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Hartland Landfill Environmental Program

2013-2014 Annual Report

Parks & Environmental Services | Environmental Protection

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HARTLAND LANDFILL ENVIRONMENTAL PROGRAM
2013-2014 ANNUAL REPORT

EXECUTIVE SUMMARY

The Hartland landfill provides solid waste disposal services for the Capital Regional District (CRD). The operation of a landfill can result in environmental effects and health and safety issues; specifically, effects to surface water and groundwater, and the production of landfill leachate and landfill gas.

Measures are in place at Hartland landfill to reduce and control releases to groundwater, surface water, leachate and air. An environmental monitoring, assessment and management program assesses the effectiveness of the control measures and identifies potential impacts. In addition, a permitting program regulates the receipt of controlled wastes which require special handling due to operational requirements, potential health and safety risk to workers or adverse effects to the environment.

This annual report presents a summary of the key findings and recommendations for the following Hartland Environmental Program components and reporting periods:

- landfill gas monitoring (January to December 2013)
- groundwater, surface water and leachate monitoring (April 2013 to March 2014)
- controlled waste permitting (January to December 2013)

The reporting period follows the calendar year with the exception of the groundwater, surface water and leachate monitoring component. The reporting period for this component is shifted to improve evaluation of trends through the complete wet winter period which is key to understanding the hydrogeological response in the system.

LANDFILL GAS

Decomposition of refuse creates landfill gas which, if not controlled, escapes to the atmosphere. Even with proper landfill gas collection and control, there will be fugitive landfill gas emissions. A number of factors influence this, such as atmospheric pressure, groundwater level, gas pressure in the refuse mass and permeability of cover systems. Hartland landfill has a landfill gas collection system to minimize fugitive emissions and a monitoring program is in place to assess the effectiveness of these controls. The landfill gas monitoring program includes the following four main components:

- **Collection and treatment system monitoring** to assess changes in gas quality over time, and evaluate data for gas collection and gas utilization to assess collection efficiency and total emissions from the landfill.

- **Perimeter and building foundation probe monitoring** to assess the potential for subsurface landfill gas migration at the eastern landfill boundary and at onsite buildings for compliance with criteria, and for worker and public health and safety.

- **Ambient grid and hot spot monitoring** to verify the effectiveness of cover and landfill gas collection systems and identify areas of concern where landfill gas is being released to the atmosphere for protection of worker and public health and safety.

- **Landfill Gas Speciation** to assess the composition of gas with regard to volatile organic compounds (VOC), sulphur gases and typical landfill gases in order to calculate ambient dilution concentrations for health and safety and infrastructure integrity purposes.

Collection and Treatment System Monitoring

Gas collection wells are adjusted monthly to optimize the flow, methane and oxygen content of the gas as recommended by the Landfill Management Facilities Guidelines. In 2013, the gas collection system consisted of 73 vertical wells, 26 horizontal wells, 11 leachate horizontal gas wells and five leachate gas trench wells, for a total of 115 wells. Six new horizontal wells were installed in completed lifts in Phase 2 as outlined in the Landfill Gas Management Plan. The top five collecting wells accounted for close to

40% of the total volume of gas collected. The well field should continue to be measured and balanced at least monthly, as was conducted in 2013.

Landfill gas is drawn under vacuum to the gas plant where it is directed to a generator and/or to a flare. The gas is then conditioned (cleaned) and methane and oxygen content is measured. Excess gas is fed back to a candlestick flare, while the groundflare is only used during extended generator downtime.

According to the Hartland landfill gas model, approximately 1,697 standard cubic feet per minute (scfm) of landfill gas was produced by the landfill in 2013. Of this, 488 scfm was utilized by the generator and 506 scfm was flared, which represents a collection efficiency of 58%. This is an improvement from 2011 (34%) and 2012 (49%) which can be attributed to the Phase 2, Cell 1 closure and an increased installation density of new gas wells. The equivalent of 103,135 tonnes CO_2e were utilized or flared resulting in total GHG emissions from the landfill estimated at 70,779 tonnes CO_2e.

Perimeter and Building Foundation Probe Monitoring

In 2013, all probes were monitored according to standard operating procedures four times. Methane was not detected in any probes with the exception of one sampling event, which can be attributed to equipment malfunction. Quarterly monitoring should continue in order to maintain and evaluate compliance with the Landfill Criteria.

Ambient Grid and Hot Spot Monitoring

A bi-annual program has been established to monitor fugitive emissions from Hartland landfill in order to track the effectiveness of the landfill gas collection network, as well as protect worker health and safety. Monitoring is conducted in accordance with the standard operating procedures which specify monitoring of total hydrocarbons (THC) and hydrogen sulphide according to thresholds established by GeoEnvironmental Programs staff. Increased monitoring is conducted when measured concentrations of THC exceed 100 ppm; areas are classified as hot spots (z-points) when THC exceeds 1,000ppm.

In 2013, two monitoring events were conducted in March and October. Hydrogen sulphide did not exceed WorkSafeBC exposure limits at any monitoring location. A total of 12 unique grid points were found to exceed 100 ppm THC. None of the elevated readings were in the closed area of Phase 1, indicating that the cover and gas collection system in the closed area is effective at preventing fugitive emissions.

At the end of 2013, there were 15 locations with THC concentrations greater than 1,000 ppm, of which 15 were existing hotspots carried over from previous surveys. The number of hot spots has reduced considerably since 2012, due to the Phase 2, Cell 1 closure, as well as an increase in gas collection efficiency. Although fugitive emissions have reduced, they continue to escape from Phase 2 in active areas without cover and at cover seams. Hot spot locations are discussed with Hartland landfill staff and mitigated, where possible.

Gas Speciation

Gas composition results show no notable changes over previous years. The data indicate that undiluted landfill gas exceeded the WorkSafeBC limits for methane, carbon dioxide, hydrogen sulphide, vinyl chloride and benzene. However, exposure to undiluted landfill gas is unlikely as fugitive emissions mix quickly with air. To support this, ambient air sampling was conducted at landfill hot spot locations between 1999 and 2001 and indicates a dilution ratio greater than 100:1.

Landfill Gas Compliance Summary and Recommendations

The following table has been prepared to summarize the results of landfill gas monitoring programs, whether the results comply with requirements, key findings and actions taken to address any non-compliance, and recommendations.

Table 1 Landfill Gas Compliance Summary 2013

Program	Compliance Location	Criteria	Findings	Actions	Recommendations
Perimeter Probe Monitoring	Probes GP-1A, 1B, 2A, 2B, 3A, 3B, 11A, 11B, 12A and 12B	Maximum 1.25% methane in subsurface soil (MOE Landfill Criteria for Municipal Solid Waste)	No exceedences. Low risk of sub-surface gas migration to adjacent properties.	None	Continue quarterly monitoring.
Building Foundation Probe Monitoring	Probes GP- 4A, 5A, 6A, 6B, 7A, 7B, 8A, 9A, 13A, 14A, 17A, 18A	Maximum 1.25% methane in any onsite facility (MOE Landfill Criteria for Municipal Solid Waste). Maximum 1% methane inside buildings (Landfill Gas Management Facility Design Guidelines).	No exceedences. Low risk of subsurface gas migration to adjacent building.	None	Continue quarterly monitoring.
Ambient Grid Monitoring	N/A	100 ppm THC (CRD internal guideline)	12 grid locations >100 ppm No cover system failures suspected in the closed area of Phase 1.	Investigated hot spots, mitigated were possible.	Continue biannual monitoring
Hot Spot Monitoring	N/A	1,000 ppm THC (CRD internal guideline).	3 new hot spots >1,000 ppm, 1 hot spots removed. Currently 2 locations for hot spot investigation.	Added new locations of hot spots to the monitoring program.	Continue biannual monitoring. Investigate remediation measures.
Well Field Monitoring and Balancing	N/A	Monitor monthly. Oxygen (<3%)	Monitoring completed monthly; oxygen did not exceed 3%.	Well field monitoring has been scheduled monthly for 2014.	Continue monthly monitoring at minimum.
Gas Speciation	N/A	N/A	Untreated landfill gas exceeded WorkSafeBC criteria for methane, carbon dioxide, hydrogen sulfide, vinyl chloride and benzene; however, ambient concentrations are likely well below WorkSafeBC limits due to dilution with ambient air.	None	Conduct speciation of landfill gas in 2015.
Gas Collection	N/A	75% gas collection efficiency commencing in 2016 as per Landfill Gas Management Plan.	Gas collection efficiency was estimated at 58.2%, based on the MOE gas generation model.	Landfill gas management plan submitted to MOE.	Continue to implement the long-term gas management plan.

GROUNDWATER, SURFACE WATER AND LEACHATE

The decomposition of solid waste, along with rain and groundwater draining through the landfill, produces leachate. Engineered controls are in place at Hartland landfill to collect and contain leachate to reduce or eliminate potential effects to groundwater and surface water quality. Since 1990, the leachate has been captured and contained on site prior to discharge by pipeline to the sanitary sewer. To verify that effects are mitigated, and resources protected, groundwater and surface water is monitored at the Hartland landfill and specific offsite locations. In addition, leachate, generated by the percolation of precipitation through the garbage, is also monitored for flow and quality.

This monitoring program evaluates groundwater, surface water and leachate quality to assess the effectiveness of the leachate management facilities and assess regulatory compliance. The monitoring program has three main components. The following summarizes these components and their primary purpose:

- **Groundwater quality monitoring** evaluates the impacts of landfill processes and operations and assesses compliance with water quality guidelines at the property boundary.

- **Surface water quality monitoring** evaluates whether the landfill processes and operations are affecting water quality and assesses compliance with water quality guidelines at the property boundary.

- **Leachate quality monitoring** is used to evaluate compliance with the Regional Source Control Program (RSCP) waste discharge permit authorizing discharge to the sanitary sewer and to identify factors that influence changes in leachate chemistry.

Based on monitoring conducted between April 2013 and March 31, 2014, the program continues to provide data needed to assess the effectiveness of the leachate containment and collection system and regulatory compliance, and provides information needed to guide management and operational decisions. The key findings of the groundwater, surface water and leachate monitoring program are summarized below.

Groundwater Quality Monitoring

- Groundwater quality and flow data indicates that landfill leachate is effectively contained and controlled on site, and statistical analysis of water quality trends, at key locations north and south of the landfill, indicates that groundwater quality is gradually improving. The program includes a total of 84 monitored groundwater wells at the landfill, with 43 groundwater monitoring wells identified as boundary compliance monitoring stations. The wells are primarily clustered along the property boundary and some are located closer to the filling area to monitor potential pathways for leachate movement in groundwater. Groundwater quality north of Phase 1 met the BC Contaminated Sites Regulation (CSR) drinking water and aquatic life groundwater standards for all boundary compliance locations. Groundwater quality in this area has improved over time or continues to remain stable based upon statistical analysis. Improvements are being considered related to the effective operation of the north purge well system.

- Groundwater quality met the BC CSR drinking water and aquatic life groundwater standards at the south boundary compliance locations. Groundwater quality is stable and gradually improving at key locations south of the landfill. These improvements are attributed to the leachate collection and containment measures, including the operation of the five south purge wells. Upgrades to the purge well system planned for 2014/2015 are expected to further improve water quality downgradient of the landfill.

- Groundwater quality north of the Hartland North pad met BC CSR drinking water and aquatic life groundwater standards at all boundary compliance locations. Based upon the results, previous impacts in this area have been reduced and overall concentrations are stable or decreasing. Improvements in groundwater quality at wells near the Hartland north pad are attributed to the cover system installed in January 2012. Groundwater quality should continue to be monitored closely and efforts should be made to reduce the volume of aggregate stored and to maintain temporary covers.

- Groundwater quality at the property boundary east of Phase 1 met BC CSR drinking water and aquatic life groundwater standards for the reporting period. Groundwater movement is directed from east to west, preventing offsite leachate migration to the east. The 2013-2014 data collected in wells east of Phase 1 confirmed that landfill leachate is effectively contained on site.

- Eleven privately-owned domestic wells were monitored during the reporting period. No leachate impacts were identified in the wells sampled.

Surface Water Quality Monitoring

- A total of five surface water monitoring stations have been identified as boundary compliance monitoring stations. These stations are concentrated north and south of the landfill where creeks flow from the landfill property to offsite locations. In addition to these boundary compliance locations, Environmental Protection staff sample 26 surface water stations at upstream and downstream locations to assess potential environmental effects to surface water on the site and flowing from the site. Water quality results are compared to the BC Approved and Working Water Quality Guidelines (BC WQG) to assess compliance with the landfill operating certificate.

- The monitoring program provides an effective measure of compliance with water quality guidelines and important information to guide management and operational decisions. A review of the surface water quality data, collected between April 2013 and March 2014, indicated that boundary compliance monitoring stations and the majority of onsite and offsite stations met water quality guidelines. The only parameters reported at concentrations above the guideline values were iron and manganese and these parameters exceeded at a single location in one of five samples during the reporting. Iron and manganese are not considered leachate indicators when observed in the absence of other indicator parameters (i.e., chloride, conductivity, etc.). Table 3 summarizes surface water quality at boundary compliance stations and recommended corrective action.

- Offsite surface water stations met water quality guidelines and no leachate impacts were identified. Water in Killarney Lake met water quality guidelines and no leachate impacts were identified. Water quality in Durrance Lake met water quality guidelines and was not impacted by landfill leachate. There have been no detectable leachate effects in Tod Creek for many years.

Table 2 Surface Water Quality Compliance Summary (2013-2014)

Station	Exceedence	Number of Exceedences	Recommended Corrective Action
North of the Landfill			
SW-N-16	Total Iron	1 of 5 sample events	Continued operation of the north purge well system to minimize leachate migration north of the landfill and consider possible augmentation of the system.
	Total Manganese	1 of 5 sample events	

Leachate Quality Monitoring

- Leachate is regulated under CRD Regional Source Control Program waste discharge permit, which authorizes discharge to sanitary sewer. Leachate discharges remained in compliance with the waste discharge permit with the exception of mineral oil and grease on one sample event.

- Leachate elevations are assessed to identify changes in leachate quantity and flow conditions within the landfill and are used to plan operational activities. Leachate elevations in 2013-2014 were consistent with recent reporting periods and indicate that the leachate containment system functioned effectively throughout the year. Continued collection of water level information within Phase 2 is important for assessing leachate elevation changes over time as waste deposition continues within the Phase 2 basin.

- In November 2013, CRD staff were alerted to a leak on the leachate pipeline. In accordance with our emergency response plan, staff responded to the incident and notified the affected community and local agencies. The leak was repaired and environmental monitoring demonstrated that landfill leachate impacts were confined to the immediate area of the leak site and conditions were improving. Corrective actions were implemented and monitoring continues to confirm the measures were effective.

Recommendations

- Continue the monitoring program (including groundwater, surface water and leachate monitoring) to provide an effective measure of compliance, and the information required to guide management and operational decisions.

- Boundary compliance stations should continue to be sampled at the following frequencies: six times per year for surface water stations; four times per year for groundwater stations; and water levels should be collected 10 times per year.

- Operation of the expanded north and south purge well systems should be continued as these wells are an effective component of the leachate control and containment systems. Water levels and the extent of the drawdown cone should continue to be validated twice annually according to standard operating procedure. This work is currently underway. Efforts should continue to achieve optimal water levels in the south purge wells to mitigate leachate migration towards the south end of the landfill.

- Water quality downgradient of the quarry and aggregate stockpile locations should continue to be closely monitored to assess the effects of these activities, as well as to monitor the effectiveness of the stockpile cover in runoff reduction. Opportunities to manage aggregate stockpiles to reduce infiltration or store stockpiles within the leachate containment area should continue to be considered and implemented.

- Groundwater quality should be closely monitored in the area of well 40 to confirm the effectiveness of the expanded north purge well operation.

- Concentrations of VOC in leachate have historically been very low. Monitoring of VOC in groundwater at property boundary stations has not identified any VOC at detectable concentrations and is not considered necessary to assess compliance. As previously recommended, the sampling and analysis of VOC in groundwater is suspended until such time that VOC are detected in leachate samples, or at a five-year interval.

- Monitoring of leachate flow and chemistry should continue, as it provides an effective measure of compliance with the RSCP permit for leachate discharges to the sanitary sewer.

- Monitoring of leachate within the collection system should continue in order to characterize the variability in leachate chemistry and identify operational factors that affect leachate chemistry.

- On an as-needed basis, the operation of the leachate treatment system, using the nitrate amendment to address periodic sulphide spikes in leachate, and monitoring to demonstrate the effectiveness of the leachate treatment system, is recommended.

- The results of the annual monitoring program should continue to be reviewed and interpreted by qualified professionals experienced in assessing the impacts of landfill leachate at large municipal landfills similar to Hartland landfill.

CONTROLLED WASTE

The controlled waste area of the landfill is a designated area that accepts a range of waste requiring special handling due to specific health and safety, operational or environmental concerns. Discharges of controlled waste are regulated through a permit system administered by Environmental Protection staff to provide control over the wastes discharged, protect worker health and safety, meet operational requirements and minimize additional contamination leading to leachate and landfill gas.

In 2013, commercial loads of construction and demolition waste were designated as a controlled waste in order to reduce the health and safety risks associated with receiving these wastes at the active face.

- During 2013, the permit system worked efficiently and provided landfill staff with the information needed to safely receive the permitted wastes.

- In 2013, a total of 178 controlled waste permits were issued.

- Minor violations or inconsistencies with permit conditions were identified through onsite inspections and audits. All issues were corrected through follow-up with the permit holders.

Recommendations

- Continue the permitting program to ensure that only suitable wastes are received and that the needs of operational requirements, environmental protection and worker health and safety are achieved.

- Continue to inspect and audit discharges to ensure that the discharged waste meets permit requirements.

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Appendix B Hartland Landfill – Landfill Gas Monitoring 2013 Annual Report by Capital Regional District

HARTLAND LANDFILL ENVIRONMENTAL PROGRAM
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1.0 INTRODUCTION

The Hartland landfill provides solid waste disposal services for the Capital Regional District (CRD). The landfill is a multi-purpose facility providing collection services for recyclable materials, household hazardous waste, items covered by product stewardship, and disposal of municipal solid waste and controlled waste. The landfill is operated in accordance with an Operational Certificate issued under the provisions of the *Environmental Management Act* by the BC Ministry of Environment (MOE).

The operation of a landfill can result in a number of environmental effects and health and safety issues. These include effects to groundwater and surface water quality and the production of landfill gas and leachate.

At Hartland landfill, control measures are in place to reduce and control effects to groundwater, surface water, leachate and air. The Hartland Landfill Environmental Program provides a comprehensive monitoring, assessment and management program to meet the Operational Certificate and regulatory requirements by:

- assessing the impact of the Hartland landfill
- evaluating the effectiveness of the control measures
- managing the acceptance of nuisance wastes and wastes that require special handling

The monitoring and assessment results are used to aid in the management of the landfill by providing information to CRD staff, managers and committees for decision making. This report presents a summary of data collected for the following Hartland Environmental Program components, and reporting periods:

- landfill gas monitoring (January to December 2013)
- groundwater, surface water and leachate monitoring (April 2013 to March 2014)
- controlled waste permitting (January to December 2013)

The reporting period follows the calendar year with the exception of the groundwater, surface water and leachate monitoring component. The reporting period for this component was shifted to facilitate evaluation of trends through the complete wet winter period which is key to understanding the hydrogeological response in the system.

This report includes a summary of the key findings and recommendations arising from the consultants' evaluation of data collected for the groundwater, surface water and leachate monitoring and a staff review of the landfill gas monitoring and controlled waste program. The report titles are as follows:

- *Hartland Landfill Groundwater, Surface Water and Leachate Monitoring Program Annual Report (April 2013 to March 2014)*, by AECOM Canada Ltd., dated October 2014

- *Hartland Landfill – Landfill Gas Monitoring Annual Report 2013,* by Capital Regional District, dated October 2014.

Complete copies of these two technical reports are attached as Appendix A and Appendix B, respectively.

2.0 BACKGROUND

The CRD took over operation of the Hartland landfill site in 1985. Prior to that, the landfill was owned and operated privately. The landfill currently occupies approximately 36 hectares with an estimated 6,500,000 tonnes of municipal solid waste in place at the end of 2013. When the landfill reaches the planned final filling elevations it will occupy approximately 46 hectares with a volume of approximately 12,000,000 tonnes of municipal solid waste. The annual disposal rate varies, but it is currently around 130,000 tonnes of residential, commercial and industrial waste.

The landfill encompasses two operational areas. Phase 1 is the older, closed area of the landfill that was operational from the 1950s to 1997, and filling in the active Phase 2 area began in spring 1997.

Phase 1 is unlined and covered with a combination geo-membrane/clay cap. Phase 2 is the current active portion of the landfill. Phase 2 was constructed within a former lake basin (now referred to as the Phase 2 basin). It is partially lined and relies on a "hydraulic trap concept" for leachate containment. Completed portions around the western perimeter of Phase 2 have been closed with an interim cover comprised of a 500-mm layer of clay, without geo-membrane. As landfill development progresses, final closure of areas will be completed. Development of the Hartland landfill is guided conceptually by the Cell Development Plan from the *Hartland Landfill Phase 2 Long Term Leachate Management Plan* – Sperling Hansen Associates (June 2007).

3.0 LANDFILL GAS

Decomposition of refuse creates landfill gas. The composition and amount of gas generated varies based on factors such as amount and type of waste; how long it's been buried; and conditions such as the moisture content. Initially, the decomposition is aerobic and produces mainly carbon dioxide. As oxygen is depleted, the decomposition occurs under anaerobic conditions. Peak gas generation occurs during the first one to three years after disposal, but gas generation continues for many years.

Landfill gas is primarily made up of methane and carbon dioxide with small amounts of water vapour, oxygen, nitrogen and trace gases. Methane is explosive at concentrations between 5 and 15% and can be an asphyxiant gas at higher concentrations. Trace gases include hydrogen sulphide, ammonia, nitrous oxide, VOC and chlorofluorocarbons. Hydrogen sulphide is odorous and can be toxic if inhaled at high concentrations. VOC can be classified as carcinogenic or as GHG and also may contribute to smog. Chlorofluorocarbons are very potent GHG and ozone-depleting substances.

Even with proper landfill gas collection and control there will be fugitive landfill gas emissions. A number of factors influence this including atmospheric pressure, groundwater level and the gas pressure in the refuse mass and permeability of cover systems. There are controls on site to reduce the amount of fugitive landfill gas emissions.

When gas pressure builds up, the gas migrates via the path of least resistance to equalize with the surrounding atmosphere. This includes moving through permeable covers to vent to atmosphere or potential subsurface movement. Hartland landfill has implemented controls for landfill capture gas and monitoring programs to evaluate the effectiveness of these controls.

In order to monitor the effectiveness of the landfill gas collection infrastructure, the Hartland landfill has several monitoring programs. The following summarizes the components of the program:

1. **Collection and treatment system monitoring** to evaluate changes in gas quality over time, and evaluates data for gas collection and gas utilization to assess collection efficiency and total emissions from the landfill.

2. **Perimeter and building foundation monitoring** to assess the potential for subsurface landfill gas migration at the eastern landfill boundary and at onsite buildings for compliance with criteria, and for worker and public health and safety.

3. **Ambient grid and hot spot monitoring** to verify the effectiveness of cover and landfill gas collection systems and identify areas of concern where landfill gas is being released to the atmosphere for protection of worker and public health and safety.

4. **Landfill Gas Speciation** to assess the composition of gas with regard to VOC, sulphur gases and typical landfill gases in order to calculate ambient dilution concentrations for health and safety and infrastructure integrity purposes.

3.1 Landfill Gas Generation Rates

On January 1, 2009, the B.C. Landfill Gas Management Regulation came into effect. The regulation provides province-wide criteria for landfill gas capture and aims to reduce GHG emissions from landfills. As a result, a Long-Term Landfill Gas Management Plan (LGMP) was prepared for Hartland landfill that specifies landfill gas collection strategies in order to achieve a design guideline of 75% collection efficiency by 2016.

In 2013, the Hartland landfill received 131,418 tonnes of waste, including 123,210 tonnes of refuse and 8,208 tonnes of controlled waste. Methane generation rates are determined from previous waste composition studies and the assessment guideline provided by MOE and is a key model input parameter. In 2013, all refuse was estimated to be 31.5% relatively inert, 39.1% moderately decomposable and 29.4% decomposable.

Table 1 shows the estimated annual methane production for Hartland landfill. The years selected for the table coincide with the activation of the gas collection system in 1998. Gas generation is predicted to slowly increase and peak shortly after the onset of the kitchen scraps diversion program in 2015.

Table 1 Year and Estimated Quantity of Landfill Gas Generated at Hartland Landfill

Year	Annual Methane* Production (tonnes/year)
1998	7,129
1999	7,117
2000	7,112
2001	7,127
2002	7,229
2003	7,360
2004	7,493
2005	7,645
2006	7,760
2007	7,885
2008	8,034
2009	8,145
2010	8,230
2011	8,277
2012	8,293
2013	8,282

Note:
*Estimates generated using the MOE model.

3.2 Landfill Gas Collection Wells

The landfill gas management system was upgraded in 1996 in conjunction with the planned closure of Phase 1. A permanent blower station, header and lateral collectors and groundflare were installed and commissioned in 1998. The blower station has three blowers, two of which have variable frequency drives which offer more control on the vacuum produced. The vacuum draws gas via two header pipes and lateral pipes from connected wells. The gas system started with vertical wells, many of them dual zone (one deep, one shallow). The system now consists of numerous horizontal wells that are installed with each lift of refuse.

In Phase 2, horizontal wells are constructed during filling operations. The horizontal wells are placed at 20-metre intervals extending 100 to 300 metres in length and are trenched into the refuse. Horizontal wells are installed in each vertical lift (every four vertical metres). This represents is a significant increase in well placement as a result of the implementation of the LGMP.

In 2013, six new horizontal wells were installed in a completed lift; no wells were disconnected. A total of 115 gas wells were operating at the end of the year. Table 2 shows the number and type of gas wells operating in 2013.

Table 2 Number and Type of Operating Gas Wells in 2013

Type of Gas Well	Number in Operation 2013
Vertical Gas Wells	73
Horizontal Gas Wells	26
Leachate Horizontal Gas Wells	11
Leachate Gas Trench	5
Total	109

3.3 Gas Well Operation and Data

Each gas collection well is equipped with a control valve to regulate gas flow. Individual wells are monitored and adjusted at least monthly to optimize methane collection and flow to the gas utilization facility.

CRD staff monitors each well for methane, carbon dioxide, oxygen, balance gas, static pressure, differential pressure, temperature and flow; wells are adjusted to optimize these factors. By regulation, the well field should be measured and balanced at least once per month and more often if there are changes in gas composition as measured at the flare station, or there are swings in the system vacuum. There are many factors that impact gas generation so frequent well adjustments are critical to maintain optimal gas generation and efficient collection.

In 2013, five wells accounted for over 40% the total landfill gas collected (Table 3). The well field was balanced 12 times (monthly) in 2013, as required.

Table 3 Top Landfill Gas Collection Wells 2013

Name	Average Methane (% by vol)	Average Flow (scfm)	Well Production (% of Total)	Cumulative Total (%)
HLGW0013	55.4	139.4	8.82	8.82
HLGW016B	59.0	126.7	8.54	17.36
HLGW017B	57.0	129.3	8.23	25.59
HLGW0012	53.9	111.1	6.84	32.43
HLGW008B	44.6	104.7	5.33	37.76

During 2013, 14 gas wells did not produce adequate amounts of methane. A process has been implemented to reduce or discontinue monitoring of non-collecting wells to optimize the time staff spend balancing the gas well field.

3.4 Landfill Gas Collection and Utilization

The gas collection and utilization system consists of a 1.6MW generator, a candlestick flare and a groundflare. Excess gas that is not used by the generator for production of electricity is directed to the candlestick flare. Currently, the infrastructure does not exist to allow simultaneous operation of the generator and the groundflare. As a result, the groundflare is used only during extended generator down time such as during power failures or periods of extended maintenance.

From 2004 to 2013, Maxim Power Corp. (MAXIM), under a contract with the CRD, operated the generator to utilize landfill gas. In September of 2013, the CRD purchased the utilization facility and now operates all aspects of the landfill gas collection system.

Flow meters at the gas plant continuously measure the total volume of collected and report the information to the CRD SCADA system. Data is compiled to determine collection and utilization rates. It is also compared to the generation model to estimate the collection efficiency of the system.

Table 4 shows the total gas collected from 2009 to 2013 in standard cubic feet per minute (scfm) and indicates the volumes of gas sent to each destruction device.

Table 4 Landfill Gas Flows to Destruction Devices (2009 to 2013)

Annual Average	Year				
	2009	2010	2011	2012	2013
Gas Collected (scfm)*	476	546	581	829	987
Gas Burned by Generator (scfm)*	449	428	359	439	488
Gas Burned by Candlestick Flare (scfm)*	9	81	131	302.9	477
Gas Burned by Groundflare (scfm)*	18	37	91	87.1	28.53
Total Gas Flared	5.6%	21.6%	38.2%	47.04%	51.2%

Notes:
*Normalized to 50% methane.

The amount of gas collected has increased significantly over the two years since the LGMP was implemented. The generator consumed an average of 488 scfm in 2013 and utilized 53% of captured gas. In addition, more flaring occurred in 2012 and 2013 due to gas volumes exceeding the needs of the generator and more downtime of the generator due to the presence of siloxane compounds in the gas. The generator is shut down during high siloxane events to avoid excess wear and tear on machinery components.

Table 5 shows the quantities of gas generated, captured, the collection efficiency and the estimated GHG emissions.

Table 5 Landfill Gas Generation, Collection, Collection Efficiency and Greenhouse Gas Emissions (GHG) 1998 to 2013

Year	Estimated Annual[1] Methane Generated (scfm)[3]	Annual Gas[2] Captured (scfm)[3]	Estimated Collection Efficiency (%)	GHG Emissions (tonnes/year CO_2e)
1998	1,461	1,[illegible]	80.8	28,680
1999	1,458	9[illegible]	64.2	53,432
2000	1,457	73[illegible]	50.6	73,716
2001	1,461	[illegible]5	38.7	91,768
2002	1,481	499	33.7	100,665
2003	[illegible]508	628	41.6	90,205
2004	1,535	593	38.6	96,589
2005	1,567	517	33.0	107,571
2006	[illegible]590	562	35.3	105,372
2007	1,[illegible]6	587	36.3	105,431
2008	1,646	504	30.6	117,066
2009	1,669	476	28.5	122,262
2010	1,687	546	32.4	116,878
2011	1,696	581	34.2	114,282
2012	1,700	829	48.8	87,542
2013	1,697	987	58.2	70,779

Notes:
[1]Generated using the MOE model
[2]Measured
[3]Standard cubic feet per minute - Normalized to 50% methane

Collection efficiency began declining in 2004/2005 due to decreased gas production, deteriorating collection infrastructure in Phase 1 and gas collection challenges in Phase 2. Gas collection in Phase 2 is more challenging due to the need to limit oxygen intake through the refuse mass. The improvement in collection efficiency beginning in 2012 is due to the ongoing installation of new horizontal wells as part of the LGMP, in addition to the installation of new wells as part of the Phase 2, Cell 1 closure. As a result, collection efficiency has increased 24% since 2011 and is expected to continue to improve towards achieving 75% collection efficiency by 2016.

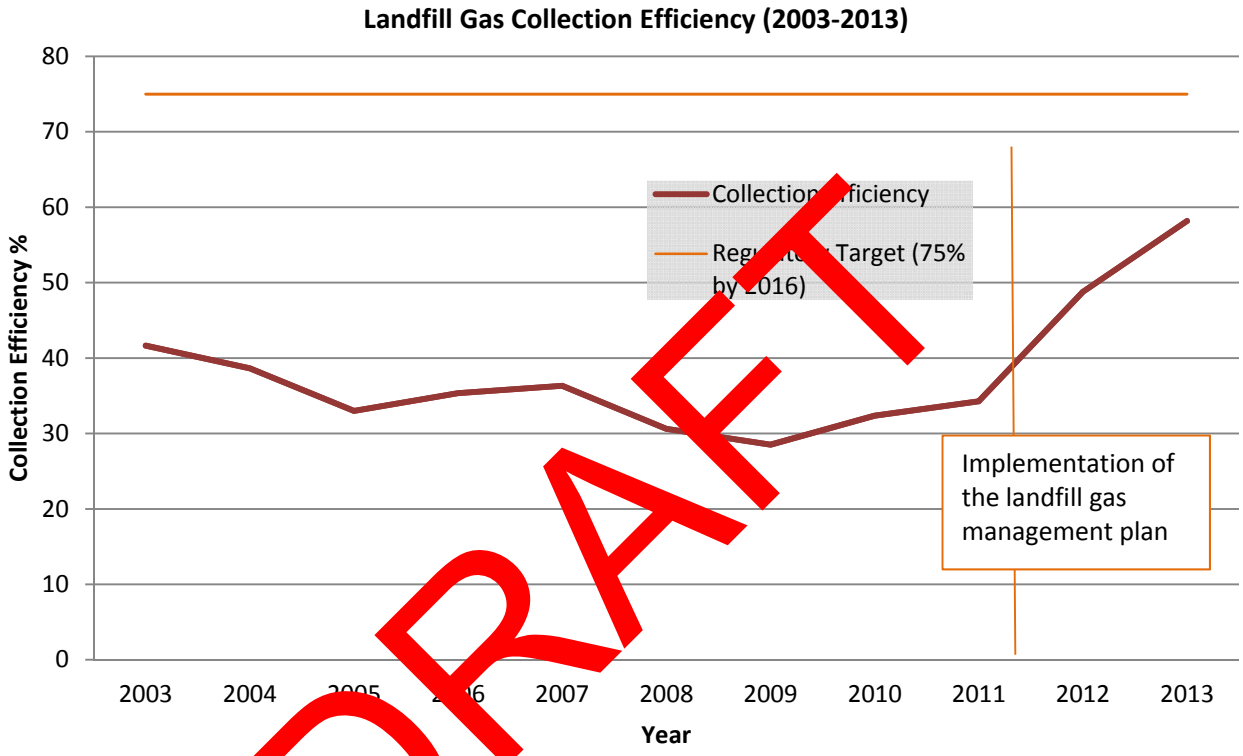

Figure 1 Landfill Gas Collection Efficiency (2003-2013)

Generator emissions are monitored annually to compare to MOE ambient air criteria and WorkSafeBC exposure limits. The data is also compared to modelled emissions rates generated in a previous study that evaluated whether emissions would meet applicable limits. The emission data are reviewed to ensure that emission rates are in line with those used in the modelling. The 2013 data indicates emissions from the generator did not exceed ambient air criteria or WorkSafeBC criteria.

4.0 LANDFILL GAS MONITORING PROGRAMS

4.1 Perimeter and Building Foundation Probe Monitoring

Subsurface gas probes were installed at the eastern perimeter and at building foundations to enable measurement of subsurface gas concentrations in order to evaluate compliance with MOE Landfill Criteria for Municipal Solid Waste (Landfill Criteria). The Landfill Criteria states that combustible gases in soils at the landfill property boundary shall not exceed the lower explosive limit (LEL) and that combustible gas in any onsite or offsite structure/facility shall not exceed 25% of the LEL. The LEL for methane is 5%.

The perimeter and building foundation probes are monitored using a LANDTEC Gas Analyzer and Extraction Monitor (GEM) 2000+.

4.1.1 Eastern Perimeter Probe Monitoring

Installation and monitoring of the eastern perimeter probes began in 1996 after concern arose over the potential migration of methane to adjacent residential properties as a result of landfilling activities near the eastern property boundary (Phase 1). Though landfilling in this area ceased in 1997, gas production from decomposition of waste and capping of the Phase 1 landfilled area created the potential for offsite gas migration.

Though installation and improvement of the landfill gas collection system has reduced the risk of offsite gas migration to the east, monitoring continues to ensure worker and public health and safety, as well as compliance with the MOE requirements. Perimeter probes are monitored quarterly for indications of landfill gas and gas migration potential.

All probes were monitored according to the standard operating procedure of four times in 2013. There was no detectable methane recorded in 2013. Consistent with historical data, CO_2 levels are slightly higher in the shallower 'B' probes than the deeper 'A' probes. Ongoing monitoring will continue to determine if any trends develop. There were no recorded exceedences of MOE criteria during the reporting period and the results are in compliance with MOE requirements. Given that no methane concentrations were recorded in 2013, there is reduced potential for offsite methane migration. .

4.1.2 Building Foundation Probe Monitoring

In 2013, there were 16 existing building foundation probes around onsite buildings at Hartland to monitor for any subsurface gas migration around building foundations. Building foundation probes are typically installed during building construction and are attached to lengths of perforated PVC piping that run along all, or a portion, of the building foundation.

Monitoring of gas concentrations in building foundation probes is conducted to determine the presence of subsurface landfill gas for protection of worker and public health and safety, as well as compliance with MOE Landfill Criteria requirements. Each probe is monitored quarterly for pressure, oxygen, carbon dioxide and methane which can indicate the potential for gas intrusion into buildings.

Data from quarters 1–3 show no detectable methane readings in any probe indicating that there is little risk of gas intrusion into existing onsite buildings. Data from quarter 4 is unreliable, due to equipment failure, though follow-up monitoring continues to show no detectable readings in any foundation probe.

4.2 Ambient Grid and Hot Spot Monitoring

A bi-annual program has been established to monitor fugitive emissions from Hartland landfill in order to track the effectiveness of the landfill gas collection network, as well as protect worker health and safety. Monitoring is conducted in accordance with the standard operating procedures which specify monitoring of total hydrocarbons (THC) and hydrogen sulphide according to thresholds established by GeoEnvironmental Programs staff. Increased monitoring is conducted when measured concentrations of THC exceed 100 ppm; areas are classified as hot spots (z-points) when THC exceeds 1,000ppm.

Table 6 shows the 2013 results of grid sampling. A total of 12 individual grid points were found to exceed 100 ppm THC. Hydrogen sulphide concentrations did not exceed WorkSafeBC exposure limits at any monitoring location. None of the elevated readings were in the closed area of Phase 1, indicating that the cover and gas collection system in the closed area is effective at preventing fugitive emissions.

At the end of 2013, there were an additional 18 locations with THC concentrations greater than 1,000 ppm, of which 15 were existing hot spots carried over from previous surveys. The number of hot spots has reduced considerably since 2011-2012, due to the Phase 2, Cell 1 closure, as well as an increase in gas collection efficiency. Although, fugitive emissions have reduced, they continue to escape from Phase 2 in active areas without cover and at cover seams. Hot spot locations should be discussed with Hartland landfill staff and mitigated if possible.

Table 6 Summary of Results of 2013 Grid Sampling

Survey date	March 2013	October 2013
Grid Points Monitored	150	146
# Grid Points >100 ppm THC	7	10
Maximum CH_4 (ppm)	339	336
Total # Hot Spots	21	18
Maximum THC (ppm)	12,500	>50,000

4.3 Gas Speciation

Decomposition of refuse produces methane and carbon dioxide gases and many other gases in trace amounts. Many of these trace gases are VOC. Some VOC are known carcinogens and/or GHG. In order to evaluate the risk of landfill staff exposure to VOC, sampling is conducted every two years. Monitoring for VOC was completed in 2013.

Samples were collected at the flare station which represents the average VOC concentrations at the landfill gas plant. A portable gas analyzer (GEM 2200+) is used to measure field concentrations of methane, carbon dioxide, oxygen, hydrogen sulphide, carbon monoxide and balance gases.

Tables 8 and 9 show the maximum concentrations of VOC in undiluted landfill gas and ambient air at landfill hot spots, respectively, both compare data to relevant WorkSafeBC exposure criteria. Gas speciation data from 2013 shows no notable changes from previous years.

Over time, the concentrations of individual VOC have varied. As the composition of refuse continues to change, regular monitoring of VOC should be conducted. Results should be compared to baseline data in order to determine whether changes in VOC concentrations have the potential to approach WorkSafeBC exposure limits.

The 2013 data indicate that undiluted landfill gas exceeded the WorkSafeBC limits for methane, carbon dioxide, hydrogen sulphide, vinyl chloride and benzene. However, exposure to undiluted landfill gas is unlikely as fugitive emissions mix quickly with air. To support this, ambient air sampling was conducted at landfill hot spot locations between 1999 and 2001, and results indicate an average dilution factor greater than 100:1. To further protect worker health and safety, personal gas detectors are set to alarm at levels consistent with 100:1 dilution factor (0.5% or 5,000 ppm methane or 10% of the LEL). Based on ambient grid and hot spot data, there is significant dilution of fugitive landfill gas emissions.

4.4 Landfill Gas Compliance and Recommendations

The following results summary table (Table 7) outlines all landfill gas monitoring programs, compliance status, any actions taken to address non-compliance and recommendations.

Table 7 Landfill Gas Compliance 2013

Program	Compliance Location	Criteria	Findings	Actions	Recommendations
Perimeter Probe Monitoring	Probes GP-1A, 1B, 2A, 2B, 3A, 3B, 11A, 11B, 12A and 12B	Maximum 1.25% methane in subsurface soil (MOE Landfill Criteria for Municipal Solid Waste)	No exceedences. Low risk of sub-surface gas migration to adjacent properties.	None	Continue quarterly monitoring.
Building Foundation Probe Monitoring	Probes GP- 4A, 5A, 6A, 6B, 7A, 7B, 8A, 9A, 13A, 14A, 17A, 18A	Maximum 1.25% methane in any onsite facility (MOE Landfill Criteria for Municipal Solid Waste). Maximum 1% methane inside buildings (Landfill Gas Management Facility Design Guidelines).	No exceedences. Low risk of subsurface gas migration to adjacent building.	None	Continue quarterly monitoring.
Ambient Grid Monitoring	N/A	100 ppm THC (CRD internal guideline)	12 grid locations >100 ppm No cover system failures suspected in the closed area of Phase 1.	Investigated hot spots, mitigated were possible.	Continue biannual monitoring
Hot Spot Monitoring	N/A	1,000 ppm THC (CRD internal guideline).	3 new hot spots >1,000 ppm, 1 hot spots removed. Currently 5 locations for hot spot investigation.	Added new locations of hot spots to the monitoring program.	Continue biannual monitoring. Investigate remediation measures.
Well Field Monitoring and Balancing	N/A	Monitor monthly. Oxygen (<3%)	Monitoring completed monthly; oxygen did not exceed 3%.	Well field monitoring has been scheduled monthly for 2014.	Continue monthly monitoring at minimum.
Gas Speciation	N/A	N/A	Untreated landfill gas exceeded WorkSafeBC criteria for methane, carbon dioxide, hydrogen sulfide, vinyl chloride and benzene; however, ambient concentrations are likely well below WorkSafeBC limits due to dilution with ambient air.	None	Conduct speciation of landfill gas in 2015.
Gas Collection	N/A	75% gas collection efficiency commencing in 2016 as per Landfill Gas Management Plan.	Gas collection efficiency was estimated at 58.2%, based on the MOE gas generation model.	Landfill gas management plan submitted to MOE.	Continue to implement the long-term gas management plan.

5.0 GROUNDWATER, SURFACE WATER AND LEACHATE MONITORING

Groundwater and surface water monitoring stations on the Hartland landfill property and specific offsite locations have been monitored since 1983. In addition to this, leachate, generated by the percolation of precipitation through the garbage, is also monitored for flow and quality. The data collected are used to assess the potential for effect of landfill processes on groundwater and surface water resources. Since 1990, the leachate has been captured and contained onsite prior to discharge by pipeline to the sanitary sewer.

The annual monitoring program has three main components:

- groundwater monitoring onsite and at selected offsite domestic wells
- surface water monitoring at onsite and offsite locations
- leachate flow and leachate quality monitoring

Water quality is evaluated by comparing the data with the appropriate Provincial drinking water or freshwater aquatic life standards or guidelines and background concentrations typical of the area. Leachate flow volumes and leachate quality monitoring are used to confirm compliance with the CRD Regional Source Control Program's (RSCP) waste discharge permit (#SC97.001) authorizing discharge to sanitary sewer.

5.1 Groundwater Monitoring Program

The purpose of the groundwater monitoring program is to assess impacts of landfill processes and operations on groundwater quality and to assess compliance with water quality standards at the property boundary.

Hartland landfill has an extensive network of groundwater wells to monitor conditions immediately adjacent to the Phase 1 and Phase 2 areas and at points adjacent to the landfill property boundary. Groundwater elevations are routinely measured in approximately 120 well locations to understand the direction of groundwater flow within the landfill property. Groundwater quality is monitored at 84 groundwater well locations to evaluate and identify changes in water chemistry that may be attributed to landfill processes and operations and specifically, the effect of landfill leachate on groundwater resources. In addition, 11 privately-owned, domestic drinking water wells within a two-kilometre radius of Hartland landfill are monitored.

Groundwater quality parameters are assessed against BC Contaminated Site Regulation (BC CSR) numerical standards for the protection of drinking water and aquatic life in groundwater. This represents a change, as the data was previously compared against only the BC water quality guidelines[1]. Water quality in 2013/2014 is generally similar to previous years, though when compared to the new standards site conditions have improved.

5.1.1 Results

The monitoring program provided an effective measure of compliance and important information to guide management and operational decisions. A total of 84 groundwater wells are monitored at the landfill; of these, 43 groundwater monitoring wells are boundary compliance monitoring stations. Boundary compliance wells are primarily clustered along the property boundary and some are located closer to the filling area to monitor potential pathways for leachate movement in groundwater. Groundwater quality data collected between April 2013 and March 2014 indicated that the majority of boundary stations were in compliance with BC CSR standards. The results of the 2013-2014 program were similar to those measured in 2013-2014 and showed improvement in several areas.

[1] BC Approved Water Quality Guidelines and the Compendium of Working Water Quality Guidelines

The results of groundwater monitoring for each of the landfill boundary areas are presented in the following sections.

5.1.2 Phase 1

Groundwater flow was consistent with historic trends. Groundwater flow directions in the Phase 1 area were primarily to the north, and most of the northward flowing groundwater was captured by the leachate containment and collection system. At the south end of Phase 1, a groundwater divide corresponding with a bedrock high, influences the groundwater flow. North of this divide, groundwater flows to the north. South of the divide, groundwater flows south and is intercepted by the leachate containment and collection system.

Elevated leachate levels (i.e., leachate mounding) continued to be present in Phase 1 areas of the landfill, as it has for many years; however, the elevations were maintained below the target elevation required to ensure that the hydraulic trap functioned effectively. Water level monitoring in this area should continue to assess leachate the effectiveness of the hydraulic trap and identify any changes to magnitude or extent of leachate conditions.

North of Phase 1

Boundary Compliance Stations:

Groundwater quality north of Phase 1 met the BC CSR drinking water and aquatic life groundwater standards for all boundary compliance locations. Groundwater quality in this area has improved over time or continues to remain stable based upon statistical analysis as summarized in Table 8 below. Improvements are considered related to the effective operation of the north purge well system.

Table 8 Groundwater Quality Compliance Summary North of the Landfill (2013-2014)

Well	Exceedences	Number of Exceedences	Trend
20-1-1	none	-	Stable
20-1-2	none	-	Stable
21-1-1	none	-	Stable
21-1-2	none	-	Decreasing conductivity
21-2-1	none	-	Stable
28-1-0	none	-	Stable
29-1-1	none	-	Decreasing sulphate and conductivity
29-1-2	none	-	Decreasing conductivity
30-1-1	none	-	Stable
30-1-2	none	-	Stable
31-1-1	none	-	Stable
31-1-2	none	-	Decreasing conductivity
39-1-1	none	-	Decreasing conductivity
39-2-1	none	-	Increasing chloride

Non-Boundary Compliance Stations:

Leachate impacts continue at well 40-1-1, located between the upper and lower lagoon at the toe of Phase 1. This well is monitored to assess the effectiveness of the north purge well system and the strength of leachate that may be migrating toward the leachate lagoons. Impacted groundwater in this area is collected by the north purge well system. The continued operation of the purge well system is expected to reinforce leachate collection and containment, and to contribute to water quality improvements in this area. Future augmentation of the north purge well system is recommended to further reduce the persistent presence of these leachate indicator parameters in groundwater at this

location. This well, and other wells located near the purge well system, should continue to be monitored closely to assess the effectiveness of the north purge well system.

Wells along Willis Point Road met BC CSR drinking water and aquatic life groundwater standards. Wells in this area have historically reported concentrations of chloride and conductivity which are elevated, but less than the CSR standards, but these concentrations are attributed to road salting activities.

South of Phase 1:

South of the Phase 1 groundwater divide, groundwater flow is directed south and is controlled by a number of leachate containment measures, including five leachate purge wells. These purge wells are designed to collect leachate flowing through the bedrock at the south end of Phase 1. The purge wells were installed to strengthen the existing leachate containment system that includes a clay berm and grout curtain installed in 1984, and a shallow toe-drain installed along the south end of the landfill during the Phase 1 closure in 1996-1997. Operational challenges related to recently increased recharge at one purge well (P1) and thus increased pumping requirements are being addressed. The purge wells continually intercept southward-flowing leachate and discharge to the leachate collection system.

Boundary Compliance Stations:

Water quality met the BC CSR drinking water and aquatic life groundwater standards at the south boundary compliance locations. Although concentrations comply with the groundwater standards, leachate indicator parameters reported at some stations indicate the possibility of leachate migration towards the south, which is consistent with data from the last few years. Potential leachate migration is being addressed through continued optimization and maintenance of the south leachate purge well system.

As shown in Table 9 below, leachate indicator parameter trends indicate that concentrations are generally either stable or decreasing.

Table 9 Groundwater Quality Compliance Summary South of the Landfill (2013-2014)

Well	Exceedences	Number of Exceedences	Trend
04-2-1	none	-	Increasing sulphate
04-3-1	none	-	Decreasing chloride and conductivity
04-4-1	none	-	Stable
71-1-1	none	-	Decreasing conductivity and sulphate
71-2-1	none	-	Stable
71-3-1	none	-	Decreasing conductivity and ammonia
72-1-1	none	-	Increasing chloride
72-2-1	none	-	Increasing conductivity and chloride. Decreasing ammonia
72-3-1	none	-	Stable
73-1-1	none	-	Decreasing conductivity
73-2-1	none	-	Stable
73-3-1	none	-	Decreasing conductivity

East of Phase 1:

Boundary Compliance Stations:

Water quality at the property boundary east of Phase 1 met BC CSR drinking water and aquatic life groundwater standards for the reporting period (as shown in Table 10). Groundwater movement is directed from east to west, preventing offsite leachate migration to the east. The 2013-2014 data collected in wells east of Phase 1 confirmed that landfill leachate is effectively contained onsite.

Table 10 Groundwater Quality Compliance Summary East of the Landfill (2013-2014)

Well	Exceedences	Number of Exceedences	Trend
18-1-1	none	-	Stable
18-1-2	No data	-	No data
18-2-1	none	-	Stable
18-2-2	none	-	Stable
54-1-1	none	-	Stable
54-2-1	none	-	Stable
54-3-1	none	-	Stable
76-1-1	none	-	Stable
76-2-1	none	-	Stable
76-3-1	none	-	Decreasing conductivity. Increasing chloride.

5.1.3 Phase 2

In the Phase 2 area, immediately west of Phase 1, groundwater flow is directed inward toward the base of the former Heal Lake, where leachate is collected by an underdrain system and discharged to the leachate lagoons. This area of the leachate collection and containment system is known as the Phase 2 basin. Because the groundwater flow is directed inward toward the basin, it is considered a hydraulic trap. Water levels in the underdrain and outside the basin are continuously monitored with automated transducers to ensure that the hydraulic trap is maintained. The 2013-2014 data indicate that the hydraulic trap functioned effectively throughout the year.

Elevated leachate levels (i.e., leachate mounding) were recorded in Phase 2 during the reporting period, however the elevations were maintained below the target elevation required to ensure that the hydraulic trap functioned effectively. As filling in Phase 2 continues, it is important to monitor leachate levels in the refuse in order to assess seismic stability and the effectiveness of the hydraulic trap. Staff will investigate the need for replacement of the transducers near the microtunnel.

North of Phase 2:

Boundary Compliance Stations:

North of Phase 2, groundwater quality met BC CSR drinking water and aquatic life groundwater standards at all boundary compliance locations (as shown in Table 11).

Table 11 Groundwater Quality Compliance Summary North of the Landfill (2013-2014)

Well	Exceedences	Number of Exceedences	Trend
53-1-1	none	-	Increasing chloride, sulphate and conductivity

North of the Hartland North Pad:

Boundary Compliance Stations:

Water quality north of the Hartland North pad met BC CSR standards at all boundary compliance locations (as shown in Table 12).

In the vicinity of the Hartland north pad, northwest of Phase 2, groundwater results indicates that over the past seven years, impacts from historical composting activities have been reduced and impacts from aggregate stockpiling on the Hartland north pad have stabilized or are decreasing. In 2011, almost every well at the Hartland north pad reported statistically significant increasing trends in sulphate concentrations due to infiltration through the aggregate stockpile stored at the site. Improvements in groundwater quality at wells near the Hartland north pad beginning in late 2012 are attributed to the cover system installed in January 2012. Groundwater quality at all stations downgradient of aggregate stockpiles should be monitored closely for changes in water quality. Efforts should be made to reduce the volume of aggregate stored at the Harland north pad and temporary covers should continue to be used to reduce infiltration through stockpiles.

Table 12 Groundwater Quality Compliance Summary Hartland North Pad (2013-2014)

Well	Exceedences	Number of Exceedences	Trend
North of Hartland North Pad			
41-1-1	none	-	Stable
42-1-1	none	-	Decreasing chloride
55-1-1	none	-	Stable
56-1-1	none	-	Stable
57-1-1	none	-	Stable

5.1.4 Domestic Well Testing

Water quality data collected in 2013 generally met applicable drinking water quality guidelines; with only iron exceeding the guideline in a single well (40-1-52). Iron is an aesthetic objective and is not a leachate indicator parameter. The results indicate that landfill leachate is not affecting any of the 11 domestic wells sampled and water quality was consistent with background conditions.

5.1.5 Recommendations

- Continue the monitoring program in order to meet regulatory requirements and to inform management and operational decisions.
- Operation of the north and south purge well systems should continue in order to provide an effective component of the leachate control and containment systems. Water levels and the extent of the drawdown cone should be validated twice annually according to standard operating procedure. This work is currently underway.
- Optimization and maintenance of the north and south purge well systems should continue and consideration should be given to converting well 40-1-1 into a north purge well.
- Continue with well and equipment maintenance in order to enable required compliance sampling.
- Water quality downgradient of the quarry and aggregate stockpile locations should continue to be closely monitored to assess the effects of these activities on water quality and the effectiveness of the cover system installed on the Hartland north aggregate stockpile in January 2012. Opportunities to manage aggregate stockpiles to reduce infiltration or store stockpiles within the leachate containment area should be considered where possible.

- VOC should only be sampled in groundwater at boundary compliance monitoring locations when appreciable concentrations of VOC are detected in leachate samples from the Phase 2 landfill, controlled waste drainage, south purge wells or north purge wells, or at a minimum of once every five years (e.g., next VOC sampling event in 2016-2017).

- The results of the annual monitoring program should continue to be reviewed and interpreted by qualified professionals experienced in assessing the impacts of landfill leachate at large municipal landfills similar to Hartland landfill.

- Sampling frequencies for all boundary compliance stations should continue to be four times per year for groundwater stations, 10 times per year for water levels and once per year for domestic wells.

5.2 Surface Water Monitoring

Hartland landfill is located within the Tod Creek watershed. Drainage south of the landfill is directed toward Killarney Lake and Prospect Lake, discharging to Tod Creek. Drainage north of the landfill flows northeasterly within Heal Creek to Durrance Creek, discharging to Tod Creek, and ultimately, to Tod Inlet. Surface water is monitored to ensure that surface water quality is not being adversely affected by landfill operations.

The monitoring program includes sites within the landfill, at the property boundary and within each of the major offsite drainages. The program includes five surface water monitoring stations identified as boundary compliance monitoring stations. These stations are concentrated north and south of the landfill where creeks flow from the landfill property to offsite locations. In addition, Environmental Protection staff sample 29 surface water stations at upstream and downstream locations to assess potential environmental effects to surface water on the site and flowing from the site. Water quality results are compared to the BC Approved and Working Water Quality Guidelines (BC WQG) for Freshwater Aquatic Life to assess compliance with the landfill Operational Certificate. It is noted that the BC WQG guidelines for sulphate were revised in April 2013 to a less stringent guideline.

5.2.1 Results

The monitoring program provides an effective measure of compliance with water quality guidelines and important information to guide management and operational decisions. A review of the surface water quality data, collected between April 2013 and March 2014, indicated that property boundary stations and the majority of onsite and offsite stations met water quality guidelines. Parameters that were reported above the guideline values included iron and manganese, which can be elevated in turbid samples.

Table 13 summarizes surface water quality at boundary compliance stations and discussion of the results follows.

Table 13 Surface Water Quality Compliance Summary (2013-2014)

Station	Exceedence	Number of Exceedences	Trend
North of the Landfill			
SW-N-05	none	-	Increasing ammonia
SW-N-16	Total iron	1 of 5 sample events	Increasing ammonia and sulphate
	Total Manganese	1 of 5 sample events	
North of Hartland North Pad			
SW-N-41s1	none	-	Decreasing conductivity
SW-M-42s1	none	-	Decreasing nitrate
South of the Landfill			
SW-S-04	none	-	Increasing chloride

5.2.2 North of the Landfill

Water quality at compliance stations north of the landfill met all provincial guidelines during the reporting period, with the exception of one station (SW-N-16) that reported total iron and manganese during a single sampling event. Iron and manganese are not considered leachate indicators when observed in the absence of other indicator parameters (i.e., chloride, conductivity, etc.).

North of the landfill, surface water drains through two boundary compliance locations (SW-N-16 and SW-N-05) to Heal Creek. North of Phase 1, surface water drains from a natural wetland to the northern property boundary station (SW-N-16). Although increasing trends of ammonia and sulphate were reported at this station, the concentrations of these parameters were less than the applied guidelines. Monitoring at these locations will continue. North of Phase 2, water leaves the landfill property via a sedimentation pond to Heal Creek at station SW-N-05. Water quality at station SW-N-05 was within provincial guidelines for all sampling events.

Sampling stations north of the Hartland north pad were in compliance with provincial guidelines. Similar to previous years, sulphate was detected above natural background concentrations, but less than the provincial guidelines at boundary compliance locations. These concentrations are considered related to aggregate stockpiling and have declined since installation of an engineered cover in January 2012. It is anticipated that the engineered cover will continue to reduce sulphate in runoff from the stockpile area.

Surface water quality in Heal Creek and Durrance Creek was in compliance with the freshwater aquatic life guidelines throughout 2013-2014. Water quality in Durrance Lake met water quality guidelines and was not impacted by landfill leachate.

No leachate effects were evident in Tod Creek and there have been no detectable leachate impacts to Tod Creek in many years.

5.2.3 South of the Landfill

Generally surface water flows in the southern areas of the landfill only during wet weather; however, groundwater seepage is occasionally observed in the Killarney Creek channel during dry periods.

Water quality south of the landfill was in compliance with provincial guidelines for all boundary compliance stations. Non-boundary stations were in compliance with provincial criteria with the exception of iron and suspended solids. These parameters each exceeded the guidelines on a single sampling event at a location directly adjacent to the recycling and waste disposal areas. Historic water quality monitoring indicated that landfill operations affected water quality within the operational and recycling areas south of Phase 1 (station SW-S-03), but that the effects were reduced to concentrations less than the provincial guidelines prior to reaching boundary compliance stations.

Water in Killarney Lake, south of the landfill, reported water quality consistent with background concentrations throughout the year, and was not affected by landfill leachate.

5.2.4 Recommendations

- The monitoring program should continue in order to meet regulatory requirements and to inform landfill management and operational decisions on site.

- Water quality downgradient of the quarry and aggregate stockpile locations should continue to be closely monitored to assess the effects of these activities on water quality. Sampling frequencies for all boundary compliance stations should be six times per year.

5.3 Leachate Monitoring

Leachate is produced from the percolation of precipitation and groundwater through the decomposing refuse in the landfill. Closure of Phase 1 involved capping the landfill area to eliminate direct infiltration of precipitation and to minimize leachate generation. Phase 2 was designed to effectively capture leachate by using gravel as an intermediate cover, to enhance drainage within the landfill, and by construction of an underdrain system in the Phase 2 basin to collect leachate. The underdrain system discharges to one of two leachate lagoons constructed to contain the leachate on site prior to controlled discharge via pipeline to the Saanich sanitary sewer and, ultimately, to the Macaulay Point outfall.

The purpose of the leachate monitoring program is to:

- determine the volume of leachate discharged and flow rates to the sanitary sewer,
- characterize the physical and chemical constituents in the leachate, and
- verify compliance with the CRD RSCP waste discharge permit (#SC97.001) at the point of discharge.

Automated monitoring of the volume of leachate discharged is maintained on the CRD SCADA system and provides a basis for measuring flow rates to the sanitary sewer and leak detection. Samples of leachate are collected monthly from the leachate flow detection (valve) chamber to verify compliance with the RSCP waste discharge permit. Monthly testing includes analysis of approximately 92 constituents, including nutrients, mineral oil and grease, organic compounds and metals. Quarterly monitoring is conducted for a larger list of constituents (approximately 19[illegible]), including an extensive list of trace organic compounds.

In November 2013, the CRD was alerted to a leak on the leachate pipeline. In accordance with our emergency response plan, staff responded to the incident and notified the affected community and local agencies. The leak was repaired and environmental monitoring demonstrated that landfill leachate impacts were confined to the immediate area of the leak and conditions were improving. Corrective actions were implemented and monitoring continued to confirm the measures were effective.

5.3.1 Results

The average leachate flow over the period April 2[illegible] to March 2014 was 10.95 L/s, which is slightly less than the long-term average flow of 1[illegible] L/s. Because leachate generation rates are closely linked to rainfall, the average annual flow varies with total precipitation each year.

Leachate quality at the point of discharge to the leachate pipeline was in compliance with the RSCP waste discharge permit throughout the reporting period with the exception of mineral oil and grease on one sampling event (August 2013). This represents an improvement from 2012-2013.

The nitrate amendment, for use during periods of elevated sulphides, was not implemented during the reporting period as elevated sulphide concentrations were not observed.

Concentrations of trace volatile and semi-volatile organic compounds were very low and mostly were not detected. Of the 102 compounds analyzed, only 116 were detected in 50% or more of the samples and of those detected, concentrations were very low. This number is slightly lower than reported in the previous reporting cycle. Additionally, the concentrations of detected compounds were low compared to those commonly found in municipal landfill leachate.

5.3.2 Recommendations

- Monitoring of leachate flow and chemistry should continue in accordance with the RSCP permit for discharges from the site and to inform landfill management and operational decisions.

- On an as-needed basis, the operation of the leachate treatment system, using the nitrate amendment, to address periodic sulphide spikes in leachate, and monitoring to demonstrate the effectiveness of the leachate treatment system, is recommended.
- Monitoring of leachate within the collection system should continue in order to characterize the variability in leachate chemistry and identify operational factors that affect leachate chemistry.

6.0 CONTROLLED WASTE PERMITTING

Controlled wastes are a range of wastes that require special handling and disposal because of specific health and safety, operational or environmental concerns. These wastes are identified in the CRD Hartland Landfill Tipping Fee and Regulations Bylaw (Bylaw 3881). Controlled wastes are disposed in trenches away from the active face and covered daily to minimize health and safety risks, as well as nuisance odours or attraction of scavenging animals. Controlled waste disposal at the landfill is regulated through a permit system administered by Environmental Protection staff.

The purpose of the controlled waste program is to regulate discharges to the controlled waste area at the landfill, to provide a level of control over the materials being disposed, to protect staff health and safety, and to minimize additional contaminant loading in the landfill and leachate.

In 2013, Environmental Protection staff was responsible for responding to enquiries, obtaining adequate physical and chemical characterization of the waste from the generator, and issuing permits with specific limitations, as required. Each permit details the information about the generator, the characteristics of the waste, discharge requirements, and specific health and safety precautions required to protect landfill staff.

The only exception to this program is asbestos which is managed by Hartland landfill staff under federal and provincial regulations. It is currently the only hazardous waste that Hartland is authorized to accept.

In 2013, changes were made to Bylaw 3881 that designate commercial quantities of construction and demolition wastes as controlled waste. Construction and demolition waste poses significant health and safety risks if not managed properly, due to the presence of hazardous materials like asbestos and lead paints. Permitting such wastes provides for a greater level of assurance that hazardous materials have been dealt with appropriately before the load is received at the active face.

6.1 Results

During 2013, the permit system worked efficiently and provided landfill staff with the information needed to ensure adequate precautions were in place to receive the permitted wastes.

Table 14 Permits and Tonnage for Controlled Waste 2009 to 2013

Year	Permits Issued	Controlled Waste Received (tonnes)	Asbestos (tonnes)	Total Controlled Waste Received (tonnes)
2013	178	6,497	1,711	8,208
2012	164	6,076	1,417	7,493
2011	150	6,753	1,012	7,765
2010	120	7,080	1,313	8,393
2009	147	7,359	572	7,931

Enquiries from the public and business operators are used as an initial screening to determine if the waste is considered to be a controlled waste. Generally, there are more enquiries than permits issued. Wastes that are not acceptable as controlled waste are directed to other disposal facilities, which may include recycling or treatment facilities.

During 2013, the highest tonnages of wastes discharged by permit were sewage sludge and screenings.

In 2013, Environmental Protection staff performed random site inspections, as well as audits of permitted wastes. Site inspections are conducted at the site where the waste is generated usually when further waste characterization is required before a permit can be issued. Where appropriate, staff request laboratory analysis or directly collect audit samples to confirm waste constituents to ensure the waste does not pose a risk to the public or landfill workers, as well as to confirm it does not exceed provincial hazardous waste limits. For each permit, the landfill maintains a record of the volume discharged and the number of discharges. No major violations of permit conditions were observed in 2013.

6.2 Recommendations

- In 2014, continue site inspections and audits to verify acceptability of wastes and to confirm that only permitted wastes are discharged.

- Continuation of the program is recommended to ensure that an adequate level of health and safety and environmental protection is maintained at the landfill.

7.0 SUMMARY OF RECOMMENDATIONS

The environmental monitoring programs at Hartland landfill provide a valuable foundation to evaluate the effectiveness of the control measures, assess potential impacts of Hartland landfill and support landfill management and operations by providing information to staff, managers and committees.

7.1 Landfill Gas Monitoring Program

- Conduct well field monitoring and balancing at a minimum frequency of once per month to meet regulatory requirements and to optimize gas collection.
- Continue to discuss landfill hotspots with Hartland staff and mitigated where possible
- Continue quarterly perimeter probe monitoring to comply with landfill criteria.
- Continue quarterly building foundation probe monitoring to comply with landfill criteria.
- Continue bi-annual ambient grid and hotspot monitoring and mitigate hotspots where possible.
- Conduct gas speciation in 2015 to enable tracking of gas composition changes.

7.2 Groundwater, Surface Water and Leachate Monitoring Program

- Continue the monitoring program to provide an effective measure of compliance, and the information required to guide management and operational decisions.

- Boundary compliance stations should continue to be sampled at the following frequencies: six times per year for surface water stations; four times per year for groundwater stations and water levels should be collected 10 times per year.

- Operation of the expanded north and south purge well systems should be continued, as these wells are an effective component of the leachate control and containment systems. Pumping levels and the extent of the drawdown cone should be validated annually according to standard operating procedure. This work is currently underway.

- Efforts should continue to achieve optimal water levels in the south purge wells to mitigate leachate migration towards the south end of the landfill.

- Water quality downgradient of the quarry and aggregate stockpile locations should continue to be closely monitored to assess the effects of these activities on water quality, as well as to monitor the effectiveness of the stockpile cover on improving runoff quality. Opportunities to manage aggregate stockpiles to reduce infiltration or store stockpiles within the leachate containment area should be considered where possible.

- Groundwater quality should be closely monitored in the area of well 40 to confirm the effectiveness of the expanded north purge well operation.

- Concentrations of VOC in leachate have historically been very low. Monitoring of VOC in groundwater at property boundary stations have not identified any VOC at detectable concentrations and are not considered necessary to assess compliance. As previously recommended, the sampling and analysis of VOC in groundwater is suspended until such time that VOC are detected in leachate samples, or at a five-year interval.

- Monitoring of leachate flow and chemistry should continue as it provides an effective measure of compliance with the RSCP permit for leachate discharges to the sanitary sewer.

- On an as-needed basis, the operation of the leachate treatment system, using the nitrate amendment to address periodic sulphide spikes in leachate, and monitoring to demonstrate the effectiveness of the leachate treatment system, is recommended.

- The results of the annual monitoring program should continue to be reviewed and interpreted by qualified professionals experienced in assessing the impacts of landfill leachate at large municipal landfills similar to Hartland landfill.

7.3 Controlled Waste Permitting

- Continue the permitting program to ensure that only suitable wastes are received in order to meet operational requirements and ensure worker and environmental health and safety objectives are achieved.

- Continue to inspect and audit dischargers to verify that only those materials authorized by permit are discharged and to ensure compliance with landfill operating permit requirements.

DRAFT Appendix A - Hartland Landfill Groundwater, Surface Water and Leachate Monitoring Program Annual Report (April 2013 to March 2014 (Saved as a separate document)
DRAFT Appendix B - Hartland Landfill - Landfill Gas Monitoring Annual Report 2013 (Saved as a separate document)