Hartland Landfill Operating & Environmental Monitoring 2021/2022 Report

Operational Certificate 12659

Capital Regional District | Parks & Environmental Services, Environmental Protection

Prepared by:
GeoEnvironmental Programs

Capital Regional District
625 Fisgard Street, Victoria, BC V8W 2S6
T: 250.360.3000 F: 250.360.3079
www.crd.bc.ca

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HARTLAND LANDFILL
OPERATING & ENVIRONMENTAL MONITORING
2021/2022 REPORT

EXECUTIVE SUMMARY

Hartland Landfill is owned and operated by the Capital Regional District (CRD) and is the only landfill in the capital region. The multi-purpose facility provides recycling, household hazardous waste collection, a salvage area, yard and garden waste collection and processing, controlled waste disposal and landfill services to commercial and residential customers.

The facility operates under an approved Solid Waste Management Plan and Operational Certificate #12659 issued by the BC Ministry of Environment and Climate Change Strategy (ENV) and is authorized to deposit waste asbestos. The CRD is required to report annually on the operating and environmental monitoring under the Hartland Operational Certificate. The required operating information includes waste tonnages, landfill lifespan, closure funding, operational and construction-related activities for the period of January 1 to December 31, 2021.

The CRD is also required to report the results of monitoring programs and activities. Hartland Landfill employs a number of engineering controls to ensure leachate and landfill gas are contained and/or controlled on site. An environmental monitoring program is in place to assess the effectiveness of these controls and to confirm regulatory compliance. Monitoring data is reported either for the period between April 1, 2021 and March 31, 2022, in accordance with the Operational Certificate.

The 2021/2022 environmental monitoring program confirms that there are no offsite groundwater impacts related to landfill activities, regulatory requirements were met and effective measures are in place to mitigate environmental impacts and to contain leachate prior to discharge to the sanitary sewer. Surface water quality data continues to confirm that nearby surface water bodies, including Tod Creek, Durrance Lake and Durrance Creek and Killarney Lake are not impacted by landfill leachate. An investigation is ongoing at the north end of the landfill to determine the source of diminished surface water quality in the area. The landfill gas collection efficiency for 2021 was 69% with ENV model, and monthly well field balancing will be conducted to continue to optimize gas collection.

In 2021, the Hartland Landfill received 190,210 tonnes of waste, which included: 166,156 tonnes of general refuse, 19,920 tonnes of controlled waste and 4,134 tonnes of asbestos. The estimated remaining capacity within Phase 2 is 6,754,100 (m^3). The estimated landfill capacity will be reached in approximately 30 years (i.e., 2050), assuming current rates of waste disposal. The Landfill Master Filling Plan was completed in 2020 to assess and optimize remaining landfill airspace capacity and to review options to extend the life of the landfill to 2100.

Hartland Landfill has an annual capital budget of approximately $2.5 million. Construction of Cell 4, 5 and 6 in 2023 - 2025 will increase the average annual capital budget to approximately $17 million to ensure the cells are ready for filling. This budget supports many capital projects focused on environmental protection and control. Operations and capital projects that occurred in 2021 include:

- Landfill operations, mechanical services, security and vector control contracts
- Fire protection/water system upgrades
- Residential renovation waste management pilot
- Outreach campaigns
- New aggregate management area development
- Gas and leachate collection infrastructure installation
- Residual Treatment Facility support infrastructure
- Annual invasive plant species control
- Litter control
- Wood Waste Diversion Program

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1.0 INTRODUCTION

Hartland Landfill is owned and operated by the Capital Regional District (CRD) and is located about 14 km northwest of Victoria. It is the only sanitary landfill in the capital region, serving a population of 432,100 people. The operation is a multi-purpose facility providing recycling, household hazardous waste collection, a salvage area, yard and garden waste collection and processing, controlled waste disposal, and landfill services to commercial and residential customers.

This report represents the consolidation of three historically separate documents (Hartland Operations Annual Report, Hartland Environmental Programs Annual Report, and Landfill Gas Annual Report). The data herein is required to meet CRD operating standards, and provincial regulatory requirements per Section 3.2 of the Operational Certificate. As required by the Operational Certificate, this report includes:

- waste tonnages
- remaining landfill lifespan
- post-closure funding
- 2021 operations activities
- 2021 construction contract-related activities
- 2021/2022 environmental monitoring program results[1]
- 2021 annual landfill gas report

2.0 SITE OVERVIEW

Hartland Landfill is located in the Tod Creek watershed, in the bedrock highlands of the Gowlland Range, northwest of Victoria. The terrain is moderately rugged with relief of up to 446 m in the area. Undeveloped CRD property (about 320 ha in total) lies to the west and south of the landfill site. Mount Work Regional Park lies to the west. Willis Point Road borders the site to the north, and beyond that is a Department of National Defense rifle range. Private residential properties are located to the east and southeast of the landfill.

The landfill is situated in a north-south trending bedrock saddle with Mount Work to the west and an unnamed bedrock ridge to the east. The crest of the landfill forms a drainage divide between the Heal Creek drainage basin to the north and the Killarney Creek drainage basin to the south.

Filling with waste started at the site in the 1950s under private ownership. The site continued to be owned and operated privately until 1975 when the CRD purchased the property. Hartland Landfill is the primary solid waste disposal site for all areas of the capital region. Landfilling operations and equipment maintenance is conducted by private companies under contract and direction of CRD staff.

The Hartland Landfill site is divided into two distinct areas referred to as Phase 1 and Phase 2. Initially, waste was deposited in Phase 1, which reached capacity in 1996 and was capped in 1997. Phase 2 is currently receiving waste. Filling of Phase 2, Cell 1 was completed in 2004. Subsequently, the filling of Phase 2, Cell 2 was completed in 2016 and its interim closure is in progress. Phase 2, Cell 3 was prepared in the summer of 2016 and became active in September 2016.

Leachate and surface runoff from the active landfill areas are directed to two leachate lagoons at the north end of the landfill. The leachate is then transported via the centrate return line (shared with the CRD's Residual Treatment Facility) to the McLoughlin Wastewater Treatment Plant. Leachate discharge to sewer

[1] Note, some data is presented in a calendar year (January to December), but environmental monitoring data is presented from April 2021 to March 2022 (so it encompasses a full wet season).

is authorized by CRD Regional Source Control Program Waste Discharge Permit SC97.001 and is subject to the CRD Sewer Use Bylaw (Bylaw No. 2922).

The CRD initiated a surface water and groundwater monitoring program for the landfill in 1983. Annual monitoring reports have been prepared and issued by consultants since 1988. The present Hartland monitoring program is required under the Amended Operational Certificate #12659 issued by the ministry and last amended January 21, 2013.

A Residuals Treatment Facility was built in the northwest corner of the Hartland Landfill property. The facility is part of the CRD's Wastewater Treatment Project, which was completed in order to comply with provincial and federal wastewater requirements at the end of 2020. The project was funded by the Government of Canada, the Government of British Columbia and the CRD. Operations and annual report for the facility is completed under Operational Certificate #109471 issued by the BC Ministry of Environment and Climate Change Strategy (ENV).

3.0 REGULATORY SETTING

The Hartland Landfill operates in accordance with an approved solid waste management plan and an Operational Certificate. The following lists key regulatory approvals for Hartland Landfill:

- Solid Waste Management Plan (2021 revision submitted and awaiting ENV approval).
- Amended Operational Certificate (#12659) approved by ENV, last amended on January 21, 2013.
- Authorization to Dispose of Hazardous Waste Asbestos at the Hartland Landfill, approved by ENV on July 23, 2012.
- Regional Source Control Program Waste Discharge Permit SC97.001, last amended on June 12, 2021, and subject to the CRD Sewer Use Bylaw (Bylaw No. 2922).
- Landfill gas is regulated by the Landfill Gas Management Regulation and various provincial guidelines and criteria. Hartland continues to operate under an approved Landfill Gas Management Plan.

3.1 BC Landfill Criteria Revised

In June 2016, the provincial Landfill Criteria for Municipal Solid Waste, Second Edition, June 2016 (Landfill Criteria) was released. The Landfill Criteria reflect ENV's expectations regarding the standards for municipal landfills in BC and provide guidance to landfill owners, operators and consultants on environmentally sound landfilling practices and procedures. Although the Landfill Criteria is not a regulatory document itself, it is legally enforceable at Hartland Landfill, because it is incorporated into the Hartland Operational Certificate. The Landfill Criteria is prescriptive in nature and has many new requirements; however, modified practices and exceptions are allowable, if supported by technical justification and formally approved. Several requirements do not apply to existing landfills until vertical or horizontal expansion is proposed.

Many aspects of Hartland's design and operation are already compliant; however, a conformance review identified some exception requirements for Hartland under status quo operation (i.e., no expansion). Non-conformance issues at Hartland are generally technical assessments, or capital improvements (e.g., landfill fire management). Many of these initiatives are already complete, or in the planning stages and have been included in the Hartland capital plan. The Hartland Landfill conformance review was submitted in 2022 along with an updated Design Operations Closure Plan (DOCP) and Upgrading Plan.

4.0 WASTE VOLUMES AND AIR SPACE CONSUMPTION

In 2021, the Hartland Landfill received a total of 190,210 tonnes of waste. The active landfilling location received 186,076 tonnes of general refuse and controlled waste (this total excludes 4,134 tonnes of asbestos). The following section reports annual landfill air space and waste tonnage statistics.

4.1 Compaction Data

Localized compaction data is obtained routinely at Hartland Landfill to support the landfill operations and to verify target compaction rates. An average compaction density of 0.85 tonnes/m^3 is targeted during landfilling operations.

4.2 Landfill Utilization – Airspace Consumption and Waste Tonnage

The CRD's Facilities Management & Engineering Service Division conducts monthly volumetric surveys at the following two locations: active landfilling (general refuse) and active asbestos (asbestos). Volumetric surveys document changes in airspace volume and support quality control, design conformance assessments, and assist in ongoing landfill optimization assessments.

The annual airspace consumed at the active landfilling location from waste and daily cover, tonnage of waste landfilled, and associated landfill utilization factor is shown below in Table 1.

Table 1 Waste Airspace Utilization

2021 Waste Airspace/Density Calculations	Quantity
Airspace consumed by landfilling waste (m^3) (includes waste and cover)	257,996
Tonnage of waste landfilled (tonnes) (scale data)	186,076
Airspace Utilization Factor (T/m^3) [1]	0.72

[1] Airspace Utilization Factor = Total tonnes disposed divided by the volume of airspace consumed, including waste and cover.

In 2021, it was not possible to accurately track the amount of cover material used for landfilling. Therefore, a landfill utilization factor will be used as a key performance indicator.

4.3 Asbestos Area Utilization – Airspace Consumption and Asbestos Tonnage

The annual airspace consumed at the asbestos location from asbestos and daily cover, tonnage of asbestos deposited, and associated asbestos utilization factor is shown below in Table 2.

Table 2 Asbestos Airspace Utilization

2021 Asbestos Airspace/Density Calculations	Quantity
Airspace consumed by asbestos (m^3) (includes asbestos and cover)	23,788
Tonnage of asbestos (tonnes)	4,134
Asbestos Utilization Factor (T/m^3) [1]	0.17

[1] Asbestos Utilization Factor = Total tonnes disposed divided by the volume of airspace consumed, including asbestos and cover.

4.4 Uncertainties

The waste deposited at Hartland Landfill is constantly compressing and settling. Settlement and airspace is assessed by monthly topographic surveys; however, this introduces uncertainty into the tracking data. The settlement factor has not been factored into the airspace utilization data above, as reporting monthly landfill tracking data is assumed to be more accurate when calculating an airspace utilization factor.

4.5 Design Conformance

Hartland Landfill is currently in Phase 2 of development. The landfill phase is designed to be constructed in a series of cells with each cell divided into a series of lifts that are progressively filled with waste. In 2021,

filling within Phase 2, Cell 3 of Hartland Landfill was ongoing, as per the DOCP and Master Filling Plan for the site.

5.0 REMAINING SITE LIFE

In 2021 the use of LIDAR (Light Detection of Ranging) technology was replaced with photogrammetry technology. Each month a drone is used to take top-down, overlapping photos of the landfill. The photos are run though photogrammetry software which produces a 3-dimensional point cloud. The point clouds are used to create 3 dimensional surfaces that allow for the filling volume calculations to be conducted monthly and assist with landfill lifespan estimates. The remaining landfill life is calculated by dividing the remaining capacity by the previous three-year average yearly landfilling volume.

The remaining capacity of the landfill is summarized in Table 3. It is estimated that Hartland's current capacity will be reached by the year 2050, giving a remaining landfill life of approximately 30 years. In 2020, the Landfill Master Filling Plan was completed to assess and optimize remaining landfill airspace capacity and develop future expansion plans; which would extend the life of the landfill to approximately 2100.

Table 3 Summary of Landfill Capacities provided by the Hartland Landfill DOCP (Design Operating and Closure Plan) Update, 2022

Phase/Cell	Gross Cell Capacity m^3	Linear Area m^2	Linear Volume m^3	Net Cell Capacity m^3
Phase 2	7,484,122	141,772	191,392	7,292,730
Phase 3 (Proposed expansion area)	8,062,484	---	---	8,062,484
Total All Phases	**15,546,606**	**141,772**	**191,392**	**15,355,214**

6.0 CLOSURE AND POST-CLOSURE FUND

A requirement of the Operational Certificate is a closure and post-closure liability fund to meet or exceed the estimated closure and post-closure costs with a reasonable contingency. At the end of 2021, the closure/post-closure fund was $11,936,637.

7.0 2021 COMPLETED STUDIES AND PROJECTS

The annual Hartland capital and operations budget supports many capital projects and studies focused on environmental protection and control. The following is a brief summary of work completed in 2021.

- **Landfill operations, mechanical services, security and vector control:** Throughout 2021, contract management continued for mechanical services, on-site security, seasonal bird control, bin haul, stewardship, household hazardous waste, recycling and ozone-depleting substance removal.
- Two landfill backup power generators were replaced (North leachate purge well and administration building).
- Numerous fencing and site safety improvements completed.

- **Fire protection system:** As a result of a 2015 active face fire, fire protection resources (including water availability) were evaluated in coordination with the local municipality and emergency service providers. Following earlier design and installation, planning for additional fire protection resources continued in 2021.
- **Residential renovation waste management:** The Reno Safe Waste Wise program continued into 2021. This screening process for renovation wastes is in place to improve health and safety at the public bins area.
- **Outreach campaigns:** Outreach campaigns were planned and implemented in 2021 regarding end markets for recyclable materials, illegal dumping prevention, household hazardous waste disposal and holiday season waste reduction.
- **New aggregate management area development:** Tendering and construction of a new aggregate storage area located in the northeast corner of the landfill property was completed in 2021.
- **Gas and leachate collection infrastructure:** Landfill gas infrastructure was installed per the Hartland Landfill Gas Management Plan. Wellheads, valves, condensation traps, monitoring points and piping are installed and commissioned to convey landfill gas to the gas plant, and leachate to the storage lagoons.
- **Air space/aggregate production:** In 2021, approximately 155,000 m^3 of rock was extracted to produce more air space. The new aggregate storage area in the northwest corner of Hartland will continue to be used as a long-term aggregate production and storage area. Future airspace production contracts are planned for 2022.
- **Design Operations and Closure Plan:** An update to the Hartland DOCP was initiated in 2021 to review the filling plan, landfill lifespan and cash flow analysis to the end of Phase 2, Cell 4.
- Design and clearing for an aggregate storage pile was completed in 2021
- **Renewable Natural Gas:** Planning and technical studies for the new Renewable Natural Gas facility are ongoing.
- **Annual invasive plant species control:** Invasive species control continued with removal of some species and spraying of others with herbicide.
- **Litter control:** Ongoing litter cleanup and installation of litter fences prioritized throughout the year.
- **Wood Waste Diversion Program:** The voluntary wood waste diversion program continued through 2021. All accumulated wood waste is ground for beneficial use as landfill cover material.
- A Solid Waste Management Plan Amendment was completed and submitted to ENV at the end of 2021.

8.0 2022 PLANNED STUDIES AND PROJECTS

- **Fire protection system:** Following earlier design and installation, additional fire protection resources will be tendered and constructed in 2022. Including a new fire line and pump, which will provide firefighters at the active face with access to leachate from the leachate lagoons, in the event of a significant landfill fire.
- **Outreach campaigns:** Public service campaigns will continue into 2022.

- **Gas and leachate collection infrastructure:** Combined landfill gas and leachate collectors continue to be installed, as landfilling progresses. Wellheads, valves, condensation traps, monitoring points and piping are installed and commissioned to convey landfill gas to the gas plant and leachate to the storage lagoons. Horizontal gas and leachate collectors will be installed and activated in Phase 2, Cell 3.
- **Groundwater monitoring network upgrades:** Ongoing upgrades to the environmental monitoring network will continue through 2022. Planned work includes the installation of automated monitoring devices to enable the tracking of water levels, where appropriate.
- **Hartland North Scale:** Construction of a new scale building, scales and site security gate at the Hartland Landfill North entrance will be completed in 2022.
- **Kitchen Scrap Transfer Station Relocation**: Relocation of the kitchen scrap transfer depot is planned for 2022/2023.
- **Access Roads:** A new haul road to allow heavy rock trucks to access the new aggregate storage stockpile will be constructed in 2022.
- The Design Operations and Closure Plan is planned for submission to ENV in 2022
- Procurement for a new Renewable Natural Gas facility will be completed in 2022.
- **Wood Waste Diversion Pilot Program:** The voluntary wood waste diversion program will continue in 2022. Pilot program(s) to beneficially utilize wood and/or yard and garden waste offsite will be studied.
- Under the CRD's Liquid Waste Management Plan, the CRD continues to produce and use Biosolids Growing Medium (BGM) as a topsoil alternative to establish vegetation to reclaim closed landfill cells and mitigate erosion on temporarily inactive landfill cells in 2022 - in accordance with the approved Short-term Contingency Plan.
- Waste Composition Study: an updated waste composition study is planned for the fall of 2022.

9.0 2021/2022 ENVIRONMENTAL MONITORING

CRD staff monitor landfill gas, groundwater, surface water and leachate quality to ensure the effectiveness of management activities, and confirm regulatory compliance. Environmental data reported herein is compared to the most current and applicable provincial standards.

Based on monitoring conducted in 2021/2022[2], the program continues to provide data needed to:

- meet Operational Certificate requirements;
- identify potential impacts of landfill operations, if any;
- evaluate the effectiveness of control measures, and plan for mitigation (if required).

The key findings of the landfill gas, groundwater, surface water and leachate monitoring program presented here are referenced from the following:

- Hartland Landfill Groundwater, Surface Water, Leachate Monitoring Program Annual Report (April 2021 to March 2022), AECOM Canada Ltd. (AECOM) – Appendix I
- Hartland Landfill – Landfill Gas Monitoring 2021 Report, Parks & Environmental Services, Environmental Protection, CRD, November 2022 – Appendix II

[2] Monitoring periods vary such that the landfill gas "year" is January to December, but the groundwater, surface water and leachate "year" is April to March (to enable review of a full 'wet season').

9.1 Environmental Monitoring Program

Engineered controls at Hartland Landfill collect and contain leachate to control contaminant migration and, therefore, reduce or eliminate potential impacts to groundwater and surface water quality. Since 1990, the leachate has been captured and discharged via pipeline to the sanitary sewer.

Groundwater and surface water monitoring stations on the Hartland Landfill property and specific off-site locations have been monitored since 1983. Monitoring is mandated through the landfill Operational Certificate and is conducted on a quarterly basis to assess the potential for landfill processes to impact groundwater and surface water resources. Additionally, leachate, generated by the infiltration of precipitation through the municipal waste, is monitored for flow characteristics, quantity and quality. The annual monitoring program has four main components, as listed below:

1. groundwater monitoring at on- and off-site locations
2. private domestic well monitoring off-site
3. surface water monitoring at on- and off-site locations
4. leachate quality and flow monitoring

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 monitored to understand the direction of groundwater flow within the landfill property. Groundwater quality is monitored at 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.

9.1.1 Groundwater Flow

Groundwater flow throughout the landfill followed previously established patterns. Flow directions in the Phase 1 area were primarily to the north, and this component of flow is captured by the northern leachate containment system. At the south end of Phase 1, a groundwater divide exists where groundwater flows towards the north (into the landfill) and south (away from the landfill). The southerly component of flow is intercepted by the south leachate containment system.

In the Phase 2 area, west of Phase 1, groundwater flow is directed inward toward the base of the former Heal Lake. Because the groundwater flow is directed inward toward the basin, it is considered a hydraulic trap. In the basin, the leachate is then conveyed into the leachate lagoons. Leachate and water levels are monitored in Phase 2 to ensure that the hydraulic trap is maintained. The 2021/2022 data indicate that the hydraulic trap functioned effectively throughout the year. Water level and quality monitoring should continue to confirm ongoing effectiveness of leachate containment and identify any changes in the extent or magnitude of leachate impacts.

9.1.2 Groundwater Quality Results

Groundwater quality is compared against BC Contaminated Sites Regulation (CSR) numerical standards for the protection of drinking water and aquatic life. To account for seasonal variations, groundwater quality is reported between April 1, 2021 and March 31, 2022.

Of the 135 wells at Hartland, 34 groundwater monitoring wells are considered boundary compliance locations. These include locations 4, 18, 20, 21, 28, 29, 30, 31, 39, 41, 42, 53, 55, 56, 57, 71, 72 and 73. Groundwater quality at all landfill boundary compliance locations was less than the applicable BC CSR standards except for one sample at well 20-1-1 that marginally exceeded the CSR DW standard of 5 mg/L for Boron. The results of the 2021/2022 program were similar to those measured in recent years and showed improvement in some areas. The results of groundwater monitoring for each of the landfill areas are presented in the following sections.

9.1.2.1 North of the Landfill

Groundwater quality in boundary compliance locations north of the landfill met the applicable BC CSR groundwater standards with the exception of one exceedance for Boron at well 20-1-1. Groundwater quality in this area for the last five years (based on conductivity, ammonia, chloride, sulphate, and nitrate) is summarized in Table 4. Parameters are stable based on statistical analysis unless noted below.

The majority of CSR exceedances in groundwater were observed in on-site monitoring wells that are located in close proximity to the waste footprint, known leachate sources, or leachate purge wells. Groundwater quality in proximity to the Phase 2 basin confirms the hydraulic trap leachate collection system is effectively containing leachate north of Phase 2. The low concentrations of leachate indicator parameters in groundwater wells 100 m north of Phase 2 indicates that groundwater quality is not affected by landfill leachate.

In 2021/2022, nitrate concentrations in three (3) shallow groundwater wells (78-2-1, 87-2-1, 88-2-1) near the Hartland North Pad exceeded applicable CSR DW standards during Q4 2021 and Q1 2022 sampling events. The nitrate exceedances were primarily attributed to runoff from aggregate stockpiles (associated with blast residue) on the bedrock ridge north of the Phase 2 landfill.

The groundwater monitoring plan is presently being reviewed to ensure monitoring of groundwater along the northern boundary of the landfill is able to detect changes in groundwater quality now that the RTF is operational and to better characterize groundwater downgradient of the aggregate stockpiles and the Northwest Sedimentation Pond (NWSP).

Operation of the Phase 1 north purge well system continues to mitigate leachate impacts north of the landfill, as indicated by long-term stable or decreasing concentrations of leachate indicator parameters at groundwater wells 40, 20 and 21.

Table 4 Compliance Groundwater Quality – North of the Landfill (2021/2022)

Well	Exceedances	# of Exceedances	Five-year Trend
20-1-1	Boron	1	Decreasing ammonia
20-1-2	none	-	Stable
21-1-1	none	-	Decreasing sulphate
21-1-2	none	-	Stable
21-2-1	none	-	Increasing conductivity
28-1-0	none	-	Increasing conductivity, nitrate
29-1-1	none	-	Increasing sulphate, nitrate
29-1-2	none	-	Decreasing conductivity, chloride. Increasing sulphate, nitrate
30-1-1	none	-	Decreasing chloride
30-1-2	none	-	Increasing sulphate
31-1-1	none	-	Increasing conductivity, sulphate
31-1-2	none	-	Increasing conductivity, sulphate
39-1-1	none	-	Stable
39-2-1	none	-	Stable
53-1-1	none	-	Decreasing chloride. Increasing conductivity, sulphate

9.1.2.2 South of Phase 1

Groundwater flows south in the furthest south portions of Phase 1. A number of leachate containment measures have been installed in this area since the mid-1980s, including a grout curtain, a clay berm, a shallow toe drain and five purge wells. In combination, these engineered improvements obstruct and intercept southward-flowing leachate, which is then directed to the leachate collection system.

Groundwater quality south of the landfill met the applicable CSR standards. Some of the wells had slightly elevated ammonia concentrations in the winter months, but were within historical ranges. Chloride concentrations in some wells continued to increase, but the source of chloride remains unknown. Present information suggests it is not likely from leachate, road salt or application of herbicide.

Water quality improvements stalled in 2021/2022 potentially due to pump failures and ongoing maintenance challenges, though no exceedances of standards were observed. Groundwater quality in this area is known to be sensitive to changes in the operation of the south purge wells and should continue to be monitored closely.

Groundwater quality in this area for the last five years (based on conductivity, ammonia, chloride, sulphate, and nitrate) is summarized in Table 5.

Table 5 Compliance Groundwater Quality – South of the Landfill (2021/2022)

Well	Exceedances	# of Exceedances	Five-year Trend
04-3-1	none	-	Decreasing nitrate. Increasing chloride, sulphate
04-4-1	none	-	Increasing chloride
07-1-0	none	-	Increasing conductivity, chloride
71-1-1	none	-	Decreasing ammonia. Increasing conductivity, chloride, sulphate
71-2-1	none	-	Increasing conductivity, chloride, sulphate
71-3-1	none	-	Increasing sulphate, nitrate
72-1-1	none	-	Decreasing nitrate
72-3-1	none	-	Decreasing chloride, nitrate
73-1-1	none	-	Decreasing ammonia. Increasing conductivity, nitrate
73-2-1	none	-	Decreasing ammonia. Increasing conductivity, sulphate, nitrate
73-3-1	none	-	Increasing sulphate, nitrate

9.1.2.3 East of Phase 1

Groundwater quality remained similar or slightly improved along the east boundary of Phase 1 and met all applicable CSR standards. Water level and quality data confirm that leachate is effectively contained on site in this area, since groundwater naturally flows inwards towards the landfill, preventing off-site leachate migration to the east. The concurrent increase in sulphate and nitrate concentrations observed from Sept-Nov may indicate impacts from dilute aggregate runoff placed on nearby access roads.

Groundwater quality in this area for the last five years (based on conductivity, ammonia, chloride, sulphate, and nitrate) is summarized in Table 6.

Table 6 Compliance Groundwater Quality – East of the Landfill (2021-2022)

Well	Exceedances	# of Exceedances	Five-year Trend
17-1-1	none	-	Stable
17-1-2	none	-	Decreasing chloride
17-1-3	none	-	Increasing chloride
18-1-1	none	-	Increasing ammonia, sulphate
18-2-1	none	-	Increasing conductivity, chloride, sulphate, nitrate
18-2-2	none	-	Decreasing ammonia. Increasing sulphate, nitrate

9.1.2.4 Hartland North Pad

Groundwater quality met BC CSR standards at all boundary compliance locations north of the Hartland North pad.

Groundwater quality was consistent with background concentrations for most parameters, except for higher sulphate, nitrate and conductivity during Q3 and Q4 sampling events, summarized in Table 7. The concurrent increase in these three parameters suggests groundwater was temporally impacted by nearby aggregate placement.

The Hartland North pad is now the location of the Residuals Treatment Facility. Continued monitoring is warranted in this area to evaluate water quality near the Residuals Treatment Facility.

Table 7 Compliance Groundwater Quality – Hartland North Pad (2021-2022)

Well	Exceedances	# of Exceedances	Five-year Trend
41-1-1	none	-	Decreasing sulphate, increasing chloride
42-1-1	none	-	Decreasing chloride, sulphate
55-1-1	none	-	Stable
56-1-1	none	-	Increasing conductivity, chloride
57-1-1	none	-	Increasing conductivity, sulphate

9.1.3 Domestic Well Monitoring Program

Since the 1980s, the CRD has performed routine sampling and analysis of domestic wells in the vicinity of the landfill that are used as the primary source of drinking water. Nineteen domestic wells were sampled in 2021, at 14 locations within a 2-km radius of the landfill (analyzed for general water quality and total metals), and 5 locations north of the Hartland North pad within a 4-km radius (analyzed for leachate indicators).

Analytical results were compared to the BC Source Drinking Water Guidelines (updated 2020) and Guidelines for Canadian Drinking Water Quality (updated 2020).

9.1.3.1 Results

Groundwater quality in all domestic wells met applicable federal and provincial drinking water quality guidelines (CDWQ and SDWQG) in 2021, indicating that offsite domestic water wells remain unaffected by landfill leachate.

9.1.4 Surface Water Monitoring Program

Hartland Landfill is located within the Tod Creek watershed. Drainage south of the landfill is directed toward Killarney and Prospect lakes, 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 it is not adversely affected by landfill operations.

The monitoring program includes approximately 23 sites within the landfill, at the property boundary and within each of the major off-site drainages. Five of these stations are considered boundary compliance monitoring stations (Table 9). These stations are concentrated north and south of the landfill where creeks flow from the landfill property to off-site locations. Water quality results are compared to the BC Approved and Working Water Quality Guidelines (BC WQG) for Freshwater Aquatic Life.

9.1.4.1 Results

Surface water quality data collected in 2021/2022 confirmed that nearby surface water bodies, Tod Creek, Durrance Lake, Durrance Creek and Killarney Lake continue to be unaffected by landfill leachate.

In 2021/2022, water quality at compliance station Sw-N-05 and was impacted by nutrient concentrations that exceeded water quality standards for nitrate and nitrite. The CRD is actively investigating the cause of these water quality issues and remedial mitigation measures are being planned and are expected to improve water quality in the area.

Surface water quality exceedances for iron and total suspended solids (TSS) at Sw-N-16 and Sw-N-41s1 are not considered attributable to leachate, but are related to any or all of the factors listed in Table 8. Water quality at compliance station SW-N-42s1 and SW-S-04 met BCWQG-MAC guidelines.

Table 8 Factors that affect surface water quality

Factor	Results
Seasonal Impacts	Heavy rain events or low-flow (dry) conditions can lead to increased total suspended solids (TSS) and total metals.
Adjacent Construction Activities	Blasting for air space, road building and construction at Hartland north can lead to increased nitrate, TSS and total metals.
Aggregate Storage	Stockpiling can result in increased sulphate and nitrate as rainwater percolates through aggregate and infiltrates surface water runoff.
Road de-icing and dust control	De-icing and dust suppression products contain salts and can lead to increased chloride concentrations in surface water runoff.

Table 9 Surface Water Quality Compliance Summary (2021/2022)

Location	Exceedances of BC Water Quality Guidelines				Trend
	Maximum Allowable Concentration	# Samples with Exceedances	30-day Average	# Samples with Exceedances	
SW-N-05	Nitrite, nitrate, dissolved copper	2	Ammonia, nitrite, nitrate, dissolved copper	4	Increasing conductivity, ammonia, sulphate, nitrate
SW-N-16	Total iron, dissolved iron	2	TSS, dissolved copper, nitrate	2	Stable
SW-N-41s1	Dissolved iron	1	TSS, dissolved aluminum	1	Increasing chloride, decreasing nitrate
SW-N-42s1	None	0	TSS, dissolved copper	3	Increasing conductivity, sulphate
SW-S-04	None	0	Total zinc, dissolved copper	1	Increasing ammonia

9.1.5 Leachate Management and Monitoring Program

Leachate is produced from the percolation of precipitation and groundwater through the decomposing refuse in the landfill. At Hartland Landfill, leachate is managed through landfill design, input monitoring, contaminant treatment, if required, and routine monitoring.

During the reporting period, leachate continued to be managed in accordance with the design, operations and closure plan, and its supporting documents.

9.1.5.1 Leachate Monitoring

A routine leachate monitoring program is conducted to:

- document leachate discharge volumes and flow rates to the sanitary sewer;
- characterize the physical and chemical constituents in the leachate; and
- verify compliance with the CRD Regional Source Control Program waste discharge permit at the point of discharge.

Automated monitoring of the volume of leachate discharged is maintained on the CRD SCADA (Supervisory Control and Data Acquisition) system and provides a basis for measuring flow rates to the sanitary sewer and leak detection. Monthly leachate samples are collected to verify compliance with the waste discharge permit and are analyzed for a variety of chemical parameters (e.g., nutrients, mineral oil and grease, organic compounds, metals and chlorinated compounds).

9.1.5.2 Results

The total volume of leachate discharged during this reporting period was 563,061m^3, which is approximately 38% higher than the previous year's volume of 419,632 m^3. The average leachate flow over this reporting period was 17.9 L/s, greater than the 2020/2021 period's flow rate of 13.3 L/s, likely caused by higher precipitation, which increased by about 12% in 2021/2022. Leachate generation rates typically vary with annual precipitation and landfill construction-related activities (e.g., interim cover installation).

The leachate quality data collected in 2021/2022 remained in compliance with the requirements of the Waste Discharge Permit at the point of discharge to via the Hartland Valve Chamber.

Leachate quality at the point of discharge complied with the applicable Regional Source Control Program waste discharge permit limits throughout the reporting period. Testing of emerging contaminants started in October 2017, with quarterly sampling of select parameters from April 2019 to March 2020. The applicability of emerging contaminant sampling will be assessed by a consultant as required.

9.2 Landfill Gas Monitoring Program

Decomposition of refuse creates landfill gas; the composition and amount of gas generated varies based on factors, such as amount, type and age of waste, as well as environmental conditions, such as moisture content. Peak gas generation occurs during the first one to three years after disposal. Landfill gas is primarily composed of methane and carbon dioxide with small amounts of water vapour, oxygen, nitrogen and trace gases. Trace gases include hydrogen sulphide, ammonia, nitrous oxide, volatile organic compounds and chlorofluorocarbons. Initially, decomposition of waste is an aerobic process and produces mainly carbon dioxide. As oxygen is depleted, the decomposition occurs under anaerobic conditions.

Landfill gas management is regulated by a variety of BC regulations (including the BC Landfill Gas Management Regulation), design guidelines, criteria, Hartland-specific management plans, and WorkSafeBC. The BC Landfill Gas Management Regulation requires landfills generating more than 1,000 tonnes per year of methane to develop landfill gas management plans that targets 75% collection efficiency in four years. A plan was completed for Hartland Landfill and submitted to the Province in April 2012, with an implementation target of the end of 2016.

Since the 1990s, Hartland Landfill has implemented a system to assess and control fugitive landfill gas emissions. The objective of these controls is ultimately to reduce emissions, ensure staff health and safety and to comply with regulations. Since the implementation of the Landfill Gas Management Regulation in 2010, landfill gas collection and/or management program at Hartland now includes gas generation modelling, gas collection infrastructure installation and maintenance, and operation of a landfill gas

beneficial use facility. Additionally, the landfill gas program monitors the effectiveness of the collection infrastructure through a variety of monitoring programs.

Landfill gas generated in the landfill 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 ground flare is only used during extended generator downtime.

To assess the effectiveness of the landfill gas collection infrastructure, Hartland Landfill monitors landfill gas collection and utilization; perimeter and foundation probes, ambient air, and landfill gas speciation. In 2019, the monitoring program confirmed that landfill gas was contained within the landfill and results were within specified criteria or regulatory limits.

9.2.1 Gas Generation

In 2021, Hartland Landfill generated 1,679 scfm of methane, based on ENV's recommended gas generation model. As required, the Province's gas generation model is updated annually with waste quantity and composition data to enable annual calculation of collection efficiency and greenhouse gas emissions.

9.2.2 Gas Collection and Utilization

In 2021, the gas collection system consisted of 58 vertical wells and 84 horizontal wells, 6 leachate horizontal gas wells for a total of 148 wells. Gas collected by the well field averaged 1,150 scfm for the year. The well field was balanced monthly in 2021, as recommended by the BC *Landfill Gas Management Facilities Design Guidelines*.

Total fugitive greenhouse gas emissions generated from the landfill for 2021 are estimated at 64,522 tonnes CO_2. This represents an overall decrease of 39% since the implementation of the Landfill Gas Management Plan in 2012. It is expected that fugitive greenhouse gas emissions will continue to decline due to improvements in gas extraction infrastructure and well field balancing.

In 2020, landfill gas emissions were measured across the site and a methane mass balance was completed. Data was compared to three landfill gas generation models (including the required ENV model) and collection efficiency was calculated. Gas generation results from the UBCi model correlate closely with the methane mass balance and result in a higher collection efficiency. The UBCi model was used along with the ENV model in 2021.

In 2021, collection efficiency using both the ENV model and UBCi model was calculated at 69% and 78%. Gas collection varies as a result of refuse age, well installation/operation, and well balancing activity.

Overall, the following observations can be made regarding gas production and collection at Hartland:

- Phase 1 gas production is depleting. Waste in this area of the landfill has been in place for more than 30 years and a decline in gas production is expected.
- There is decreased gas production in some high producing wells in Phase 2, which is expected due to age of refuse and advanced methanogenic processes.
- Activation of gas wells in Cell 3 required sufficient refuse in place to prevent oxygen intrusion. Wells in Cell 3 are now producing sufficient gas. More wells will be brought online in 2022.

The Landfill Master Filling Plan (Detailed Phase 2 Filling Plan), includes an overview of landfill gas management and future potential, and is expected to prompt a future update of the Landfill Gas Management Plan.

9.2.3 Gas Monitoring and Compliance Summary

Numerous monitoring programs are in place to evaluate the performance of landfill gas system. Table 10 summarizes the results of these monitoring programs, compliance status, remedial actions, if any, and recommendations.

Table 10 Landfill Gas Compliance Summary 2021

Program	Compliance Location	Criteria	Findings	Mitigation/Actions	Recommendations
Perimeter Probe Monitoring	Probes GP-1A, 1B, 2A, 2B, 3A, 3B, 11A, 11B, 12A and 12B	Methane must not exceed 5% in subsurface soils (BC *Landfill Criteria for Municipal Solid Waste* & BC *Landfill Gas Management Facilities Design Guidelines*)	No exceedances 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% methane in any on-site facility (BC *Landfill Criteria for Municipal Solid Waste* & BC *Landfill Gas Management Facilities Design Guidelines*)	No exceedances Low risk of subsurface gas migration to adjacent building	None	Continue quarterly monitoring.
Ambient Grid Monitoring	N/A	100 ppm total hydrocarbon (THC), as methane (CRD internal guideline)	18 grid locations >100 ppm No cover system failures suspected in the closed area of Phase 1	Investigated hot spots and mitigated, where possible.	Continue annual monitoring.
Hot Spot Monitoring	N/A	1,000 ppm THC (CRD internal guideline)	Three new hot spots (z-points) >1,000 ppm Currently 26 locations for hot spot investigation	Added new locations of hot spots to the monitoring program.	Continue annual monitoring. Investigate mitigation options.
Well Field Monitoring and Balancing	N/A	Monitor monthly. Oxygen 2.5% - gas optimization and reduction of fire potential *(BC Landfill Gas Management Facilities Design Guidelines)*	Monitoring completed monthly; Oxygen did not exceed 2.5%	None	Continue monthly monitoring at minimum.
Gas Collection	N/A	75% gas collection efficiency target by the end of 2016, as per *Landfill Gas Management Plan*	Gas collection efficiency was estimated at 69%, based on the ENV gas generation model. Collection efficiency using an alternative model (UBCi) was estimated at 78%.	*Landfill Gas Management Plan* submitted to ENV.	Continue to implement the gas management plan and optimize methane and nitrogen, oxygen levels in the well field

Notes: ppm = parts per million

9.3 Summary and Recommendations

The environmental monitoring program at Hartland Landfill provides the 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. Overall, the monitoring programs (landfill gas, groundwater, surface water, domestic wells and leachate) confirm that regulatory requirements are met.

- Future landfill development planning (Cell 4 development and beyond) should include a detailed hydrogeological evaluation to ensure that proposed works will not compromise the integrity of leachate containment, and that the existing monitoring network and monitoring program remain sufficient to mitigate future environmental impacts.
- The Hartland capital plan should continue to routinely include funds supporting monitoring infrastructure improvements.
- Airspace utilization and compaction rates should continue to be regularly evaluated to accurately assess future air space/landfilling needs. Additional measures/procedures to increase compaction rates should be evaluated.
- The continuous improvement program implemented at Hartland that evaluates data, sampling techniques and site quality should continue. The annual monitoring program must 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.
- Landfill gas monitoring programs should continue (i.e., perimeter probes, building foundation probes, ambient grid, hot spot monitoring and speciation) to measure and ensure regulatory compliance. Landfill gas collection efficiency for 2021 was 69% with the ENV model. Continued monthly well field balancing is necessary to optimize gas collection.
- The environmental monitoring program and data should be evaluated against the applicable standards, in accordance with the Landfill Criteria and the BC CSR, to continue meeting regulatory requirements, and to determine if monitoring program changes are warranted. Operation of the north and south purge well systems effectively control and maintain the collection of leachate and will continue to be verified by monitoring water levels and water quality closely. Planned optimization efforts and maintenance activities at the purge wells have had beneficial results and will continue. The extent of the drawdown cone of the north purge wells should be verified routinely with the next validation planned for 2024.
- Recent groundwater and surface water characterization between the Phase 2 Basin and the Northwest Sedimentation Pond indicate additional leachate containment or groundwater management measures need to be implemented to mitigate the potential for off-site migration of impacted water. The role of historical buried utilities should be investigated as a possible subsurface conveyance pathway contributing to leachate impacts in the Northwest Sedimentation Pond water quality at Sw-N-05.
- Aggregate management and blasting activities should be conducted in accordance with previous recommendations, to maintain the integrity of leachate containment and to protect downgradient water quality. Specifically, blasting should be designed to mitigate impacts to bedrock flow regime and aggregate storage must be managed to mitigate impacts to water quantity and quality (i.e., both surface water and groundwater). Water quality downgradient of aggregate stockpile areas should continue to be closely monitored to confirm the effectiveness of cover systems.
- Where possible, aggregate stockpiles should be located within the leachate collection system and covered to minimize impacts on downgradient groundwater and surface water. Direct runoff from aggregate stockpiles should be effectively diverted away from natural watercourses and minimize infiltration into the underlying leachate collection system. A site-wide aggregate management plan will be developed in 2022/2023 to evaluate current stockpile usage, impacts and potential environmental controls.

9.4 CONCLUSIONS

In 2021, Hartland Landfill received 190,210 tonnes of waste (including controlled waste and asbestos). At the current disposal rate, it is estimated that Hartland's current capacity will be reached in approximately 2050.

Leachate and landfill gas are being managed in accordance with regulatory requirements and data are reported in Appendices 1 and 2, respectively.

The 2021/2022 environmental monitoring program confirms that there are no offsite groundwater impacts related to landfill activities, regulatory requirements were met and effective measures are in place to mitigate environmental impacts and to contain leachate prior to discharge to the sanitary sewer (see Appendix 1). Surface water quality data continues to confirm that nearby surface water bodies, including Tod Creek, Durrance Lake and Durrance Creek and Killarney Lake are not impacted by landfill leachate. An investigation is ongoing at the north end of the landfill to determine the source of diminished surface water quality in the area and mitigation measures are being actively implemented.

10.0 REPORT SIGNOFF

Approved by:

Kelly Tradewell, Supervisor, GeoEnvironmental Programs

Certified by:

Ian Wiebenga, P.Eng.
Manager, Project Engineering

Reviewed by:

Glenn Harris, Ph.D., R.P.Bio., Senior Manager, Environmental Protection

Russ Smith, Senior Manager, Environmental Resource Management

Ian Weibenga, P.Eng, Manager Landfill Operations