for simplification.
		CH4	No	Excluded from the project to enable the potential creation of future beneficial use offset project
		N2O	No	Excluded for simplification. This is conservative
Project Activity	Emissions from fossil fuel consumption for purposes other than electricity generation or transportation due to the project activity	CO2	No	While fossil fuel (propane) is used for flare pilots to ignite the flares, usage is very small as the propane consumption for the flare pilot is only required during the flare ignition sequence. Once the flare is ignited and at operating temperature, the pilot gas is shut off, therefore any increase in emissions from use of propane due to the project is insignificant and not considered in the project activity.
		CH4	No	Excluded for simplification and as noted above.
		N2O	No	Excluded for simplification and as noted above.

Table 5: Summary of GHG Sources, Sinks, and Reservoirs Descriptions

	Source	Gas	Included?	Justification/Explanation
	Emissions from electricity consumption due to the project activity	CO2	No	No new electricity from grid or captive power plants consumed as a result of project, and also per PCT guidance documentation, any such electricity is also considered carbon neutral.
		CH4	No	Excluded for simplification and for reasons noted above.
		N2O	No	Excluded for simplification and for reasons noted above.

4.1.2 EXPLANATION OF SSR CATEGORIZATION

Only methane emission from the decomposition of waste at the landfill site is considered.

Emissions from electricity generation, heat generation, and use of natural gas in the baseline case, and fossil fuel consumption and electricity use in the project case are excluded to enable the potential creation of future beneficial use offset project(s) as well as the BC electrical grid carbon neutrality.

4.2 DETERMINING THE BASELINE SCENARIO

(ISO-14064-2: Clause 5.4, BC_Reg: Section 3, subsection 2i)

In order to calculate the amount of GHG emission reductions that have resulted from a particular undertaking, it is necessary to first estimate the quantity of GHG emissions that would have occurred had the project not been implemented. This 'baseline' takes into consideration the economic, political, and technological conditions within which the implementing entity would have operated into the future. The baseline assessment and additionality will be determined using the PCT "Guide to Determining Project Additionality."

4.2.1 IDENTIFICATION OF BASELINE ALTERNATIVES

(ISO-14064-2: Clause 5.4, BC_Reg: Section 3, subsection 2i (i))

As per BC Reg: Section 3, subsection 2i (i), alternative baseline scenarios must be considered when selecting the project's baseline. These scenarios must be in compliance with mandatory laws and regulations. The PCT "Guide to Determining Project Additionality" has been used to identify baseline alternatives.

PCT "Principle One: The baseline scenario is a representation of what would have reasonably been expected to have occurred in the project's absence"

Several scenarios have been considered to predict the activities that reasonably would have been expected to occur in the absence of the project. Because data from the existing LFG capture system exists, and generation of LFG is not expected to significantly change over the four years of the project activity, a historical baseline will be selected over a prospective baseline.

PCT "Principle Two: For all projects there must exist at least one baseline scenario"

The potential scenario alternatives are as follows:

LFG1 – The project activity is implemented without being registered as a GHG emission reduction project and no trading/selling of carbon credits, with increasing GHG emission reductions ahead of 2016 Provincial regulation.

LFG2 – LFG infrastructure and improvements are not undertaken to increase LFG collection system efficiency at the site until 2016 when Provincially regulated to do so, with continuation of the current LFG collection system operation at the 2010 system collection efficiency, resulting in a reduced LFG collection efficiency of no additional GHG emission reduction until 2016.

LFG 3 – The LFG system is shut down and not operated and LFG emissions to the atmosphere increase over historical levels. This scenario can be discounted immediately because shutting down the system and not operating even at a lower efficiency is not an option, based on the following reasons: 1) the LFG collection system operating at a lower efficiency is still providing an acceptable level of odour control at the site, and 2) the COV currently has a contractual agreement with a third party developer (Maxim) to use best efforts to supply LFG for beneficial end use.

E&H 1 – Electricity and heat generation from LFG captured and supplied to an offsite cogeneration facility is currently undertaken by a private developer (Maxim) through a separate utilization agreement. The COV receives a small annual payment from Maxim for LFG used within the cogeneration facility. Additional power generation equipment could be installed; however, additional agreements, permits, and facilities would not likely be approved, installed, and in operation ahead of 2016 Provincial regulation. Therefore, scenarios whereby additional power generation equipment is installed are excluded from further analysis.

Selection of the baseline scenario is described in section 4.2.2

4.2.2 EVALUATION OF BASELINE ALTERNATIVES AND SELECTION OF BASELINE SCENARIO

(ISO-14064-2: Clause 5.4, BC_Reg: Section 3, subsection 2i (ii))

PCT "Principle Three: The baseline scenario must be comparable to the project scenario"

The potential baseline candidates and evaluation criteria summarized in Table 6 were used to select the most appropriate baseline scenario for the project.

Table 6: Potential Baseline Evaluation

Baseline Approach	Discussion of Suitability
LFG-1	The existing LFG system is operating at a low LFG collection system efficiency. Implementing the project ahead of the 2016 Provincial regulation is a voluntary undertaking to reduce GHG emissions in advance of regulatory requirements. The project activity does not have to be implemented until 2016. The project is technically viable based on the LFG assessment and LFG collection system review contained within the LFG Management Facility Design Plan (SCS Engineers, December 2011).
LFG-2	Not implementing the project activity and continuing to operate the LFG collection system at a lower capture efficiency until 2016 is technically feasible and the system would still satisfy contractual, regulatory, and social obligations for the landfill site.
LFG-3	Decommissioning of the facility is not a suitable baseline because odour control and LFG supply for the utilization project would not be realized. As stated above, this baseline alternative has been excluded from further analysis.
E&H-1	Additional power generation could be installed outside the LFG utilization agreement for gas supply above the supply agreement level, however additional agreements, permits and facilities would not likely be approved, installed and in operation significantly ahead of the 2016 Provincial regulation. As stated above, this baseline alternative has been excluded from further analysis.

Baseline alternatives LFG 1 and LFG 2 provide an equivalent level of service for disposal of waste in the landfill.

LFG-2 was selected as the most probable project baseline, for the following reasons:

1) The baseline is comparable in service, operating conditions, and life span to the project scenario.

2) Provides the COV with higher net present value (NPV) costs compared to LFG-1, as discussed further in Section 4.2.4 under Barrier Analysis.

3) Maintains a level of LFG management that will satisfy odour control for the site.

4) Maintains a minimal contractual level of LFG supply for beneficial use.

5) Has no regulatory requirement prior to 2016.

PCT "Principle Four: Baselines move"

Baseline Movement

Based on the historical record, and current landfill operations and filling scenario, the baseline is estimated to remain relatively constant over the project period. The baseline will change in 2016 with implementation of the BC LFG regulation's LFG collection system efficiency performance objective of 75 percent, at which time the project would no longer be additional

PCT "Principle Five: Baseline scenario emissions must be calculated based on the holistic representation"

All direct and indirect impacts of the potential project activity have been considered in assessing the boundaries of the baseline scenario, within the context of the SSRs indentified by the selected LFG offset methodology. Although the heat generation source has been omitted from the baseline for reasons noted above, this results in a conservative estimate of baseline emissions.

4.2.3 TEMPORAL APPLICABILITY OF SELECTED BASELINE

(ISO-14064-2: Clause 5.4, BC_Reg: Section 3, subsection 2i (iii))

The baseline scenario is applicable until December 31, 2015. As of January 1, 2016, the COV is required under regulatory changes to implement a LFG Facilities Design Plan as part of the Landfill Gas Management Regulation, which includes a system Performance Standard for installing and operating the LFG collection and flaring system to achieve a Performance Objective of 75 percent LFG collection system efficiency.

4.2.4 PROJECT ADDITIONALITY

(ISO-14064-2: Clause 5.4; BC_Reg: Section 3, subsection 2k, l)

The PCT "Guide to Determining Project Additionality" Section 6.1 to Section 6.5 has been used to assess the additionality of the project activity. This methodology reviews the investment, project barriers, and common practice analysis to assess the project additionality.

PCT "Principle Six: Barriers must exist that would prevent the project from being implemented"

PCT "Principle Seven: The barriers to the project must, partially or entirely, overcome the project barriers"

<u>Barrier Analysis</u>

As noted above, the NPV analysis provided below demonstrates that baseline LFG-2 represents a lower project lifecycle cost alternative to the COV as compared to LFG-1, and no other factors would prevent it. Therefore, it is selected as the most likely baseline.

LFG-1, the project activity implemented in the absence of carbon revenue, is shown to be approximately $400,000 more expensive as compared to LFG-2 NPV. However, shown in the NPV analysis, and as discussed further below, revenue from carbon offsets overcomes this financial barrier, and the project activity is demonstrated to be additional.

Consistency with mandatory laws and regulations:

The project scenario and baseline alternatives presented above are currently consistent with mandatory laws and regulations. However, LFG2 is only applicable until January 1, 2016, which is the regulatory compliance time set when the BC Landfill Gas Management Regulation (December 2009) requires that regulated landfills install and operate a LFG collection system and achieve a system performance objective of 75 percent LFG collection efficiency.

Investment Analysis

The following NPV analysis demonstrates that baseline alternative LFG-2 represents a financially preferential scenario as compared to LFG-1 (the project activity in the absence of carbon revenue), and that the carbon revenue in the project scenario overcomes the financial barrier.

The capital costs associated with the upgraded LFG capture system are substantial, and could be reduced by over 50% with the presence of carbon revenue depending on the value applied to the carbon credits. Although the revenue from additional generation of power by Maxim partially overcomes the capital cost, overall LFG-1 is substantially more expensive than LFG-2. The comparison is detailed in Table 7.

Table 7: Project Activity with Potential Carbon Offsets Applied

	2011 NPV		Estimated Annual Costs and Revenues					
			2011	2012	2013	2014	2015	2016
LFG – 2	($21,669,806)	Capital Cost	$0	$0	$0	$0	($26,339,784)	
LFG – 1		Capital Cost	($1,893,394)	($12,149,939)	($10,061,300)			
		Est. Cogen Revenue[5]		$100,000	$200,000	$200,000	$200,000	
		Est. Cogen O&M costs[5]		($12,500)	($25,000)	($25,000)	($25,000)	
	($22,053,453)	Total	($1,893,394)	($12,062,439)	($9,886,300)	$175,000	$175,000	
Project with carbon offsets		Capital Cost	($1,893,394)	($12,149,939)	($10,061,300)			
		Est. Cogen Revenue[5]		$100,000	$200,000	$200,000	$200,000	
		Est. Cogen O&M costs[5]		($12,500)	($25,000)	($25,000)	($25,000)	
		Potential Carbon Revenue[8]		$1,287,932	$3,467,369	$4,709,427	$4,699,590	
	($9,747,300)	Total	($1,893,394)	($10,774,507)	($6,418,931)	$4,884,427	$4,874,590	

Assumptions:

1. To comply in 2015, capital cost would be incurred in 2015.
2. Capital costs would be the same in 2015, except for inflation.
3. All costs and revenues are the same between alternatives in 2016.
4. Assume discount rate equal to cost of financing.
5. Cogeneration revenue and estimated Cogeneration O&M costs assumed for LFG-1 are simply an order-of-magnitude number for calculation purposes and are conservative.
6. Discount rate of 5% has been applied.
7. Inflation rate of 3% has been applied
8. Assumed carbon revenue at $20/t CO2e

The NPV analysis shows LFG-2, not implementing the project and waiting until 2015 prior to investing the capital to increase the system collection efficiency, has the lowest Net Present Cost to the COV.

Even with the additional power generation revenue, LFG-1 has the highest Net Present Cost and clearly shows a financial (investment) barrier to proceeding with the project activity. The COV has committed the funds for the project activity; however, the potential value of the emission reduction revenue reviewed during the decision to implement the project was a factor in the decision to proceed, in addition to the GHG emission reductions that would be realized.

Adding the potential revenue from the offset project will completely overcome the investment barrier associated with the project activity, as seen in Table 7. Note that negative numbers (in parentheses) represent costs to COV, whereas positive numbers are revenues. Thus, LFG-1 is shown to have higher costs than LFG-2, but the project scenario has lower cost than either baseline.

Technological Barriers

No technical barriers are associated with the two scenarios identified.

Social Barriers

No social barriers are associated with the two scenarios identified.

Common Practice Analysis

It is common practice at larger landfills in BC, such as the Vancouver Landfill, to have a LFG collection system; however, it is not common practice to increase the efficiency of the LFG recovery system in advance of the 2016 regulation. The commitment to reducing the landfill emissions and the voluntary installation of additional LFG recovery infrastructure and upgrading of the existing system is not a common practice, especially given the financial implications associated with the Stage 1 and Stage 2 project activities.

There is another similar project that has been approved as a valid emission reduction project, and that is the Fraser Fort George Landfill Gas Management Project. Although similar, the project baseline is different and produces fewer emission reduction credits based on the small landfill site and project.

Based on the above additionality analysis, the project satisfies the BC Emission Offsets Regulation requirement “that there are financial, technological, or other obstacles to carrying out the project that are overcome or partially overcome by the incentive of having a greenhouse gas reduction recognized as an emission offset under the Act.”

4.3 IDENTIFICATION OF BASELINE SSRS

(ISO-14064-2: Clause 5.5, BC_Reg: Section 3, subsection 2i)

4.3.1 DESCRIPTION OF THE BASELINE SSRS

See Section 4.1.1 Table 5.

4.4 QUANTIFICATION OF PROJECT AND BASELINE EMISSIONS

4.4.1 QUANTIFICATION METHODOLOGIES

Quantification methods to be used to calculate GHG emissions for the project and baseline are based on methods in the CDM methodology "Approved consolidated baseline and monitoring methodology ACM0001 Version 13.0.0, Flaring or use of landfill gas", and associated CDM methodological tools "Project emissions from flaring" (Version 02.0.0), "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"(Version 01), "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (Version 02), "Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (Version 02.0.0). Methodological tool "Emissions from solid waste disposal sites" (Version 06.0.1) is normally used with ACM0001, but as explained below, has been replaced by the BC Ministry of Environment approved "Landfill Gas Generation Estimation Tool".

Baseline emissions are determined according to equation (1) presented in section 4.5.2 and would generally comprise the following sources:

(A) Methane Emissions from the solid waste disposal site (SWDS)
(B) Electricity generation using fossil fuels or supplied by the grid in the absence of project activity
(C) Heat generation using fossil fuels in the absence of the project activity
(D) Natural gas used from the natural gas network in the absence of the project activity.

In review of the greenhouse gases and potential sources earlier in this document, emissions from electricity generation, heat generation, and use of natural gas in the baseline case are excluded to enable the potential creation of future beneficial use offset project(s). The City of Vancouver are currently investigating the feasibility of biomethane production from LFG at the site, however as noted above has been excluded and considered zero in the baseline emissions and in the project activity.

As indicated above, the ACM0001 protocol normally utilizes the CDM methodological tool, "Emissions from solid waste disposal sites," version 06.0.0. This tool is used to estimate the amount of methane in the LFG that is generated from the SWDS in the baseline scenario. We have proposed a deviation from this methodological tool by using the Landfill Gas Generation Assessment Report Vancouver Landfill (CRA, January 2011) and recent updates in the LFG generation assessment, also prepared by CRA in July 2012. The LFG Generation Tool uses a similar methodology to estimate the amount of methane in the LFG that is generated from the SWDS during the baseline scenario. The generation assessment was prepared following the procedures outlined within the Landfill Gas Generation Assessment Procedure Guidance Report and the Landfill Gas Generation Estimation Tool, which has been approved for use by the BC MOE for use in estimating and reporting LFG generation assessments from municipal solid waste landfills in BC as per the Landfill Gas Management Regulation. The Landfill Gas Generation assessment tool uses the First-Order Kinetic Decay model with calculated inputs for methane generation potential, methane generation rate constants, and waste history very similar to the CDM "Emissions from solid waste disposal sites." The Landfill Gas Generation assessment provides a site-specific estimate of the amount of methane in the LFG that is generated from the Vancouver Landfill site in the baseline scenario. One of the primary differences between the BC LFG Generation Assessment tool and the CDM tool is the fact that the CDM tool uses an oxidation factor (which accounts for a percentage of methane which could potentially be oxidized through the landfill cover). The BC LFG Generation Assessment tool does not consider methane oxidation and assumes that the total theoretical LFG generation could be emitted to the atmosphere. A methane oxidation factor has been applied to the methane emissions calculated under the *Landfill Gas Generation Assessment Report* data (CRA, 2012), to align with the CDM methodologies and common industry practices.

The project benefit is the baseline emissions minus the project emissions. As the project emissions are zero as per the definition of the protocol, and the emissions associated with B, C and D above are zero, then the project benefits become equal to the baseline methane emissions from the SWDS.

4.4.2 SUMMARY OF EQUATIONS

Baseline emissions for methane are determined according to the following equation:

$BE_y = BE_{CH4,y} + BE_{EC,y} + BE_{HG,y} + BE_{NG,y}$ (1)

Where:

BE_y = Baseline Emissions in year y (t CO_2e/yr)

$BE_{CH4,y}$ = Baseline Emissions of methane from the SWDS in year y (t CO_2e/yr)

$BE_{EC,y}$ = Baseline Emissions associated with electricity generation in year y (t CO_2/yr)

$BE_{HG,y}$ = Baseline Emissions associated with heat generation in year y (t CO_2/yr)

$BE_{NG,y}$ = Baseline Emissions associated with natural gas use in year y (t CO_2/yr)

As noted above and also stated in section 4.5.1, the emissions associated with electricity generation. Heat generation and natural gas use are excluded from the baseline and the project.

Therefore, equation (1) becomes:

$BEy = BE_{CH4,y}$ (1a)

Baseline Emissions of Methane from the SWDS

Baseline emissions of methane from the SWDS are determined as follows, based on the amount of methane that is captured under the project activity and the amount that would be captured and destroyed in the baseline (such as, as a result of regulations). Baseline emissions of methane are calculated by the difference of the quantity captured and burned in the project case and the baseline quantity captured and flared, which is then reduced by the oxidation factor for the landfill cap.

$BE_{CH4,y} = (1-OX_{top\_layer}) \times (F_{CH4,PJ,y} - F_{CH4,BL,y}) \times GWP$ (2)

Where:

$BE_{CH4,y}$ = Baseline emissions of LFG from the SWDS in year y (t CO_2e/yr)

OX_{top_layer} = Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline (dimensionless)

$F_{CH4,PJ,y}$ = Amount of methane in the LFG which is flared and/or used in the project activity in year y (t CH4/yr)

$F_{CH4,BL,y}$ = Amount of methane in the LFG that would be flared in the baseline in year y (t CH4/yr)

GWP_{CH4} = Global warming potential of CH4 (t CO_2e/t CH4)

The above equation provides for the emission of methane occurring in the baseline, but not in the project.

An ex ante estimate of the amount of methane in the LFG which is flared and/or used in the project activity in year y ($FCH4,_{PJ,y}$) is required to estimate the baseline emissions of methane from the SWDS (in equation (2)) in order to estimate the emission reductions of the proposed project activity in the CDM methodology. The amount of methane in LFG that is flared or used in the project year (y) can be determined using the following equation:

$F_{CH4,PJ,y} = \eta_{PJ} \times BE_{CH4,SWDS,y} / GWP_{CH4}$

Where:

$F_{CH4,PJ,y}$ = Amount of methane in the LFG that is flared and/or used in the project activity in year y (t CH4/yr)

$BE_{CH4,SWDS,y}$ = Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year y (t CO_2e/yr)

H_{pj} = Efficiency of the LFG capture system that will be installed in the project activity

GWP_{CH4} = Global warming potential of CH4 (t CO_2e/t CH4)

As an example for the first project year 2012, using annual values provided in Appendix 3 and assuming that the collection efficiency during the project year is 53 percent, a destruction efficiency of 52 percent (which would be achieved based on both Stage 1 and Stage 2 project activities), and the above equation, the amount of methane in LFG that is flared or used in the project year is estimated as follows:

$F_{CH4,PJ,y}$ = (0.53 x 637,853 t CO_2e/yr) / 21

= 16,072 t CH4/yr

In order to determine the amount of methane in the LFG that would be flared in the baseline in year y, the following cases are considered as presented in Table 8.

Table 8: Cases for Determining Methane Captured and Destroyed in the Baseline Year

Situation at the Start of the Project Activity	Requirement to Destroy Methane under Landfill Gas Emissions Regulation	Existing LFG Capture and Destruction System
Case 1	No	No
Case 2	Yes	No

Table 8: Cases for Determining Methane Captured and Destroyed in the Baseline Year

Situation at the Start of the Project Activity	Requirement to Destroy Methane under Landfill Gas Emissions Regulation	Existing LFG Capture and Destruction System
Case 3	No	Yes
Case 4	Yes	Yes

Case 3 is the applicable case to use in determining the methane captured and destroyed in the baseline year. In Case 3, there is no requirement to destroy methane and a LFG capture system exists. In this situation, the following equation applies:

$F_{CH4,BL,y} = F_{CH4,BL,sys,y}$

Because there is no way to monitor baseline gas flow separately from project gas flow, but there are historical data on the amount of methane that was captured in the year(s) prior to the implementation of the project activity, the following equation applies:

$F_{CH4,BL,sys,y} = F_{CH4,hist,y}$

In the CDM methodology ACM0001 Version 13.0.0, "Flaring or use of landfill gas", when determining $F_{CH4,hist,y}$ it is assumed that the fraction of LFG that was recovered in the year prior to implementation of the project activity is equal to the same fraction recovered under the project activity and the following equation applies:

$F_{CH4,hist,y} = (F_{CH4,BL,x-1} / F_{CH4,x-1}) \times F_{CH4,PJ,capt,y}$

Where:

$F_{CH4,hist,y}$ = Historical amount of methane in the LFG that is captured and destroyed (t CH4/yr)

$F_{CH4,BL,x-1}$ = Historical amount of methane in the LFG that is captured and destroyed in the year prior to implementation of the project activity (t CH4/yr)

$F_{CH4,x-1}$ = Amount of methane in the LFG generated in the SWDS in the year prior to implementation of the project activity (t CH4/yr)

$F_{CH4,PJ,capt,y}$ = Amount of methane in the LFG that is captured in the project activity in year y (t CH4/yr)

$F_{CH4,x-1}$ will be estimated using the BC LFG Generation Assessment, as previously noted.

However, in review of the above calculation of the historical baseline, it makes more sense to substitute and use the equation from the CDM methodology ACM0001 Version 11 to determine the historical baseline, as the baseline will move for each project year as opposed to staying fixed. The historical baseline also uses an adjustment factor (AF) in the Ex Ante calculation of the historical baseline emission resulting is a more conservative (higher) historical baseline for which the project emissions are calculated against, resulting in a lower baseline emission for each project year.

Using the equation (2) from the CDM AMC0001 Version 11

$MD_{BL,,y} = MD_{project,,y} * AF$

Where:

$MD_{project,y}$ = Amount of methane that would have been destroyed/combusted during the year in the project scenario (t CH4/yr)

$MD_{BL,y}$ = Amount of methane in the LFG that is captured/destroyed in the year in the absence of the project scenario (t CH4/yr)

AF = adjustment factor in this case where a LFG collection and combustion system has been installed for reasons other than regulatory or contractual requirements

In order to calculate the AF for the project year, first the system destruction efficiency in the year prior to the start of the project must be calculated based on the following equation (3):

$E_{BL} = MD_{HIST} / MG_{HIST}$

Where:

E_{BL} = destruction efficiency of the baseline system (% faction)

MD_{HIST} = amount of methane destroyed historically measured for the previous year before the start of the project activity (t CH4).

MG_{HIST} = amount of methane generated historically by the solid waste disposal site for the previous year before the start of the project activity (t CH4).

Using Option 2 to determine the destruction efficiency of the system used in the project activity for every year as follows:

$E_{PR,y} = MD_{project,y} / MG_{PR,y}$

Where:

$E_{PR,y}$ = Destruction efficiency of the system used in the project activity for year y (fraction)

$MD_{project,y}$ = amount of methane destroyed by the project activity in year y of the project activity (t CH4).

$MG_{PR,y}$ = amount of methane generated during year y of the project activity by the solid waste disposal site (t CH4).

Then to calculate the AF if using option 2, the following equation applies:

$AF_y = E_{BL} / E_{PR,y}$

Where:

AF_y = adjustment factor for every year y, which is used in equation (2) above.

Ex ante calculations for emission reductions are provided by projecting future GHG emissions of the landfill. $MD_{project,y}$ will be determined ex post by metering the actually quantity of methane captured and destroyed once the project activity is implemented. During the crediting period, the tonnes of CH4 in year y is based on the sum of the amount of methane that is destroyed/combusted through flaring or beneficial use through the cogeneration system (engines and boilers).

There have not been any previous source stack emission testing to confirm methane destruction efficiencies, however for the Ex Ante calculations the thermal destruction efficiency for the enclosed flares, engines, boilers and administrative building heating unit have been all taken at 98%. For the Ex Post calculations, the default value of the flare thermal destruction efficiency will be the manufacturer's declared efficiency rather than the value proposed in the methodological "tool to determine project emissions from flaring gases containing methane" (Annex 13/EB28/CDM Executive Board). This default is in agreement with the "Methodology Addendum – CDM ACM0001 Use Under BC Emissions Offset Regulation". As in the methodology addendum, COV will continuously monitor compliance with manufacturer's specifications of flare characteristics (such as, temperature and flow rate of residual gas at the inlet of the flare) as per the modification (see Appendix 1).

Note that the LFG collection system efficiency in 2012 is estimated at 53 percent with the completion and full operation of Stage 1 and the installation of the LFG system infrastructure and improvements associated with Stage 2. For project year 2013 the estimated LFG collection system efficiency is estimated to increase to 72 percent with additional stage 2 LFG system improvements. In 2014, and 2015, the amount of methane in LFG that is flared or used in the project year will increase with the LFG collection system efficiency increase from 72 to 83 percent resulting from the Stage 2 LFG infrastructure completion.

The amount of methane in the LFG that would be flared or used in the cogeneration system in the year prior to the project activity $F_{PJ,x-1}$ has been estimated using the average of the previous two (2) years (2010 – 2011)and is calculated as 12,123 t CH4/yr (254,574t CO2e/year) based on historical records provided from the site (annual LFG summary spreadsheet).

Based on the above CDM methodology and equations, the amount of methane that would be destroyed during the year with the absence of the project is not fixed and will move for each project year.

The estimated baseline emissions, amount of methane that would have been destroyed/combusted during the project years ($F_{PR,y}$ or $MD_{project,y}$) and the amount of methane that would have been destroyed/combusted during the years in the absence of the project ($F_{BL,y}$ or $MD_{BL,y}$) are presented in Table 9.

Table 9: Estimated Baseline Emissions, Methane Destroyed in Project Scenario, and Methane Destroyed in Absence of Project in Year Y

Year (y)	$F_{PJ,y}$ (t CO2e/yr)	$F_{BL,y}$ (t CO2e/yr)	BE_y (t CO2e/yr)
2012	330,759	259,207	64,397
2013	452,352	259,720	173,368
2014	520,771	259,136	235,471
2015	519,683	258,595	234,979

The LFG generation estimates were based on waste quantities and the methodology accepted by BC MOE to estimate methane emissions for regulated landfills under the Landfill Gas Regulation. This assessment for LFG generation estimates has been updated in July 2012 to reflect the addition of demolition waste and demolition/hog waste that was not included within the historical waste tonnage used in the model. The LFG generation model also does not take into consideration methane oxidation of non-captured LFG through the cover soils. As a result, a methane oxidation factor (OX = 0.1) has been applied to the methane emissions estimated under the *Landfill Gas Generation Assessment Report* data (CRA, 2012) to align with the CDM methodologies and has been included in the calculation of the baseline emissions in the project year (BE_y).

The updated LFG generation estimates can be found in Appendix 2.

The emission reduction, (ER) for each year of the project activity is calculated as the baseline emissions (BE) minus the project emissions (PE) for that activity year.

$ER_y = BE_y - PE_y$

where:

ER_y = Emission reductions in year y (t CO_2e)

BE_y = Baseline emissions in year y (t CO_2e)

PE_y = Project emissions in year y (t CO_2e)

Project emissions are calculated as the sum of emissions from the consumption of electricity and emissions from the consumption of fossil fuels. As there are no emissions associated with consumption of electricity or fossil fuels in the project activity, for reasons discussed earlier in this section, then the emission reduction (project benefit) for each project activity year is equal to baseline emission for each project year.

The GHG emission reduction realized from the project activity is summarized in the LFG Capture/Destruction Table provided in Appendix 3.

During the crediting period, the amount of methane in the LFG that is flared or used in the project activity for each year will be equal to the amount of methane the LFG is destroyed by flaring, used for electrical power generation and heat generation. In each year this would also include the amount of methane in LFG sent to a natural gas distribution network, however this is not applicable within project activity. The equation used is as follows:

$$F_{CH4,PJ,y} = F_{CH4,flared,y} + F_{CH4,EC,y} + F_{CH4,HG,y} + F_{CH4,NG,y}$$

Where:

$F_{CH4,PJ,y}$ = Amount of methane in the LFG flared and/or used in the project activity in year y (t CH4/yr)

$F_{CH4,flared,y}$ = Amount of methane in the LFG destroyed by flaring in the project activity in year y (t CH4/yr)

$F_{CH4,EC,y}$ = Amount of methane in the LFG used for electricity generation in the project activity in year y (t CH4/yr)

$F_{CH4,HG,y}$ = Amount of methane in the LFG used for heat generation in the project activity in year y (t CH4/yr)

$F_{CH4,NG,y}$ = Amount of methane in the LFG sent to a natural gas distribution network in the project activity in year y (t CH4/yr)

The amount of methane in the LFG used for flaring, electricity, and/or heat generation is calculated using the "tool to determine the mass flow of a greenhouse gas in a gaseous stream" and monitoring the facility/equipment online hours. The operation of the engines and boilers will be tracked directly through Maxim Power online continuous supervisory control and data acquisition operations providing an online equipment utilization (Opj,h,y). The mass flow of CH4 is calculated and reported on an hourly basis. The continuous operation of the flares (Opj,h,y) at the manufacturer's specifications will be monitored by the COV using the flare temperature thermocouples.

5.0 MONITORING PLAN

(ISO-14064-2: Clause 5.10, BC_Reg: Section 3, subsection 2n)

5.1 PURPOSE OF MONITORING

The monitoring plan is intended to guide the GHG data monitoring activities for both project and baseline such that high-quality, accurate data are collected in a manner sufficient to calculate post-project emission quantification.

5.2 MONITORING ROLES AND RESPONSIBILITIES

Each staff position related to data monitoring is identified and described in Table 10, along with any requisite qualifications, training requirements, and the specific names of assigned personnel. Documentation indicating how each assigned staff member meets the requisite qualification and training requirements does not need to be included in the plan, but needs to be available should it be requested by validators/verifiers.

Table 10: Roles and Responsibilities of Personnel

Position Description	Requisite Qualifications	Training Requirements	Names of Assigned Personnel
Senior LFG Facility Operator	Technician	Fully trained on blower/flare station equipment and controls, PLC and system programming, data processing for GHG emission reporting, equipment calibration	Don Darrach
LFG Technician	Technician	LFG well field monitoring system, blower/flare station controls, GHG monitoring equipment calibration, operations and maintenance (O&M)	Eric Nielsen
Landfill Site Engineer	Engineer	Provide technical support to LFG technical staff and review emission reduction data and reports. Prepare final emission reduction reports.	Brian Beck
Landfill Site Manager	Senior Engineer	Quality assurance/quality control (QA/QC) for internal review of emissions reduction data reporting, support O&M requests. Solid Waste Association of North America (SWANA) Manager of Landfill Operations (MOLO) certification.	Lynn Belanger
Maxim Facility Operations	Technician	Trained on utilization facility LFG O&M procedures, control system and data acquisition and reporting.	

Records regarding staff qualifications and training are available for review as required. Staff involved in the LFG operations have been trained in the operation of the blower/flare system.

5.3 GHG INFORMATION MANAGEMENT SYSTEM (IMS)

The monitoring methodology is based on direct measurement of LFG capture and thermal destruction. The monitoring plan provides for continuous monitoring of the quantity and quality of the LFG that is captured and routed to the flare system or utilization system (Table 11). The main parameters that are required to be measured are the quantity of methane that is captured, and quantity of methane that is flared or utilized.

The process and instrumentation diagram (P&ID) for City of Vancouver LFG blower/flare system and Maxim's utilization system are shown in Figures 8 and 9, respectively. LFG quantity and quality is measured using thermal mass flow meters and LFG analyzers. The LFG supply to the flare system and LFG supply to the utilization system have separate continuous flow meters and continuous LFG analyzers. Methane concentration is determined using infrared detection and oxygen concentration is measured using electrochemical cells.

Figure 8: COV LFG Piping and Instrumentation Diagram

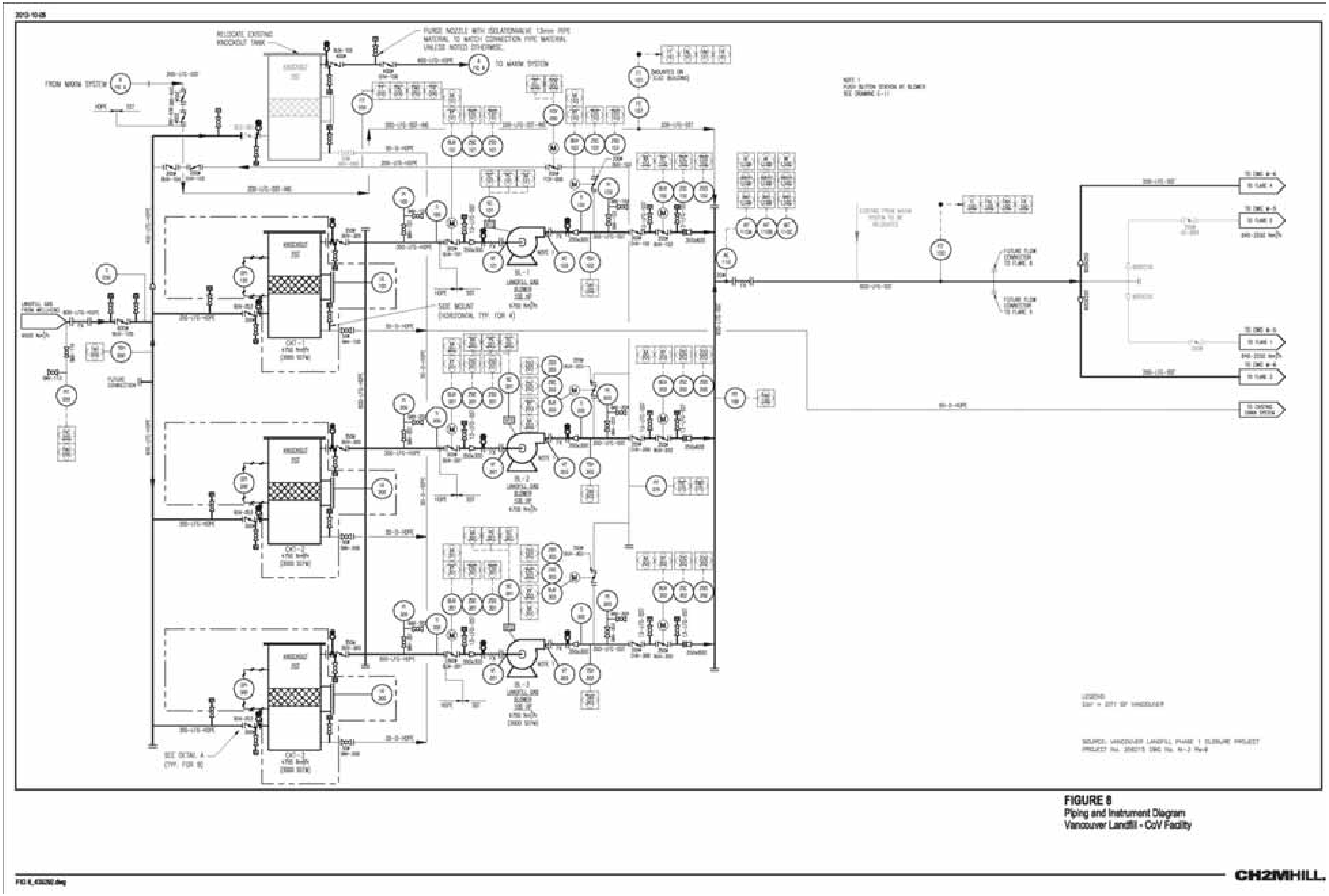

Figure 9: Maxim LVPV Process and Control Diagram (Maxim Facility)

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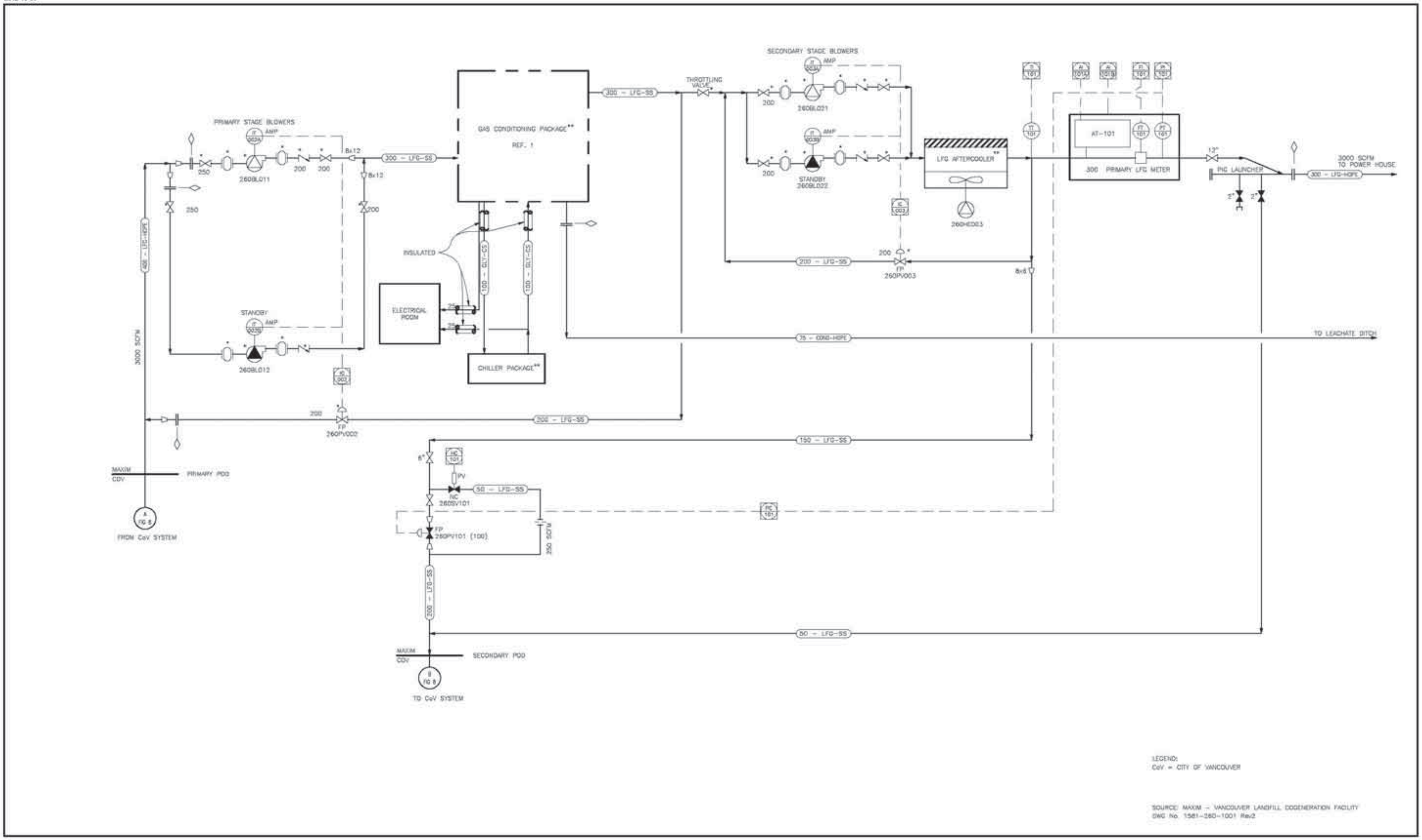


FIGURE 9
LPVP Process and Control Diagram
Vancouver Landfill - Maxim Facility

FIG 9_439292.dwg

CH2MHILL.

The programmable logic controller (PLC) system for the blower/flare station monitors and records the LFG captured and routed to the flare system. A separate PLC system for the utilization system monitors and records the continuous flow rate and quality of methane that is routed to the cogeneration facility. Table 11 lists the parameters that are monitored, and the frequency of monitoring. LFG quantity and quality data records are provided to the City from Maxim, as well as a link to the Maxim data from the COV PLC system through a data highway plus connection.

Table 11: Data Parameters Monitored, and Frequency

Data Recorded	Description	Units	Source	Frequency	Measurement Procedure
LFG Total, y	Total LFG capture at Standard Pressure and Temperature (STP)	Nm3	Gas - Sum of flared + Utilized	continuous @ min. 2 second intervals – to be aggregate period not less than 5 minutes	Automated
LFG Flare, y	Total LFG flared	Nm3 (from scfm)	Gas - Thermal mass meter (FIT-100)	continuous @ min. 2 second intervals – to be aggregate period not less than 5 minutes	Automated
LFG Utilized, y	Total LFG Utilized	Nm3 (from scfm)	Gas - DP flow meter (FT-101)	continuous @ min. 2 second intervals – to be aggregate period not less than 5 minutes	Automated
CH4	Methane Concentration in LFG	% by volume	Siemens LFG Analyzer (COV)	continuous @ min. 2 second intervals – to be aggregate period not less than 5 minutes	Automated
O_2	Oxygen in LFG	% by volume	Siemens LFG Analyzer (COV)	continuous @ min. 2 second intervals – to be aggregate period not less than 5 minutes	Automated
Project emissions from flaring	Project Emissions from Flaring	t CO_2e	Calculated based on flare hours of operation, LFG flared, and flare efficiency	daily, monthly, annually	Automated
Project emissions from utilization	Project emissions from Utilization	t CO_2e	Calculated based on engine hours of operation, LFG to utilization system, and combustion efficiency	Daily, monthly, annually	Automated

Table 11: Data Parameters Monitored, and Frequency

Data Recorded	Description	Units	Source	Frequency	Measurement Procedure
Time stamp	historical record for data collection	day/mth/yr and hr/min/sec	data logging system	continuous @ min. 2 second intervals	Automated
Annual LFG generation estimate	Amount of methane generated annually	tonnes CH4	Estimated using CRA model	annually for project life	Scale data and landfill records, waste stream composition data.
Opj,h,y	Operation of Equipment that consumes LFG	hours	Combustion temperature & data logging system	hourly	Automated

For data composition analysis, nitrogen is not measured; however, it is assumed to be the balance percent by volume and can be calculated using the difference between 100 percent by volume subtracted from the sum of methane, carbon dioxide, and oxygen percent by volume.

Data monitored for the project are recorded on a continuous basis. The current data monitoring software includes Rockwell Automation Factory Talk View Studio Site Edition, Factory Talk View SE Station 100 Display, and RSLogix 500 Professional Edition.

The continuous monitoring data are transferred to an Excel file format to generate the daily, monthly, and annual LFG recovery and flaring reports.

Additional data logging capability and reporting is currently being added to the human-machine interface (HMI) system to provide a more efficient data recording system for calculation and reporting purposes.

5.4 DATA MONITORING – CONTINGENCY PROCEDURES

As a backup, contingency procedures can be implemented if there is a data monitoring failure.

Examples are as follows:

If there is a fault or failure of the COV LFG analyzer, the Maxim LFG analyzer logged readings can be used to confirm CH4 composition.

In the highly unlikely event of failure of both LFG analyzers, the portable GEM 2000 LFG analyzer could be used at the blower/flare station to record the LFG composition.

If there is a failure in the LFG flow meter, there are no redundant back-up flow meters installed within the process; however, the total LFG volume to the blower/flare station can be manually monitored using pitot tube readings (from the main inlet header and collection system subheaders) to determine the estimated LFG flow rates and capture.

The station capacity is 6,000 scfm. The flares and blowers that are set to operate automatically operate in lead/lag and standby. If one flare goes offline because of a fault, the next in sequence is brought online.

If monitoring equipment is found to be measuring incorrectly and outside of the +/-5% materiality threshold the data will be adjusted based on the specific equipment. For example, if the COV gas analyzer calibration is found to be out by more than the materiality threshold, the Maxim LFG analyzer historical readings would be used to adjust the gas composition since the last equipment calibration period. The opposite also applies if the Maxim LFG analyzer is found to be out by more than the materiality threshold (and the gas would be adjusted based on the COV gas analyzer historical data to the time of the last calibration).

If the flow meters are measuring incorrectly and outside the +/- 5% materiality threshold, the following adjustments will apply:

- If the calibration of the flow meter or methane analyzer indicate the unit to be under reporting (at a less than 5% inaccuracy) the metered values will be used without correction.

- If the calibration of the flow meter or methane analyzer indicate the unit to be over reporting (at a greater than 5% accuracy) the metered values will be adjusted based on the greatest calibration drift recorded at the time of calibration.

The well field data measurements at the main headers and plant inlet can be used to determine the when and where the drift occurred, if required. The readings will not be as accurate as the facility flow meters, however the flow rate readings will be consistent and the trend in-flow rate measured in the field can be compared with the trend measured at the LFG plant and the point at which the readings became incorrect or trended outside the threshold could be determined. Calibration frequency has been established for gas analyzers to minimize risk of drift outside of equipment accuracy range. Gas analyzers are bump tested with certified calibration gas between calibration intervals to maintain the highest level of accuracy and minimize drift between calibration intervals. Instruments and analyzers are also inspected frequently to minimize meter inaccuracies that may lead to emission reduction revisions.

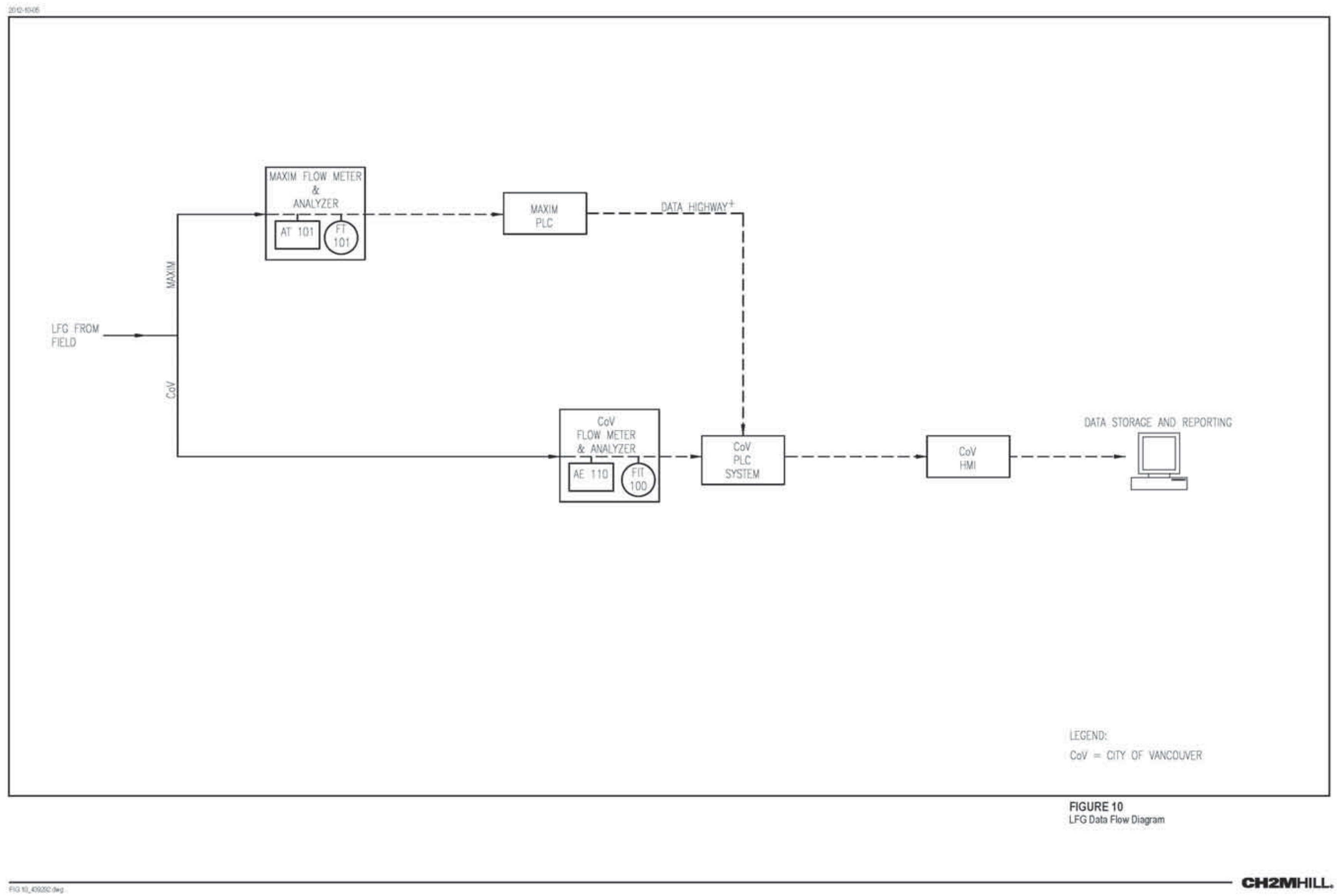
For temperature thermocouples, the flare operating temperatures can be easily compared between Callidus Flares #1 and #2 and John Zink Flares #3 and #4. The trends in flare operation temperatures can easily be established with inaccuracies identified through continuous monitoring.

6.0 DATA QUALITY MANAGEMENT PLAN

(ISO-14064-2: Clause 5.9)

Continuous raw project data are collected from monitoring equipment (LFG flow meters and LFG analyzers) installed within the blower/flare station and Maxim's LFG operations. Figure 10 is a data flow diagram showing the path of data from collection to reporting of GHG emission reductions.

Figure 10: LFG Data Flow Diagram



6.1 DATA QUALITY MANAGEMENT PLAN OBJECTIVE

The data quality management plan objective is to make sure that all data recorded and processed as part of the project activity meet with the quality assurance (QA) and quality control (QC) requirements set forth for reporting GHG emission reductions resulting from the project activity.

6.2 RESPONSIBLE PERSONNEL, QUALIFICATIONS, AND TRAINING

Responsible personnel, qualifications, and training are provided in Section 5.2 (see Table 11).

6.3 QUALITY ASSURANCE AND QUALITY CONTROL PROCEDURES

The QA and QC procedures form part of the operational procedures for the LFG blower/flare station. The facility is fenced, with a secure access for trained staff and management. The PLC and HMI are housed in the LFG control building, which is locked when unattended.

Equipment used for data monitoring is maintained and calibrated as per manufacturer's recommendations to make sure the accuracy of equipment is maintained within the specified accuracy ranges.

The COV LFG Thermal Instruments flow meter Model 62-9/926 was calibrated in 2001, 2006 and 2011. This flow meter was used as the primary LFG flow meter to the flares until the commissioning/start-up of the Phase 1 blower/flare station upgrades in 2011. This flow meter was calibrated and relocated to the Maxim LFG supply line in 2011 to separately measure the LFG supply from the Maxim system. A new Fox Thermal Instruments Inc. model FT2 thermal mass flow meter was calibrated and installed in the COV flare line in 2011 and serves as the primary flow meter (FIT-100) for LFG supplied to the COV flares for thermal destruction. To insure continuing high accuracy of the meter Fox Thermal Instruments provides a full National Institute of Standards and Technology (NIST) traceable calibration. The minimum re-calibration interval is two years, unless otherwise recommended by FOX.

The Maxim flow meter (FT-101 for Maxim's system) at the blower/flare station is a Thermo Brandt MST2400 Flow transmitter with a pitot averaging flow sensor. There is also the same make and model LFG flow meter located at the Village Farms facility. The Brandt flow meters are calibrated quarterly by G.A.S. Analytical Systems Inc. Note in May 2010, the Brandt flow transmitter was replaced with a Rosemount transmitter.

A Sensus R-275 meter is used to measure LFG supplied to the administration building.

LFG samples are taken periodically and sent out for routine gas analysis, as well as trace contaminant analysis, to a third party accredited laboratory. Routine gas composition analysis is compared to LFG analyzer readings taken at the time of sampling for quality assurance.

As part of the overall blower/flare station and Maxim facility configuration and operations, there are a total of 2 in-line continuous LFG analyzers at the LFG facility. One is owned by the City, which measures LFG methane composition to the flare system; the other is owned and operated by Maxim, which measures LFG methane content in gas routed to the Village Farms cogeneration facility. These are both Siemens LFG analyzers and serve both as a check as well as a backup to one another. Third party calibration for both the Siemens LFG analyzers (COV and Maxim) is completed by a G.A.S. Analytical Systems Ltd. using certified calibration gas on a quarterly basis.

Operations and maintenance (O&M) records, including flare system upsets or trips, are recorded on the PLC system and documented within the plant manual logs, which are kept onsite.

The data monitoring system is fully automated with a call-out system in case of system alarm conditions.

There is always (24/7) a trained operator on call to receive facility monitoring alarm conditions and respond accordingly.

The operator also has the ability to connect remotely through a secured (password protected) internet access to assess the alarm condition or routinely check in on system operation after hours or from the landfill office.

6.4 DATA CONTROLS

The data are transferred to a file system and stored. The current data logging system, installed as part of the Phase I LFG blower/flare station upgrades in 2010, is currently being updated to provide a more robust data logging system that will provide a higher degree of flexibility and efficiency for data storage and the reporting of daily, monthly, and annual reports.

6.5 DATA CHAIN OF CUSTODY AND SECURITY

Data collection for the facility is controlled by the lead LFG Operator. The data are backed up on a daily basis. Facility reports are generated from the data and are reviewed by senior landfill staff.

Data will be transferred to a third party verifier to confirm accuracy and quantification of data reported to calculate annual GHG emission reductions.

6.6 RECORD BACK-UP AND ARCHIVING

All data have been historically stored at the LFG facility and landfill site office for auditing purposes. Data will continue to be stored at the LFG facility and backed up to disk on a regular basis. Data transfer and archiving will follow COV procedures and security requirements for data transfer and archiving of data records.

6.7 PERIODIC QUALITY ASSURANCE REVIEW

A periodic quality review will be conducted by a senior project staff member responsible for the checking and quantification of the GHG emission reduction based on the data and calculations used.

The data will be checked against the calculations. Areas where there is uncertainty will be reviewed and confirmed prior to verification of GHG emission offsets.

6.8 DETAILED RESULTS AND UNCERTAINTY ASSESSMENT

(ISO-14064-2: Clause 5.7, 5.8)

A summary of the detailed emission estimates for the project and the baseline, and the net emission reductions, is presented in Table 12 (previously shown in Section 3.8, Table 2).

Table 12: Annual Emission Estimates

Year	Modelled Methane Generation[1] (t CH4)	Baseline Methane Destruction (t CH4)	Estimated LFG Collection System Efficiency (%)	Project Methane Destruction (t CH4)	Net Benefit from (Project activity – Baseline) (t CH4)	Estimated Potential GHG Emission Reduction Credits Generated (t of CO_2e)
2012	30,374	12,343	53	15,750	3,067	64,397
2013	30,434	12,368	72	21,541	8,256	173,368
2014	30,366	12,340	83	24,799	11,213	235,471
2015	30,302	12,314	83	24,747	11,189	234,979
Total Estimated Project Emission Reductions					**33,725**	**708,216**

Notes:

1. The Landfill Gas Generation Assessment Procedure Guidance Report and the Landfill Gas Generation Estimation Tool LFG model used for landfill site LFG and methane generation estimation. Data adjusted to reflect revised Conestoga-Rovers & Associates (CRA) LFG emissions modeling conducted in July 2012 to include demo and demolition/hog waste not originally accounted for in 2011 LFG assessment
2. Methane mass emission in the model calculated using methane gas density of 0.6557 kg./m3 at 1 atm. and 25 ˚C.
3. GWP of 21 used in calculation of t of CO2e
4.. Net benefit and potential GHG emission reductions include a methane oxidation factor of 10%
5. LFG collection system efficiency has been calculated with the methane oxidation factor included. LFG efficiency under BC Regulation does not include the methane oxidation factor and will result in lower efficiency when applied to Table 12. LFG collection system efficiency in 2014 and 2015 is equivalent to 75% without the methane oxidation factor included

Because Stage 1 LFG collection system wells were installed in 2011 but were not fully operational until 2012, potential GHG emission credits for 2011 during system testing, commissioning, and startup of the LFG recovery areas in Phase 1 and Phase 2 prior to December 31, 2011, have not been included.

The uncertainty in the above detailed emission estimates will be associated with the LFG generation and emission modeling because the modeled methane generation represents a theoretical value calculated using a tool developed to estimated LFG emissions from SWDS. The uncertainty is reduced through the use of site-specific waste compositional data to calculate methane generation potential and methane generation rate constants used in the first-order kinetic decay model. The methane generation emissions are also based on the most reasonable waste generation forecast for the Vancouver Landfill in years 2012 through 2015, with no future waste diversion programs being considered. Changes in waste composition and landfill tonnages from 2012 through 2015 will in turn affect the methane emissions in the project and the net benefit based on the 75 percent efficiency estimate resulting from implementing the project activity.

7.0 SUMMARY OF GHG ASSERTIONS

The Proponent makes the following greenhouse gas assertions:

7.1 BASELINE RESULTS IN CONSERVATIVE GHG ESTIMATE

(BC_Reg: Section 3, subsection 2j)

The Proponent asserts that the baseline scenario selected in this GHG project plan will result in a conservative estimate of the GHG reduction to be achieved by the project.

Please see Section 4.2.2 Evaluation of Baseline Alternatives and Selection of Baseline Scenario for supporting information.

7.2 PROJECT ADDITIONALITY

(BC_Reg: Section 3, subsection 2k)

The Proponent asserts that there are financial barriers to carrying out the project that are overcome by the incentive of having a GHG reduction recognized as an emission offset under the Greenhouse Gas Reduction Targets Act.

Please see Section 4.2.4 Project Additionality, for supporting information.

7.3 PROJECT START DATE

(BC_Reg: Section 3, subsection 2l)

The Proponent asserts that the project start date, as defined in the Emission Offsets Regulation, is no earlier than November 29, 2007.

7.4 ACCURATE AND CONSERVATIVE ESTIMATE OF GHGS

(BC_Reg: Section 3, subsection 2o)

The Proponent asserts that the selected baseline, SSRs, and quantification methods will assure that the total of the emission reduction and the removals enhancement is an accurate and a conservative estimation of the GHG reduction, with respect to which the Proponent has ownership, that is to be achieved during the validation period from controlled SSRs in British Columbia, taking into account increases in emissions or reductions in removals, as compared to the baseline scenario, from SSRs other than controlled SSRs.

Please see Section 4.2.2 Evaluation of Baseline Alternatives and Selection of Baseline Scenario, and Section 4.5 Quantification Methodologies, for supporting information.

7.5 OWNERSHIP

(BC_Reg: Section 3, subsection 2q)

The Proponent asserts that with respect to the GHG reduction to be achieved by carrying out the project, they have a superior claim of ownership of the reduction to that of any other person or entity.

The Vancouver Landfill is owned and operated by the COV.

There is a December 18, 2002 'Landfill Gas Utilization Project' Agreement between Maxim Power Corporation and the COV for the supply of up to 3,000 scfm of LFG for energy use for 20 years (equal to 1,500 scfm methane based on 50 percent methane content at Vancouver Landfill).

The Agreement states that all right, interest, and benefit in and to all combustion GHG Credits/Green Tags will remain with the COV and will not pass or transfer to Maxim, regardless of any sale, transfer, or other disposition of LFG, GHG (Incremental) Credits or Green Tags (Incremental) pursuant to the agreement (ref page 53 sec 6.4 (a)).

(Combustion GHG credit definition: credit associated with actual or assumed reduction of emissions from any pollution control system or energy generation system regardless of ownership, and to which the COV would have had right, title, interest and benefit to had the Vancouver (Cogen/Heating) Plant not been constructed and the COV continued to collect the LFG via the LFG Control system and flare the LFG via the blower/flare system.)

Also note that the Maxim contract states that the COV may negotiate or publically tender beneficial use of any 'new' LFG gas beyond this 3000 commitment (ref. page 52 6.3 (a)).

7.6 CONFORMANCE WITH EMISSION OFFSETS REGULATION

(BC_Reg: Section 3, subsection 2w)

The Proponent asserts that this GHG project plan meets the requirements of the Emission Offsets Regulation.

7.7 CONFORMANCE WITH ISO 14064-2

The Proponent asserts that this GHG project plan meets the requirements of ISO 14064-2:2006.

8.0 REFERENCES AND SUPPORTING DOCUMENTS

2011 Annual Report for the Vancouver Landfill, Transfer & Landfill Operations, City of Vancouver, March 30, 2012.

"Approved consolidated baseline and monitoring methodology ACM0001 Version 13.0.0, "Flaring or use of landfill gas", The Clean Development Mechanism (CDM).

"Approved consolidated baseline methodology ACM0001 Version 11, "Consolidated baseline and monitoring methodology for landfill gas project activities", The Clean Development Mechanism (CDM).

BC Landfill Gas Management Regulation, December 8, 2008.

City of Vancouver Administrative Report RTS No.: 09154, May 31, 2011.

Foothills Boulevard Regional Landfill Gas Management Project, GHG Project Plan, Leading Carbon, Sept. 9, 2011.

Greenhouse Gas Reduction Targets Act, EMISSION OFFSETS REGULATION, B.C. Reg. 393/2008, December 9, 2008.

Guidance Document to the BC Emission Offsets Regulation v2.0, Pacific Carbon Trust, November 2010.

Guide to Determining Project Additionality, Discussion Document Version 1.0, Pacific Carbon Trust.

Landfill Gas Generation Assessment Report Vancouver Landfill, CRA, January 2011.

Landfill Gas Management Facilities Design Guidelines, BCMOE, CRA, March 2010.

Landfill Gas Management Facilities Design Plan for the Vancouver Landfill, SCS Engineers, December 23, 2011.

'Landfill Gas Utilization Project' Agreement between Maxim Power Corporation and the City of Vancouver, December 18, 2002.

Methodology Addendum – CDM ACM001 Use Under BC Emissions Offset Regulation

Methodology for Reporting 2011 B.C. Local Government Greenhouse Gas Emissions, Version 2.0, B.C., Ministry of the Environment, February 2012.

Updated LFG Emissions for the Vancouver Landfill July 2012 – Landfill Gas Generation Assessment Report.

Vancouver Landfill Gas Capture Optimization – City of Vancouver – Delta, Project Information Document (PID) PCT Version 3.0.

Pacific Carbon Trust

Appendix 1

Methodology Addendum – CDM ACM001

Use Under BC Emissions Offset Regulation

Methodology Addendum – CDM ACM0001 Use Under BC Emissions Offset Regulation

METHODOLOGY ADDENDUM

This addendum refers to:

Approved consolidated baseline methodology ACM0001
"Consolidated baseline and monitoring methodology for landfill gas project activities"
Version 11 – Sectoral Scope 13 / EB 47 / CDM Executive Board

Additions:

Section I - Applicability (pg 2)

The following applicability conditions will also apply for use in British Colombia, Canada, for projects falling within the scope of the BC Emissions Offset Regulation.

(d) *The project start date is no earlier than November 29, 2007*

(e) *The relevant SSRs for the baseline and project condition identified occur in the Province of British Colombia, Canada*

(f) *Achievement and appropriate quantification of real emission reductions will be ensured through the development of a GHG project plan in accordance with ISO 14064-2, the BC Emission Offset Regulation, other relevant requirements and good practice guidance.*

(g) *There is an upgrade or expansion of an existing landfill gas capture and destruction system under the project activities and this expansion is applicable to one or more of the scenarios described under points (a), (b) or (c).*

Modifications: *None*

Omissions: *None*

METHODOLOGY ADDENDUM

This addendum refers to:

Methodological "Tool to determine project emissions from flaring gases containing methane"
Annex 13 / EB 28 / CDM Executive Board

Additions: *None*

Modifications:

Section II – Baseline Methodology Procedure

The default value of the flare efficiency will be the manufacturer's declared efficiency rather than the value proposed in the methodology.

Fourth Paragraph of Section II (pg 3):

For enclosed flares, either of the following two options can be used to determine the flare efficiency:

a) *To use a manufacturer's declared minimum efficiency as a default value. Continuous monitoring of compliance with manufacturer's specifications of flare (temperature, flow rate of residual gas at the inlet of the flare) must be performed. If in a specific hour any of the parameters are out of the limit of manufacturer's specifications, a 50% default value for the flare efficiency should be used for the calculations for this specific hour.*

Omissions: *None*

METHODOLOGY ADDENDUM

This addendum refers to:

Tool to calculate baseline, project and/or leakage emissions from electricity consumption
Annex 7 / EB 39 / CDM Executive Board

Additions:

Section II – Baseline Methodology Procedure

The options in scenario A for determining the emission factors for electricity generation will include emission factors determined by governmental or regulatory bodies and made publicly available.

Scenario A: Electricity consumption from grid (pg 4)

Option A3: Use a provincial emission factors for electricity consumption which is declared by Environment Canada for the region where electricity consumption occurs applicable in the time periods when the consumption occurs.

Modifications: *None*

Omissions: *None*

Pacific Carbon Trust

Appendix 2

Landfill Gas Assessment –

Emission Generation Update (July 2012)

TABLE 2-3

LANDFILL GAS GENERATION RESULTS
LANDFILL GAS GENERATION ASSESSMENT REPORT FOR THE VANCOUVER LANDFILL
CITY OF VANCOUVER

	Relatively Inert	Moderately Decomposable	Decomposable	
Gas Production potential, Lo =	20	120	160	m^3 CH_4/tonne
Waste Composition (1991)	21.4%	46.9%	31.7%	
Waste Composition (1992)	27.6%	45.4%	27.0%	
Waste Composition (2001) - Adjusted for STPR	32.5%	44.9%	22.6%	
Waste Composition (2005) - Adjusted for STPR	32.5%	45.9%	21.6%	
Waste Composition (2009) - Adjusted for STPR	34.5%	37.7%	27.7%	
Waste Composition (2010) -	33.1%	41.6%	24.8%	
lag time before start of gas production, lag =	1 years			
Historical Data Used (years)	43			
1st Year of Historical Data Used	1967			
4 Years after reporting year	2015			
methane (by volume)	50%			
carbon dioxide (by volume)	50%			
methane (density)	0.6557 kg/m^3		(25°C,1 ATM)	
carbon dioxide (density)	1.7988 kg/m^3		(25°C,1 ATM)	

Year	MSW Tonnage (tonnes)	Demo (tonnes)	Demo-hog (tonnes)	Annual Waste Tonnage	Cumulative Waste-in-place (tonnes)	Waste Tonnage Relatively Inert (tonnes)	Waste Tonnage Moderately Decomposable (tonnes)	Waste Tonnage Decomposable (tonnes)	Methane Generation Rate, k Relatively Inert ($year^{-1}$)	Methane Generation Rate, k Moderately Decomposable ($year^{-1}$)	Methane Generation Rate, k Decomposable ($year^{-1}$)	Annual Methane Production (tonnes/yr)	Landfill Gas Production (m^3/hr)	Greenhouse Gas Emissions (as CO_2e/year)
1967	136,365	28,600	4,100	169,065	169,065	41,794	83,994	43,278	0.02	0.06	0.11	0.0	0.0	0
1968	169,210	35,500	5,100	209,810	378,875	51,869	104,240	53,701	0.02	0.06	0.11	872.4	303.8	18,321
1969	199,284	41,800	6,000	247,084	625,959	61,082	122,757	63,246	0.02	0.06	0.11	1882.9	655.6	39,540
1970	196,577	41,300	5,900	243,777	869,736	60,274	121,117	62,387	0.02	0.06	0.11	3002.5	1045.4	63,053
1971	206,830	43,400	6,200	256,430	1,126,166	63,393	127,396	65,641	0.02	0.06	0.11	4013.3	1397.4	84,279
1972	193,733	40,700	5,800	240,233	1,366,399	59,396	119,353	61,484	0.02	0.06	0.11	5007.4	1743.5	105,156
1973	217,968	45,800	6,500	270,268	1,636,667	66,822	134,270	69,175	0.02	0.06	0.11	5837.6	2032.6	122,589
1974	223,083	46,800	6,700	276,583	1,913,250	68,374	137,410	70,799	0.02	0.06	0.11	6756.5	2352.5	141,886
1975	219,638	46,100	6,600	272,338	2,185,588	67,329	135,304	69,705	0.02	0.06	0.11	7634.7	2658.3	160,328
1976	215,728	45,300	6,500	267,528	2,453,116	66,144	132,920	68,465	0.02	0.06	0.11	8421.3	2932.2	176,847
1977	196,532	41,300	5,900	243,732	2,696,848	60,264	121,096	62,372	0.02	0.06	0.11	9121.2	3175.9	191,544
1978	187,941	39,500	5,600	233,041	2,929,889	57,619	115,776	59,646	0.02	0.06	0.11	9643.8	3357.9	202,520
1979	185,907	39,000	5,600	230,507	3,160,396	56,985	114,522	59,000	0.02	0.06	0.11	10071.7	3506.9	211,506
1980	213,792	44,900	6,400	265,092	3,425,488	65,540	131,702	67,850	0.02	0.06	0.11	10454.9	3640.3	219,552
1981	199,934	42,000	6,000	247,934	3,673,422	61,300	123,181	63,452	0.02	0.06	0.11	10988.4	3826.0	230,756
1982	259,006	54,400	7,800	321,206	3,994,628	79,417	159,590	82,200	0.02	0.06	0.11	11392.7	3966.8	239,247
1983	328,796	69,000	9,900	407,696	4,402,324	100,792	202,556	104,348	0.02	0.06	0.11	12145.3	4228.9	255,051
1984	511,006	100,000	15,300	626,306	5,028,630	153,727	310,403	162,176	0.02	0.06	0.11	13285.5	4625.9	278,996
1985	588,400	100,000	17,700	706,100	5,734,730	170,976	348,386	186,738	0.02	0.06	0.11	15480.0	5390.0	325,079
1986	678,509	100,000	20,400	798,909	6,533,639	191,031	392,543	215,335	0.02	0.06	0.11	17945.3	6248.4	376,851
1987	762,919	100,000	22,900	885,819	7,419,458	209,809	433,886	242,124	0.02	0.06	0.11	20732.2	7218.7	435,377
1988	591,773	100,000	17,800	709,573	8,129,031	171,727	350,038	187,808	0.02	0.06	0.11	23780.8	8280.2	499,397
1989	467,329	98,100	14,000	579,429	8,708,460	143,249	287,866	148,314	0.02	0.06	0.11	25588.1	8909.5	537,349
1990	468,883	98,500	14,100	581,483	9,289,943	143,771	288,905	148,807	0.02	0.06	0.11	26525.9	9236.0	557,043
1991	464,881	97,600	13,900	576,381	9,866,324	142,496	286,348	147,537	0.02	0.06	0.11	27406.0	9542.5	575,525
1992	453,028	95,100	13,600	561,728	10,428,052	167,139	272,288	122,301	0.02	0.06	0.11	28196.6	9817.8	592,129
1993	440,880	162,000	13,200	616,080	11,044,132	190,427	306,632	119,022	0.02	0.06	0.11	28595.5	9956.6	600,505
1994	420,981	0	12,600	433,581	11,477,713	119,955	199,976	113,650	0.02	0.06	0.11	29102.9	10133.3	611,161
1995	410,970	79,700	12,300	502,970	11,980,683	148,983	243,040	110,947	0.02	0.06	0.11	29018.8	10104.0	609,395
1996	396,617	102,300	11,900	510,817	12,491,500	153,942	249,803	107,072	0.02	0.06	0.11	29122.4	10140.1	611,571
1997	349,348	48,450	10,500	408,298	12,899,798	118,937	195,049	94,311	0.02	0.06	0.11	29217.9	10173.3	613,575
1998	371,423	101,200	11,427	484,050	13,383,848	146,407	237,372	100,271	0.02	0.06	0.11	28916.1	10068.3	607,238
1999	357,443	111,830	11,699	480,972	13,864,820	146,883	237,592	96,497	0.02	0.06	0.11	28913.5	10067.4	607,184
2000	310,833	147,892	12,313	471,038	14,335,858	148,629	238,495	83,914	0.02	0.06	0.11	28881.1	10056.1	606,504
2001	390,198	70,806	31,368	492,372	14,828,230	164,370	239,709	88,215	0.02	0.06	0.11	28728.2	10002.9	603,292
2002	389,855	142,197	49,363	581,415	15,409,645	198,214	294,986	88,138	0.02	0.06	0.11	28657.6	9978.3	601,810
2003	449,311	107,918	47,112	604,341	16,013,986	203,123	299,549	101,579	0.02	0.06	0.11	28866.0	10050.8	606,186
2004	475,279	139,205	45,711	660,195	16,674,181	223,646	329,005	107,450	0.02	0.06	0.11	29244.2	10182.5	614,129
2005	525,074	146,151	36,300	707,525	17,381,706	239,946	354,208	113,371	0.02	0.06	0.11	29809.7	10379.4	626,004
2006	608,979	150,619	42,891	802,489	18,184,195	270,971	400,030	131,488	0.02	0.06	0.11	30528.5	10629.7	641,098
2007	510,135	124,709	49,938	684,782	18,868,977	230,607	344,029	110,146	0.02	0.06	0.11	31621.4	11010.2	664,049
2008	508,206	145,042	56,618	709,866	19,578,843	240,117	360,019	109,729	0.02	0.06	0.11	32138.0	11190.1	674,898
2009	478,427	86,760	51,960	617,147	20,195,990	215,391	268,858	132,741	0.02	0.06	0.11	32697.3	11384.8	686,642

TABLE 2-3

LANDFILL GAS GENERATION RESULTS
LANDFILL GAS GENERATION ASSESSMENT REPORT FOR THE VANCOUVER LANDFILL
CITY OF VANCOUVER

Year	MSW Tonnage (tonnes)	Demo (tonnes)	Demo-hog (tonnes)	Annual Waste Tonnage	Cumulative Waste-in-place (tonnes)	Waste Tonnage: Relatively Inert (tonnes)	Waste Tonnage: Moderately Decomposable (tonnes)	Waste Tonnage: Decomposable (tonnes)	Methane Generation Rate, k: Relatively Inert ($year^{-1}$)	Methane Generation Rate, k: Moderately Decomposable ($year^{-1}$)	Methane Generation Rate, k: Decomposable ($year^{-1}$)	Annual Methane Production (tonnes/yr)	Landfill Gas Production (m^3/hr)	Greenhouse Gas Emissions (as CO_2e/year)
2010	439,575	140,733	47,526	627,834	20,823,824	216,234	300,383	109,186	0.02	0.06	0.11	33053.0	11508.7	694,114
2011	468,547	194,044	45,585	708,176	21,532,000	246,578	343,051	116,383	0.02	0.06	0.11	33264.1	11582.2	698,547
2012	450,000	95,000	40,160	585,160	22,117,160	199,186	272,119	111,776	0.02	0.06	0.11	33748.8	11751.0	708,725
2013	450,000	49,500	37,090	536,590	22,653,750	180,065	242,670	111,776	0.02	0.06	0.11	33815.6	11774.2	710,128
2014	450,000	49,500	37,090	536,590	23,190,340	180,065	242,670	111,776	0.02	0.06	0.11	33739.6	11747.8	708,532
2015	450,000	49,500	37,090	536,590	23,726,930	180,065	242,670	111,776	0.02	0.06	0.11	33669.2	11723.2	707,052
2016	450,000	49,500	37,090	536,590	24,263,520	180,065	242,670	111,776	0.02	0.06	0.11	33603.9	11700.5	705,681
2017	450,000	49,500	37,090	536,590	24,800,110	180,065	242,670	111,776	0.02	0.06	0.11	33543.4	11679.5	704,412
2018	450,000	49,500	37,090	536,590	25,336,700	180,065	242,670	111,776	0.02	0.06	0.11	33487.5	11660.0	703,238
2019	450,000	49,500	37,090	536,590	25,873,290	180,065	242,670	111,776	0.02	0.06	0.11	33435.8	11642.0	702,152
2020	450,000	49,500	37,090	536,590	26,409,880	180,065	242,670	111,776	0.02	0.06	0.11	33388.1	11625.4	701,150
2021	450,000	49,500	37,090	536,590	26,946,470	180,065	242,670	111,776	0.02	0.06	0.11	33344.0	11610.0	700,224
2022	450,000	49,500	37,090	536,590	27,483,060	180,065	242,670	111,776	0.02	0.06	0.11	33303.4	11595.9	699,371
2023	450,000	49,500	37,090	536,590	28,019,650	180,065	242,670	111,776	0.02	0.06	0.11	33266.0	11582.9	698,585
2024	450,000	49,500	37,090	536,590	28,556,240	180,065	242,670	111,776	0.02	0.06	0.11	33231.6	11570.9	697,863
2025	450,000	49,500	37,090	536,590	29,092,830	180,065	242,670	111,776	0.02	0.06	0.11	33200.0	11559.9	697,199
2026	450,000	49,500	37,090	536,590	29,629,420	180,065	242,670	111,776	0.02	0.06	0.11	33171.0	11549.8	696,590
2027	450,000	49,500	37,090	536,590	30,166,010	180,065	242,670	111,776	0.02	0.06	0.11	33144.4	11540.5	696,033
2028	450,000	49,500	37,090	536,590	30,702,600	180,065	242,670	111,776	0.02	0.06	0.11	33120.1	11532.1	695,523
2029	450,000	49,500	37,090	536,590	31,239,190	180,065	242,670	111,776	0.02	0.06	0.11	33098.0	11524.4	695,058
2030	450,000	49,500	37,090	536,590	31,775,780	180,065	242,670	111,776	0.02	0.06	0.11	33077.8	11517.3	694,634
2031	450,000	49,500	37,090	536,590	32,312,370	180,065	242,670	111,776	0.02	0.06	0.11	33059.5	11511.0	694,249
2032	450,000	49,500	37,090	536,590	32,848,960	180,065	242,670	111,776	0.02	0.06	0.11	33042.9	11505.2	693,901
2033	450,000	49,500	37,090	536,590	33,385,550	180,065	242,670	111,776	0.02	0.06	0.11	33027.9	11500.0	693,586
2034	450,000	49,500	37,090	536,590	33,922,140	180,065	242,670	111,776	0.02	0.06	0.11	33014.4	11495.3	693,303
2035	450,000	49,500	37,090	536,590	34,458,730	180,065	242,670	111,776	0.02	0.06	0.11	33002.3	11491.1	693,049
2036	450,000	49,500	37,090	536,590	34,995,320	180,065	242,670	111,776	0.02	0.06	0.11	32991.6	11487.3	692,823
2037	450,000	49,500	37,090	536,590	35,531,910	180,065	242,670	111,776	0.02	0.06	0.11	32982.0	11484.0	692,622

Sources:

-Landfill Gas Generation Assessment Procedure Guidance Report, Conestoga-Rovers & Associates, March 2009

-STPR: Sewage Treatment Plant Residuals - assumed to be relatively inert

Appendix 3

Detailed Landfill Gas Capture Table

Appendix 3 – Detailed Landfill Gas Capture Table

Updated for LFG Emission Forecast by CRA, July 2012

Vancouver Landfill Estimated Gas Capture, Destruction and Estimated Baseline Emissions

Year	LFG Capture ** (scf/year)	Methane Conc. (% by Vol.)	LFG Capture** (m^3/year)	Methane Capture** (m^3/year)	Methane Capture** (t CH4/year)	Methane Capture** (tCO2e/year)	Methane Destruction (tCO2e/year)	Baseline Destruction (tCO2e/year) $F_{CH4,BL,y,x-1}$	LFG Capture Eff. (avg annual %)	LFG Destruction Eff. (avg annual %)	LF Emissions* (tCO2e/year)	Baseline Emissions (tCO2e/year)	Project Emissions (tCO2e/year)	Emission Reductions (tCO2e/year)
2010	1,444,772,060	51.66	40,911,610	21,134,152	13,858	291,011	285,191	285,191	47	46	624,703			
2011	1,144,969,277	51.19	32,422,095	16,596,371	10,882	228,527	223,957	223,957	36	36	628,692			
2 yr avg (2010-11)* **	**1,294,870,669**	**51.42**	**36,666,853**	**18,865,262**	**12,370**	**259,769**	**254,574**	**254,574**	**41**	**41**	**626,697**			
Forecasts							$F_{CH4,PJ,y}$	$F_{CH4,BL,y}$	n_{PJ}		$BE_{CH4,SWDS,y}$	BE_y	PE_y	ER_y
2012	1,639,379,128	52.80	46,422,299	24,510,974	16,072	337,509	330,759	259,207	53	52	637,853	64,397	0	64,397
2013	2,276,538,141	52.00	64,464,731	33,521,660	21,980	461,583	452,352	259,720	72	71	639,115	173,368	0	173,368
2014	2,620,871,148	52.00	74,215,208	38,591,908	25,305	531,399	520,771	159,136	83	82	637,679	235,471	0	235,471
2015	2,615,396,605	52.00	74,060,186	38,511,297	25,252	530,289	519,683	258,595	83	82	636,347	234,979	0	234,979
											Estimated Totals	**708,216**	**0**	**708,216**

Conversion factors:

LFG scf to LFG m3	0.028317	at standard temperature and pressure
LFG m3 to methane m3	Used annual average methane concentration from LFG Summary table for 2009 - 2012, used 52% methane annual average for 2013, 2014, 2015)	
methane m3 to tCO2eq	0.0137697	using methane density: 0.6557kg/m3 (25C and 1atm) (CRA, 1996)
GWP_{CH4}	21	

Notes:

* From CRA Report Jan 2011 Ref No. 053470 (04) – forecast does not subtract captured gas (Updated July 18, 2102 incl. C&D waste and Demo-Hog waste)

** For 2010 to 2011 – Data extracted from CoV Annual LFG Summary Spreadsheet Updated 2012.
Total LFG Capture includes source data from Maxim Power Corp. and COV (Total annual supply to Flares/Cogeneration/Admin building)

*** Baseline Scenario using 2 year average methane emissions for baseline year prior to project activity

Methane Capture (tCO2e/year) based on methane density of 0.6557 kg/m3 (0.0006557 t/m3) at 1 atmosphere (101.325 kPa) and 25 deg. C and GWP of 21

Baseline emissions estimated using CDM Methodology ACM0001 “Flaring or use of landfill gas” Ver. 13.0.0

Methane oxidation factor has been considered in LFG generation from SWDS using the CRA 2011 LFG Generation Assessment, therefore added to Eq. 2 baseline emissions from CRA emissions estimate in project year.

Historical amount of methane that would have been captured and destroyed in project year calculated using CDM Methodology ACM0001 , Ver. 11

Increased LFG Capture efficiency in years 2013, 2014 and 2015 to adjust for oxidation factor applied to LFG emission forecast by CRA in LFG assessment (BC LFG Regulation does not account for Methane Ox in Capture efficiency calculation)