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2015 - FIVE YEAR FOLLOW-UP REPORT

Landfill Gas Generation Assessment Report Update

Submitted to:
Regional District of Central Okanagan
1450 KLO Road
Kelowna, BC
V1W 3Z4

REPORT

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Golder Associates

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1.0 INTRODUCTION

The Regional District of Central Okanagan (RDCO) has retained Golder Associates Ltd. (Golder) to complete a supplementary assessment report for Westside Landfill to satisfy Section 15 of the Province of British Columbia Ministry of Environment's (MoE's) *Landfill Gas Management Regulation* (December 8, 2008, Order in Council No. 903). The Regulation requires that such a report be completed between January 1 and March 31 of the fifth calendar year after the preliminary assessment, which was completed by CH2M Hill Limited (CH2M Hill) in 2010 (See Appendix A). The current report is submitted to satisfy that requirement.

Section 15 of the *Landfill Gas Management Regulation* applies in cases where the estimated emission of methane was less than 1000 tonnes annually in the initial assessment, which is the case for Westside Landfill (CH2M Hill Canada Ltd., 2010). Section 15, under 15 (1), requires that a qualified professional either:

- Conduct a supplementary assessment that includes the assessments required under 4 (2) (a) to (c) and (e), and an estimate of the quantity of methane generated at the landfill site each of the calendar years preceding the calendar year in which the supplementary assessment is conducted; or,
- Reviews the previous assessment to determine whether there have been any material changes in the information since the previous report.

Given that CH2M Hill included estimated filling at Westside Landfill, up to the end of 2010, and that acceptance of waste at the site ceased as planned in June of 2010, Golder has elected to complete a review of the previous assessment to determine whether there have been any material changes in the information since the previous report.

CH2M Hill used the Landfill Gas Calculation Tool provided by the MoE in conjunction with the *Landfill Gas Management Regulation*, and as described in the estimate emissions. Any "material" changes to the inputs would be expected to change the estimated gas emissions, although the change could be either a decrease or increase in the estimate. In Section 2.0 of this report, each of the key inputs required for operation of the Landfill Gas Calculation Tool are reviewed, along with specific recommendations provided by CH2M Hill. Section 3.0 includes additional assessment based on review of landfill gas monitoring program results for the period from late 2000 to the end of 2014, review of the additional analysis completed for the 2010 assessment, and discussion of recommendations from the 2010 assessment. Section 3.0 includes a brief summary of the key points from the 2015 supplementary Landfill Gas Assessment.

2.0 REVIEW OF KEY PARAMETERS

The inputs required for the Landfill Gas Calculation Tool include:

- Annual totals of waste disposed at site;
- Waste Characterization, including classification by percentage composition; and,
- Methane generation parameters (a set of three).

The original selection of values for each of these inputs, and whether or not there have been any substantive changes or new information, is discussed in Sections 2.1 through 2.3.

2.1 Annual Totals of Waste Disposed at Site

CH2M Hill prepared estimates of the total waste disposed at site up to the scheduled end of filling in 2010. Golder understands that waste disposal did in fact stop at the site in 2010 as planned, and thus no additional filling took place. Golder is not aware of any revisions in the estimates of waste disposed at site. Thus, there does not appear to be any reason to modify the estimate of annual disposal rates at the site that CH2M Hill used in their 2010 assessment.

It should be noted that methane generation rate from waste disposed in a given year is assumed to decline exponentially in the equations used in the Landfill Gas Calculation Tool. Thus, since no waste has been disposed at the site in the last five years, the total emissions estimated from Westside Landfill would be lower, if redone in 2015, because of this exponential decay in contributions.

2.2 Waste Composition

CH2M Hill used the results of a Waste Audit for Glenmore Landfill completed by the Regional Waste Reduction Office in 2008 as a basis for assigning the proportions of “decomposable”, “moderately decomposable” and “relatively inert” waste. However, CH2M Hill increased the proportion of waste in the “decomposable” category by 5% to 42% of the total waste stream, which resulted in decreasing the assumed percentage for “relatively inert” waste by 5% to 23%. The proportion of “moderately decomposable” waste was set to 35%, the same value found in the Waste Audit.

Glenmore Landfill serves a nearby “waste catchment” area and it appears reasonable to assume that waste disposed at Westside Landfill would be similar in catchment. By increasing the assumed percentage of “decomposable waste”, CH2M Hill would get a higher emission rate estimate than would have been the case if they had used the Waste Audit results for Glenmore Landfill as the basis for their estimate. Golder is not aware of any new information that suggests that the original composition estimates should be modified such that the percentages of either “decomposable” or “moderately decomposable” waste be increased, which would be the only change that would lead to an increase in the emission rate.

2.3 Methane Generation Parameters

There are three methane generation parameters included in the model: (1) the methane generation potential (commonly represented as Lo); (2) the methane generation rate (commonly represented as k); and (3) the water addition factor.

2.3.1 Methane Generation Potential

The Landfill Gas Guideline sets methane generation potential (Lo) for each of the three types of waste – “decomposable”, “moderately decomposable”, and “relatively inert”. Thus, this factor is not adjusted independently, but rather its effect on the emission estimate simply follows from the waste disposal and waste composition estimates discussed in Section 2.2.

2.3.2 Methane Generation Rate

The methane generation rate (k) depends on both the relative amounts of the different classes of wastes ("decomposable", "moderately decomposable", and "relatively inert") and the annual precipitation. CH2M Hill selected values for k for the different classes of wastes from those described in the Guidelines, assuming that annual precipitation at Kelowna was on average 415 mm, which falls within the 250 mm to 500 mm class. Environment Canada's 30-year normal precipitation is 344.5 mm annually for the period from 1981 to 2010 for the Kelowna PC Burnetts Nursery Station, which is the closest station to Westside Landfill. This result falls into the same 250 mm to 500 mm annual precipitation band selected by CH2M Hill, thus, there does not appear to be any rationale for adjusting CH2M Hill's selection of "k" values.

2.3.3 Water Addition Factor

The water addition factor, which based on criteria in the Guidance document, can vary from 0.9 to 1.1, depending on site conditions. This factor is used to modify "k", the methane generation rate constant. CH2M Hill selected a water addition factor of 0.9, based primarily on their judgement based on the storm water management practices in place at the site and the fact that there is no leachate recapture and recirculation on site. The factor k is a constant in an exponential decay function in the model, and thus there is not a linear change in the estimated generation of methane. Golder is not aware of any questions being raised regarding CH2M Hill's selection of "k" in the original assessment. Golder notes that the estimate of methane generation provided by CH2M Hill would have been somewhat higher had a water addition factor of 1.0 been selected instead of 0.9. However, as discussed in the following section, the assumptions regarding the percentage of methane in landfill gas generated at Westside Landfill included in the calculation procedure can be refined based on data collected over the period 2000 to 2014, which suggest much lower rates of methane production than suggested using the Landfill Gas Calculator.

3.0 ADDITIONAL CONSIDERATIONS

In Section 3.1, additional considerations based on the results from the landfill gas monitoring program are discussed. In Section 3.2, the additional analysis included in the 2010 is discussed, and in Section 3.3, recommendations from the 2010 assessment are discussed.

3.1 Additional Considerations Based on Monitoring Results

Landfill gas monitoring has been taking place at the site since late in 2000. The program has evolved somewhat over time. Currently, and for most of the monitoring events since 2000, measurements of methane, carbon dioxide, carbon monoxide, hydrogen sulphide and oxygen have been made. Golder has assembled the data for the period from December of 2000 to December of 2014. Over that period of time, some 1439 landfill gas measurements have been made, of which 1006 readings include values for methane and carbon dioxide. Of these 1006 readings, some 208 had methane or carbon dioxide levels that were either at or so close to zero (lower than the level expected in the atmosphere) that they are considered to be non-detectable.

For the readings with detectable levels of methane and carbon dioxide, the percentage of methane to the combined total of methane and carbon dioxide was estimated. The Landfill Gas Calculation Tool estimates are based on the assumption that methane and carbon dioxide will each comprise 50% of the landfill gas generated, which is what is expected with anaerobic decomposition of waste. Since there is some methane and carbon dioxide in the atmosphere, these ambient levels were subtracted from the measured values in the landfill gas to better reflect the concentration that could be attributed to generation from decomposition of waste. After making these corrections, only 2.3% of the gas generated was methane, with the other 97.7% being carbon dioxide. This result is the same as results for the period from 2000 to 2014, and for 2014.

The monitors are primarily located along the perimeter of the landfill and not across the entire surface, and thus the results may not be fully representative. However, the source of the methane and carbon dioxide would be from decomposition of waste (adjustments were made to take into account the amounts normally present in the atmosphere), and thus provide some indication of the processes that are at work in the landfill. Based on the data from the landfill gas monitoring program, it appears that percentage of methane in the landfill gas that is generated in Westside Landfill is likely much lower than 50%, indicating that aerobic decomposition or oxidation of methane may be significant at this landfill. This is plausible since the landfill is located in a semi-arid area, and that most or all of the waste appears to lie above the water table. In order to further assess the issue of whether or not aerobic decomposition is more significant than anaerobic at this site, some additional analysis of monitoring data has been completed.

Aerobic decomposition is expected to result in “consumption” of oxygen and “production” of carbon dioxide. Thus, potting the “consumption” of oxygen, which is taken as the level of oxygen in the atmosphere less the amount measured in the soil vapour, against the carbon dioxide produced, which is the carbon dioxide measured in the soil vapour less the amount naturally in the atmosphere, should result in a 1:1 relationship. Some 753 of the soil vapour measurements used in the analyses presented above had oxygen measurements as well as the carbon dioxide measurements. These data were used to estimate the amount of oxygen consumed (the atmospheric value less the measured value) and the amount of carbon dioxide produced (the measured value less the level in the atmosphere). The resulting estimates of carbon dioxide “produced” against the corresponding estimate of the amount of oxygen “consumed’ are plotted in Figure 1, as a bubble chart, with the bubble area being proportional to the methane level.

As can be seen in Figure 1, much of the data is scattered around the 1:1 line, as would be expected from aerobic decay. As oxygen “Consumption” approaches the approximately 21% maximum (the amount of oxygen in the atmosphere), methane levels tend to increase, as indicated by the bubble size (which reaches an artificial limit at the upper resolution limit of the methane detectors typically used). The results in Figure 1 are consistent with aerobic decomposition being the dominant form of decomposition for much of the data.

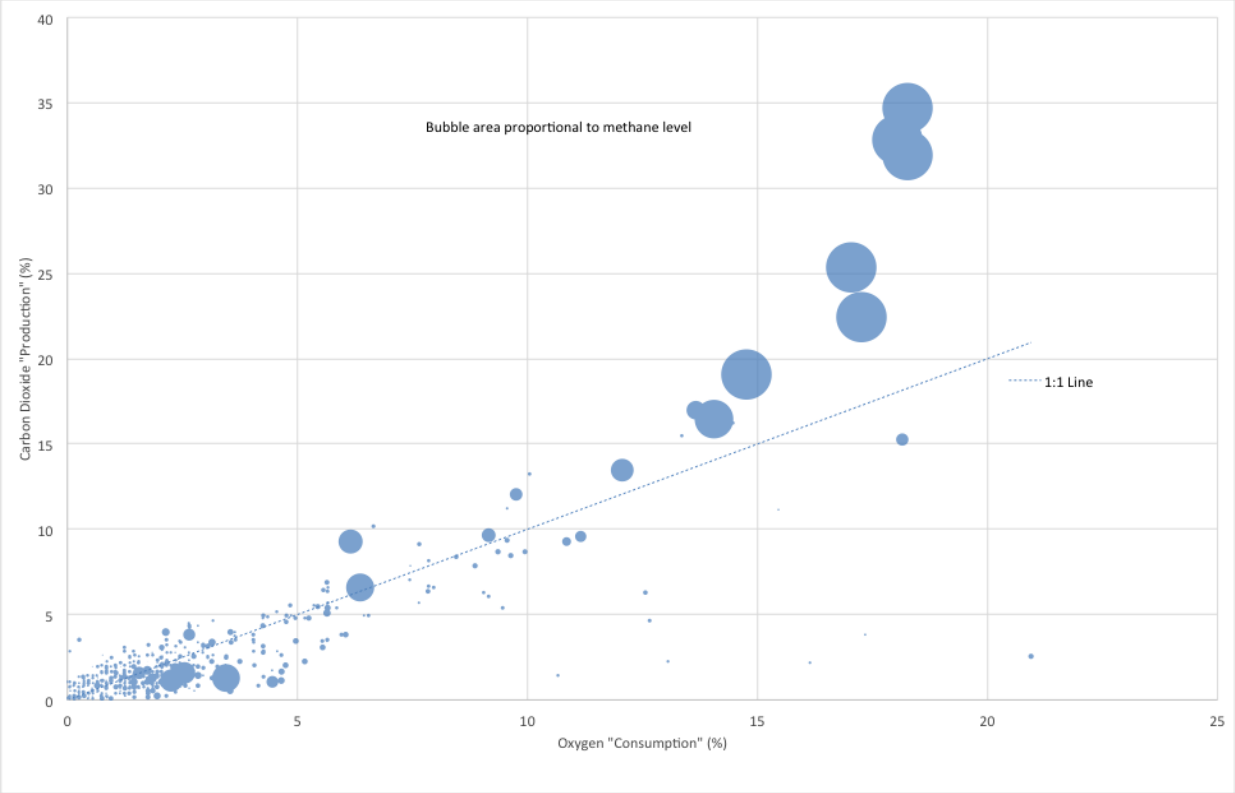

Figure 1: Carbon Dioxide "Production" versus Oxygen "Consumption"

3.2 Discussion of Additional Analysis from the 2010 Assessment

The 2010 assessment also included an estimate of emissions of non-methane organic compounds (NMOCs), using the United States Environmental Protection Agency's Landfill Gas Emission Model (LandGEM). CH2M Hill used version 3.02 of the LandGEM model, which is still the most current version of the model. They estimated that emissions of NMOCs would be between 31 and 54 metric tonnes, depending on the selection of parameters. One of the key input parameters for the model is the amount of waste disposed by year. There has been no additional placement of waste on site beyond that assumed by CH2M Hill in the 2010 assessment. One of the variable parameters in the LandGEM model is the percentage of methane in the landfill gas. The default is 50%, which as discussed in Section 2.4, is much higher than the percentage estimated from monitoring results. However, the model only accepts values for the percentage of methane levels in the landfill gas in the range from 40% to 50%, hence rerunning the model would not allow use of significantly more accurate values.

3.3 Discussion of Recommendations from the 2010 Assessment

CH2M Hill noted that given the proximity of the landfill to residential areas to the east and taking into consideration a preliminary assessment of risks related to possible migration of landfill gas (Golder, 2009), that there should be additional investigation to determine whether or not LFG collection and treatment is required.

Golder concurs, and a proposed plan for further investigation will be included in an updated closure report that is in preparation by Golder.

4.0 CLOSURE

This report reviews a Landfill Gas Assessment report by CH2M Hill completed in 2010, to fulfil the requirements outlined in the Landfill Gas Management Regulation for a review after five calendar years for landfills that in a preliminary assessment were estimated to emit less than 1000 tonnes of methane annually. The 2010 assessment included estimated waste disposed to closure in 2010. Since there has been no additional placement of waste beyond the closure in 2010, the assessment primarily included a review of the selection of parameters for use in estimation of the methane. As discussed, the parameter values selected for the earlier assessment appear to be reasonable. As further discussed, however, the monitoring results now available suggest that aerobic decomposition of waste is much more significant at the site than anaerobic, with methane probably comprising less than 3% of the landfill gas generated on average, rather than 50% assumed in the screening level modelling. Based on the landfill gas monitoring completed at the site, it appears likely that the actual methane emissions are considerably lower than estimated in the 2010 assessment.

The Landfill Gas Management Regulation does not specify that there is a requirement for additional assessment after the completion of a supplementary assessment. Given the results of the supplementary assessment presented herein and the fact that the landfill no longer receives waste, it is suggested that no further assessment under the Landfill Gas Management Regulation appears to be required. It should be noted that landfill gas monitoring is ongoing, but the focus is on assessing potential off-site migration of landfill gas, rather than estimation of methane emissions to the atmosphere. The landfill gas monitoring program will continue, with results being reported to the Ministry of Environment regularly (currently annually).

Yours truly,

GOLDER ASSOCIATES LTD.

Gary Barrett, Ph.D., P.Geo.
Senior Consultant

Rick Peleshytyk, P.Eng.
Principal

GB/RP/kv

https://capws.golder.com/sites/1406505westsidelandfillclosureplan/phases and tasks/07 deliverables/1406505-002-r-rev1-8001-landfill gas generation assessment update-18mar_15.docx

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APPENDIX A

2010 Landfill Gas Assessment

Findings of Initial Landfill Gas Generation Assessment Report – Westside Landfill, Regional District of Central Okanagan (RDCO)

PREPARED FOR:	Chris Radford, RDCO
PREPARED BY:	Caroline Théoret, P.Eng., CH2M HILL
REVIEWED BY:	John Muller, P.Eng., CH2M HILL
COPIES:	Scott Gamble, P.Eng., CH2M HILL
DATE:	May 25, 2010
PROJECT NUMBER:	401157

At the request of the RDCO, CH2M HILL Canada Limited (CH2M HILL) has prepared the following Technical Memorandum (TM) to summarize findings associated with the initial Landfill Gas (LFG) generation assessment (the Assessment) conducted as part of the ongoing Detailed Closure Plan being developed for the Westside Landfill (Site). The Assessment was completed in accordance with the British Columbia Ministry of Environment (BC MOE) Landfill Gas Management Regulation (Regulation) that was approved on December 8, 2008.

1. Background

The Site began receiving Municipal Solid Waste (MSW) in 1960 and currently operates under the Operational Certificate (OC) PR12217 issued by the BC MOE on May 28, 1997. The Site primarily services residents and businesses on the west side of Lake Okanagan (municipalities of Westside and Peachland) and RDCO's west electoral area. The Site is scheduled to close in the summer of 2010. The total waste buried at the Site in 2008 was 33,659 metric tonnes (Golder Associates, 2009). Based on a 3-percent population increase, approximately 36,800 metric tonnes of waste will be diverted in 2011 for disposal to the Glenmore Landfill in Kelowna, British Columbia (BC) following Site closure. CH2M HILL was retained in 2010 by RDCO to prepare the Detailed Closure Plan for the Site.

2. Regulation

On December 8, 2008, a new regulation for the management of LFG at BC-regulated landfill sites was ordered and approved. The Regulation describes a regulated landfill site as a site with 100,000 metric tonnes or more of MSW in place, or that has received 10,000 or more metric tonnes of MSW annually for disposal into the landfill site in any calendar year after 2008 (BC MOE, 2008). Since a total of 10,624 metric tonnes of MSW was buried at the Site in 2009 (Rotheisler, 2010), the Site is considered a regulated landfill and subject to the Regulation. The total quantity of waste buried at the Site was estimated to be approximately 778,000 metric tonnes, which also falls under a regulated landfill.

The Assessment and report must be conducted in accordance with Regulation requirements and submitted to the BC MOE Director no later than January 1, 2011. An LFG management facilities design plan must be prepared for the Site if the generation of methane is estimated to be 1,000 metric tonnes or more in the calendar year immediately preceding the Assessment. This plan must be submitted no later than 1 year after the date the Assessment Report was submitted to the director. The Regulation defines LFG management as including managing LFG migration, collection, storage, and flaring. The LFG management facilities and practices must be installed and implemented no later than 4 years after the LFG management facilities design plan submittal date.

The Regulation states that the Assessment must be conducted in accordance with the most recent edition of LFG guidelines as approved by the BC MOE Director. The LFG Generation Assessment Procedure Guidance Report (CRA, 2009) is the LFG Guideline used by the BC MOE. It is available on the BC MOE Regulation official website and must be used to guide the Assessment. The Regulation further states that the Assessment must be prepared by a qualified professional who will use his or her knowledge with respect to solid waste and LFG management to select models for LFG estimation, assess results, and provide required recommendations.

3. Initial LFG Assessment

The Assessment has been conducted according to the Regulation. The report will be included in the Detailed Closure Plan for the Site. This TM prepared by CH2M HILL summarizes findings of The Assessment. This section details the methodology used to complete the Assessment, the annual waste buried at the Site, the references for the selected methane generation input parameters, the results, and an overview of the next steps required by the Regulation.

3.1 Methodology

LFG production at the Site was estimated using the calculation tool available on the BC MOE Regulation official website and according to the BC MOE LFG Guideline.

The model is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of wastes in MSW landfills. Exhibit 1 presents the parameters required to run the model.

EXHIBIT 1
Input Parameters used in the BC MOE LFG Guideline Calculation Tool

Input Parameters or Constants	LFG Generation Model
	BC MOE LFG Guideline, Calculation Tool
Landfill first year	1980
Landfill closure year	2010
Annual waste tonnage	Annual waste acceptance for 30 years (from 1980 to 2010) Annual waste tonnages for relatively inert waste and moderately decomposable and decomposable wastes
k	methane generation rates
methane generation rates	for relatively inert, and moderately decomposable and decomposable wastes
Lo	potential methane generation capacity
Waste types	relatively inert, moderately decomposable, and decomposable wastes

k = Methane Generation Rate per year

Lo = Potential Methane Generation Capacity (m^3 methane / Mg of waste) or (m^3 methane / metric tonne of waste)

m^3/Mg = cubic meters per megagram

m^3/ metric tonne = cubic meters per metric tonne

The model accounts for different factors associated with the generation of LFG and contains a matrix that requires the user to define historical waste characteristics.

3.2 Waste Characteristics

Characterization according to Waste Types is required to conduct the simulation using the BC MOE LFG Guideline calculation tool. Waste must be characterized into three categories: relatively inert, moderately decomposable, and decomposable. As is the case for most BC landfill sites, waste composition studies have not been conducted at the Site. A Waste Audit was conducted by the Regional Waste Reduction Office in conjunction with the Glenmore Landfill between April 28 and May 2, 2008 at the Glenmore Landfill. Considering the proximity of both landfills, the above-mentioned Glenmore waste composition study has been selected to define the Waste Type for the Westside Landfill. Considering that, as is the case for most BC landfill sites, waste composition studies have not been conducted every year or on a regular basis, it should be noted that the Waste Type percentages have been used to characterize the waste for every year of landfill development, from beginning to closure.

Based on the above-mentioned study and on Appendix A, Categorized Waste Types, from the BC MOE LFG Guideline, decomposable waste represents the most significant component of the waste stream, with 37 percent; followed by relatively inert waste, with 28 percent; and a quantity of moderately decomposable wastes of approximately 35 percent.

In a landfill, methane generation is directly linked to waste decomposition and its organic content. Considering this and that there is no waste composition study for the Site, in order to conduct a conservative assessment, Waste Type percentages were modified, and the following were used in the simulation:

- Decomposable waste: 42 percent (was increased by 5 percent)
- Moderately decomposable: 35 percent
- Relatively inert waste: 23 percent (reduced by 5 percent)

3.3 Annual Waste Buried

Exhibit 2 presents the estimated annual amount of MSW disposed at the Site from years 1960 to 2010. The waste history estimates are based on the annual quantity of waste buried at the site between 2000 and 2008 (Susan, 2008), the estimated remaining quantity of waste to be disposed in 2010 in order to reach closure capacity for the Site, the estimated total volume of waste buried at the Site, and the following assumptions:

- Population increase of 3 percent after 1960
- Tonnages per capita per year (tcy) of 0.70 from 1960 to 1990
- Tonnages tcy of 0.65 from 1991 to 1999

The estimated total amount of waste buried at the Site was based on the following site data and waste factors:

- Estimation of total landfill volume using the May 20, 2009 topographic survey that was conducted by Ansell Construction Ltd.
- 30 percent volume for cover material
- Waste density of 0.7 metric tonne/m^3

EXHIBIT 2
Annual Quantity of Waste Disposed at the Site

Years	Waste Disposed	Cumulative Waste Disposed	Population	tcy
	Metric tonnes	Metric tonnes		
1960	7,041	7,041	10,059	0.70
1961	7,259	14,301	10,370	0.70
1962	7,484	21,784	10,691	0.70
1963	7,715	29,500	11,022	0.70
1964	7,954	37,453	11,363	0.70
1965	8,200	45,653	11,714	0.70
1966	8,453	54,107	12,076	0.70
1967	8,715	62,821	12,450	0.70
1968	8,984	71,806	12,835	0.70
1969	9,262	81,068	13,232	0.70

EXHIBIT 2
Annual Quantity of Waste Disposed at the Site

Years	Waste Disposed	Cumulative Waste Disposed	Population	tcy
	Metric tonnes	Metric tonnes		
1970	9,549	90,617	13,641	0.70
1971	9,844	100,461	14,063	0.70
1972	10,148	110,609	14,498	0.70
1973	10,462	121,072	14,946	0.70
1974	10,786	131,858	15,408	0.70
1975	11,120	142,977	15,885	0.70
1976	11,463	154,441	16,376	0.70
1977	11,818	166,258	16,883	0.70
1978	12,183	178,442	17,405	0.70
1979	12,560	191,002	17,943	0.70
1980	12,949	203,951	18,498	0.70
1981	13,349	217,300	19,070	0.70
1982	13,762	231,062	19,660	0.70
1983	14,188	245,250	20,268	0.70
1984	14,626	259,876	20,895	0.70
1985	15,079	274,955	21,541	0.70
1986	15,545	290,501	22,207	0.70
1987	16,026	306,527	22,894	0.70
1988	16,522	323,048	23,602	0.70
1989	17,033	340,081	24,332	0.70
1990	17,559	357,640	25,085	0.70
1991	16,809	374,450	25,861	0.65
1992	17,329	391,779	26,661	0.65
1993	17,865	409,644	27,485	0.65
1994	18,418	428,062	28,335	0.65
1995	18,987	447,050	29,211	0.65
1996	19,575	466,624	30,115	0.65
1997	20,180	486,804	31,046	0.65
1998	20,804	507,609	32,006	0.65
1999	21,448	529,056	32,996	0.65

EXHIBIT 2
Annual Quantity of Waste Disposed at the Site

Years	Waste Disposed	Cumulative Waste Disposed	Population	tcy
	Metric tonnes	Metric tonnes		
2000	19,939	548,995	34,017	0.59
2001	19,460	568,455	35,069	0.55
2002	24,030	592,485	36,154	0.66
2003	24,040	616,525	37,272	0.64
2004	30,498	647,023	38,424	0.79
2005	28,244	675,267	39,613	0.71
2006	28,857	704,124	40,838	0.71
2007	31,429	735,553	42,101	0.75
2008	33,659	769,212	43,364	0.78
2009	10,624	779,836	44,665	0.24
2010	2,562	782,398	46,005	0.06

Notes:

1: Waste disposed at the Site between 2000 and 2007 (Susan, 2008).

2: Waste disposed at the Site in 2008 (Golder Associates, 2009).

3: Waste disposed at the Site in 2009 (Rotheisler, 2010).

4: Estimated waste quantity to be buried in 2010 considering the Site closure.

3.4 Methane Generation Parameters

3.4.1 Methane Generation Potential (Lo)

The input parameters used for the Lo value are based on the BC MOE LFG Guideline calculation tool (Table 5.1). For this Site, the model uses a Lo-value of 20 m^3 methane (CH_4)/ metric tonnes of waste for relatively inert waste, 120 m^3 CH_4/metric tonnes of waste for moderately decomposable waste, and 160 m^3 CH_4/metric tonnes of waste for decomposable waste.

3.4.2 Methane Generation Rate (k)

Input parameters used for the methane generation rate constant (k) are based on the BC MOE LFG Guideline calculation tool (Table 5.2), which are based on annual precipitation. For this Site, the model uses a k-value of 0.01/year (yr) for relatively inert waste, 0.02/yr for moderately decomposable waste, and 0.05/yr for decomposable wastes. The annual precipitation for the Site has been estimated at 415 millimeters (mm) based on the selected Environment Canada weather station located in East Kelowna.

3.4.3 Water addition factor

According to the BC MOE LFG Guideline, Section 5.4, the selected k-value should be corrected based on the landfill operation and maintenance practices, including: stormwater management, cover properties, and the extent of leachate recirculation or stormwater

injection. Based on Table 5.3 of the BC MOE LFG Guideline, the water addition factor appropriate for the Site conditions in 2009 is 0.9.

Low-permeability final cover has been installed on a portion of the Site, and the landfill stormwater management works have been implemented partially across the Site. An additional assessment has been conducted using the BC MOE LFG Guideline calculation tool with a water addition factor of 1.0 to estimate the methane generation, assuming low-permeability final cover installed across the entire Site and stormwater best management practices fully implemented across the Site. The result is discussed in the following section.

3.5 Results of the Assessment

The estimated LFG generation rates for the Site are shown in Exhibit 3.

EXHIBIT 3
Estimated LFG Generation Rates for the Site

		LFG Generation Model		
Parameters	**Units**	**BCMOE guideline, calculation tool, (Note)**		
		Waste Characteristics		
		Relatively inert 23 %	**Moderately decomposable 35%**	**Decomposable 42 %**
k	per yr	0.01	0.02	0.05
Lo	m^3 CH_4 / metric tonnes of waste	20	120	160

Results	**Units**	
Methane generated in 2009	metric tonnes CH_4/yr	953

Note:
(Regional Waste Reduction Office, 2008)

According to the BC MOE LFG Guideline calculation tools, the quantity of methane generated in 2009 at the Site is 953 metric tonnes, using a water addition factor of 0.9, the waste characteristics according to the Waste Audit Report for the Glenmore Landfill (Regional Waste Reduction Office, 2008), and increasing the decomposable waste content by 5 percent to be conservative, as discussed in Section 3.2.

3.6 Additional Assessment

A simulation was conducted using the LandGEM – Landfill Gas Emission Model, version 3.02 (LandGEM), United State (U.S.) Environmental Protection Agency (EPA) to estimate the Non-methane Organic Compounds (NMOCs). Results of the Assessment show that the emissions included 31 and 54 metric tonnes of NMOCs in 2009, using a k-value of 0.02 /yr and Lo-value of 100 and 170 m^3 CH_4/metric tonnes of waste. References for the Lo-value are described as follows:

- Reference for Lo of 170 m^3 CH_4/metric tonnes of waste: Clean Air Act (CAA) default. The CAA defaults are based on requirements for MSW landfills.
- Reference for Lo of 100 m^3 CH_4/metric tonnes of waste: Inventory defaults are based on emission factors in EPA's Compilation of Air Pollutant Emission Factors (AP-42) and can be used to generate emission estimates for use in emission inventories and air permits in the absence of site-specific test data.

4. Conclusion and Next Steps

This TM summarizes findings associated with the Assessment conducted as part of the Detailed Closure Plan that is currently being developed for the Site. The Assessment has been completed in accordance with Regulation requirements. According to the BC MOE Guideline calculation tools, the quantity of methane generated in 2009 is not greater than 1,000 metric tonnes.

It should be noted that the result of the Assessment is based on methane generation input parameters as recommended in the BC MOE LFG Guideline. Also, historical data prior to 2000 were not available to estimate the total quantity of waste buried at the Site, which has been estimated based on the May 20, 2009 topographic survey conducted by Ansell Construction Ltd and assumed density. Finally, the Waste Type percentages are based on the Waste Audit Report (Regional Waste Reduction Office, 2008), and have been used to characterize the waste for every year of landfill development from beginning to closure. Considering the above, the estimated methane generation calculated in 2009 for the Site could vary based on actual tonnage of waste landfilled and different site-specific input parameter assumptions.

It should be noted that the rate of LFG direct emission to the atmosphere could be lower than the LFG generation rate considering methane oxidation through the landfill cover which has been installed over a large area of the landfill's slopes. The LandGEM assessments conducted for this Site show the emission of NMOCs is below 150 metric tonnes/yr.

According to the Regulation, if the estimate of methane generated in 2009 is not greater than 1,000 metric tonnes, a LFG management facilities design plan for the Site is not required. The Regulation states that if the estimate of methane generated in 2009 is not greater than 1,000 metric tonnes, a supplementary assessment following Section 15 of the Regulation must be conducted during the fifth calendar year following the calendar year of the previous assessment (2010). The supplementary assessment report must be submitted to the Director no later than March 31, 2015.

Considering the east landfill footprint is at the property boundary and the proximity of the residential area, and based on CH2M HILL's evaluation of the Landfill Gas Monitoring and Preliminary Vapour Risk Assessment for the Westside Landfill (Golder, 2009), there are a number of issues that are a cause for concern and would make it very difficult to support the conclusions without additional investigation. Therefore, CH2H HILL recommends additional investigation to evaluate whether LFG collection and treatment is required for LFG migration and odor control.

5. References

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Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
220 - 1755 Springfield Road
Kelowna, British Columbia, V1Y 5V5
Canada
T: +1 (250) 860 8424

Golder Associates