Hartland Landfill Operating & Environmental Monitoring 2022/2023 Report

Operational Certificate 12659

Capital Regional District | Parks & Environmental Services, Environmental Protection

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HARTLAND LANDFILL
OPERATING & ENVIRONMENTAL MONITORING
2022/2023 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, 2022.

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 onsite. An environmental monitoring program is in place to assess the effectiveness of these controls and to confirm regulatory compliance. Monitoring data is reported for the period between April 1, 2022 and March 31, 2023, in accordance with the Operational Certificate.

The 2022/2023 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, Durrance Creek and Killarney Lake are not impacted by landfill leachate. Monitoring is ongoing at the north end of the landfill to evaluate the engineering controls that were installed in 2022 to address diminished surface water quality in the area. These controls were installed to capture/divert impacted water from known locations; additional engineering controls are planned for 2023. The landfill gas collection efficiency for 2022 was 70% with the ENV model, and monthly well field balancing will be conducted to continue to optimize gas collection.

In 2022, the Hartland Landfill received 201,981 tonnes of waste, which included: 180,004 tonnes of general refuse, 17,832 tonnes of controlled waste and 4,145 tonnes of asbestos. The estimated remaining capacity within Phase 2 is 6,533,036 (m^3). The estimated landfill capacity will be reached in approximately 30 years (i.e., 2050), assuming current rates of waste disposal. The Hartland Design, Operations and Closure Plan (DOCP) was updated and submitted to ENV in May of 2022. The DOCP update included updated air space and lifespan projections as well as a conformance review under the 2016 Landfill Criteria for Municipal Solid Waste for the Phase 3 (Hartland 2100) landfill expansion.

Hartland Landfill has an annual capital budget of approximately $2.5 million. Construction of Cells 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 efficient landfill operation, health and safety, waste diversion infrastructure, and environmental protection. Operations and capital projects that occurred in 2022 include:

- Ongoing landfill operations, mechanical services, security and vector control contracts
- Fire protection/water system upgrades
- Residential renovation waste management pilot
- Education and Outreach campaigns
- Installation of new engineering controls to address diminished surface water quality in the north
- Ongoing aggregate management area development
- Gas and leachate collection infrastructure installation
- Continued air space/aggregate production
- Construction of a new aggregate stockpile and stockpile access road

- Preliminary design and construction for a new Material Diversion Transfer Station
- Design Operations and Closure Plan update
- Hartland North Scale construction
- Annual invasive plant species control
- Litter control
- Wood Waste Diversion Program
- Yard and Garden Diversion Program
- Shredding of Construction and Demolition (C&D) waste pilot.
- Use of shredded C&D as alternative daily cover
- Implementation of CRD's updated and approved Solid Waste Management Plan (SWMP)
- Waste Composition Study
- Biosolids management and biosolids growing medium (BGM) production and application
- Secured a design/build contract for the renewable natural gas facility
- Aggregate Management Plan project initiated

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1.0 INTRODUCTION

Hartland Landfill (Hartland) 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 approximately 440,000 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 documents (Hartland Landfill Operations Annual Report, Hartland Landfill 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
- 2022 operations activities
- 2022 construction contract-related activities
- 2022/2023 environmental monitoring program results[1]
- 2022 annual landfill gas report summary

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 Point Wastewater Treatment Plant. Leachate discharge to

[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).

sewer is authorized by CRD Regional Source Control Program Waste Discharge Authorization 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 current Hartland monitoring program is required under the Amended Operational Certificate #12659 issued by the ministry and last amended January 21, 2013.

The 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 reporting 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 (2022 version received approval from ENV in July 13, 2023).
- 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 Authorization SC97.001, last amended on December 20, 2022, 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 exceptions required 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). A conformance review and upgrading plan addressing these issues was submitted as part of the Design, Operations and Closure Plan (DOCP) in the spring of 2022.

4.0 WASTE VOLUMES AND AIR SPACE CONSUMPTION

In 2022, the Hartland Landfill received 201,981 tonnes of waste, which included 180,004 tonnes of general refuse, 17,832 tonnes of controlled waste and 4,145 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. Four compaction tests were conducted in 2022. The average compaction achieved was 0.98 tonnes/m^3.

4.2 Airspace Utilization –Consumption and Waste Tonnage

The CRD's Facilities Management & Engineering Service Division conducts monthly volumetric surveys at the active face (general refuse) and asbestos disposal area. 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 Airspace Utilization Factor is shown below in Table 1.

Table 1 Waste Airspace Utilization

2022 Waste Airspace/Density Calculations	Quantity
Airspace consumed by landfilling waste (m^3) (includes waste and cover)	306,501
Tonnage of waste landfilled (tonnes) (scale data)	197,836
Airspace Utilization Factor (tonnes/m^3) [1]	0.64

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

In 2022, it was not possible to accurately track the amount of cover material used for landfilling. Therefore, an Airspace Utilization Factor will be used as a key performance indicator.

4.3 Asbestos Airspace Utilization –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

2022 Asbestos Airspace/Density Calculations	Quantity
Airspace consumed by asbestos (m^3) (includes asbestos and cover)	16,751
Tonnage of asbestos (tonnes)	4,145
Asbestos Airspace Utilization Factor (tonnes/m^3) [1]	0.25

[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 are 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 and is being constructed in a series of cells with each cell divided into a series of lifts that are progressively filled with waste. In 2022, 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 three-dimensional point cloud. The point clouds are used to create three-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.

In 2022 the Hartland DOCP was updated, and remaining airspace reassessed. Evaluation of site capacity and landfill lifespan was carried out and the concept of extending the life of the landfill to 2100 was also presented (Phase 3). The remaining capacity of the Phase 2 landfill is summarized in Table 3. It is estimated that Hartland's current capacity will be reached by the year 2050. Additional potential capacity, as part of the Phase 3 (Hartland 2100) expansion is also presented.

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 2022, the closure/post-closure fund was $12,695,021.

7.0 2022 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 2022.

- **Landfill operations, mechanical services, security and vector control:** Throughout 2022, contract management continued for mechanical services, on-site security, seasonal bird control, bin haul, stewardship, household hazardous waste, recycling and ozone-depleting substance removal.

- **Fire protection system:** Construction and commissioning of a new fire suppression line and pump was completed in 2022. The fire protection system allows leachate from the upper lagoon to be used to fight major landfill fires. System training, maintenance, and operation is facilitated by a partnership between CRD Operations, Engineering, and Integrate Water Services staff and the Saanich Fire Department.

- **Residential renovation waste management:** The Reno Safe Waste Wise program continued into 2022. 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 2022 including: issuance of 16 Rethink Waste Grants, support to 10 local non-profit reuse organizations, resumption of in-person school and educational tours, launching the Rethink Waste Newsletter, and the establishment of a Local Government Waste Reduction Working Group.

- **Engineered water quality controls/mitigation:** staff and consultants worked throughout 2022 to implement surface water and groundwater controls to mitigate water quality impacts related to quarrying and aggregate production, and landfilling. Controls included two purge wells; a collection sump; an expanded monitoring well network; and diversion of impacted water to leachate collection. A detailed aggregate management plan is being developed to address site-wide management practices.

- **Aggregate management area:** Construction and operation of the aggregate storage areas located in the northwest and northeast corner of the landfill property continued in 2022.

- **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 2022, approximately 247,000 m^3 of rock was extracted to produce more air space. The 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 2023.

- **Construction of a new aggregate stockpile and stockpile access road**: A new stockpile and access road was constructed in 2022.

- **Preliminary design and construction for a new Material Diversion Transfer Station**: Site preparation and clearing was completed to make way for a new Material Diversion Transfer Station that will make beneficial use of wood, asphalt shingles and carpet/underlay.

- **Design Operations and Closure Plan:** An update to the Hartland DOCP was initiated in 2021 and submitted to ENV in 2022

- **Hartland North Scale:** Construction of a new scale building, scales and site security gate at the Hartland Landfill North entrance was 90% completed in 2022. Final finishes and occupancy permits will be secured in 2023.

- **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 2022. All accumulated wood waste is ground for beneficial use as landfill cover material.

- **Yard and Garden (Y&G) diversion program:** Diversion of Y&G materials continued in 2022. Y&G is sent off-site to be beneficially used at an external composting facility.

- **Shredding of Construction and Demolition (C&D) Waste Pilot**: The CRD piloted various different shredder models to assess their ability to improve density/compaction targets by reducing bulky C&D waste to a smaller particle size. Ongoing trials will be conducted to understand the benefits shredders may have on landfilling operations and performance.

- **Use of shredded C&D as alternative daily cover**. The use of shredded C&D as an alternative daily cover was trialed in early 2022 and formally incorporated into a DOCP update in the spring of 2022. Use of shredded C&D reduces overall demand and use of virgin aggregate material and conserves airspace.

- The CRD's **Solid Waste Management Plan Amendment** was approved by ENV in July 2022.

- **Waste Composition Study**: An updated waste composition study was finalized in winter 2022.

- **Biosolids management and biosolids growing medium (BGM) production**. In accordance with the CRD's short term biosolid contingency plan, approximately 595 tonnes of biosolids were blended with sand and wood to fabricate BGM. Approximately 2,830 m^3 of BGM was land applied in Hartland Landfill in 2022. The land applied areas were hydroseeded.

- **Renewable Natural Gas (RNG):** Design of a biogas upgrading facility was initiated in 2022 with construction planned to start in 2023.

- **Aggregate Management Plan:** A review of aggregate management and storage practices was initiated in 2022 and is expected to be complete in 2023. The project will consider source control and run-off mitigation options for all aggregate stockpiles on site in efforts to improve on-site surface water quality.

8.0 2023 PLANNED STUDIES AND PROJECTS

- **Fire protection system:** Enhancements to the fire protection system using leachate are planned for 2023 to allow the Saanich Fire department to attach standard firehoses to the system to assist with fire fighting.

- **Outreach campaigns:** Public service campaigns will continue into 2023.
- **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. Additional studies/projects will be implemented in conjunction with the design/construction of the RNG facility and upgrades to existing onsite infrastructure.
- **Air space/aggregate production:** Major airspace production activities to prepare Cell 4 surfaces will conclude in 2023.
- **Design of Phase 2, Cells 4, 5 and 6** will begin in 2023.
- **Procurement of Cell 4 construction** services will be initiated in late 2023.
- **Renewable Natural Gas**: Design to be completed by Q3 2023 and construction to commence in late summer 2023.
- **Material Diversion Transfer Station**: Procurement of a Design/Build/Operate Tender for an onsite transfer station to divert wood, asphalt shingles and carpet/underlay from the landfill will be initiated in 2023.
- **Environmental monitoring network review:** Delivery of an updated groundwater, surface water and leachate monitoring plan is expected in late 2023. This update will ensure that the monitoring program remains effective in monitoring any cumulative impacts of current and future landfill operations including aggregate production, stockpiling, leachate discharge and on-going construction.
- **Kitchen Scraps Transfer Station Relocation**: Design and construction of the kitchen scraps transfer depot is planned for 2023/2024.
- **Access Roads**: Construction of the new North Commercial access road to future Cell 4 and kitchen scraps transfer depot is planned to begin in 2023.
- **Wood Waste Diversion Pilot Program:** The voluntary wood waste diversion program will continue in 2023. Pilot program(s) to beneficially utilize wood and/or yard and garden waste offsite will be studied. Shredding of C&D waste pilot to continue into 2023 and 2024.

- **Methane mitigation:** Application of biocover, to mitigate methane on temporarily inactive landfill areas will be completed in 2023 in accordance with the approved Short-term Contingency Plan for the CRD's Class A biosolids.

9.0 2022/2023 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 2022/2023[2], the program continues to provide data needed to:

- meet Operational Certificate requirements;
- identify potential impacts of landfill operations, if any; and
- 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 2022 to March 2023), AECOM Canada Ltd. (AECOM) – Appendix I
- Hartland Landfill – Landfill Gas Monitoring 2022 Report, Parks & Environmental Services, Environmental Protection, CRD, November 2023 – Appendix II

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 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.

[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’).

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 groundwater levels are monitored in Phase 2 to ensure that the hydraulic trap is maintained. The 2022/2023 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, 2022 and March 31, 2023.

Of the approximately 103 groundwater wells monitored at Hartland, 36 groundwater monitoring wells are considered boundary compliance locations, listed below:

South of the Landfill (10)

- 04-3-1, 04-4-1
- 71-1-1, 71-2-1, 71-3-1
- 72-1-1, 72-3-1
- 73-1-1, 73-2-1, 73-3-1

East of the Landfill (6)

- 17-1-1, 17-1-2, 17-1-3
- 18-1-1, 18-2-1, 18-2-2

North of the Landfill (15)

- 20-1-1, 20-1-2
- 21-1-1, 21-1-2, 21-2-1
- 28-1-0
- 29-1-1, 29-1-2
- 30-1-1, 30-1-2
- 31-1-1, 31-1-2
- 39-1-1, 39-2-1
- 53-1-1

North of the Hartland North Pad (5)

- 41-1-1
- 42-1-1
- 55-1-1
- 56-1-1
- 57-1-1

Groundwater quality at all landfill boundary compliance locations was less than the applicable BC CSR standards except for the sample at well 21-1-1 that exceeded the CSR drinking water standard for copper. This recorded exceedance may not be representative of in-situ groundwater quality due to high a high relative percent difference (RPD) discrepancy. If reliable, the copper exceedance is unrelated to landfill activities, as indicated by low concentrations of parameters associated with aggregate runoff and leachate. Further results of the 2022/2023 groundwater quality monitoring program were similar to those recorded in recent years and are presented by area in the following sections.

9.1.2.1 North of the Phase 1 and Phase 2

Groundwater quality in boundary compliance locations north of the landfill met the applicable BC CSR groundwater standards with the exception of an anomalous exceedance for copper at well 21-1-1 in May 2022. Groundwater quality is summarized in Table 4.

Similar to previous years, most exceedances were present in groundwater wells in close proximity to leachate purge wells and known leachate sources. Nitrate concentrations in several groundwater wells (e.g., 16-1-1, 25-1-1, 104-1-1, 105-1-1, 106-1-1, 107-1-1) located downgradient of aggregate stockpiles exceeded applicable CSR DW standards on one or more sampling event, attributed to aggregate runoff (not boundary compliance wells). In all wells except 106-1-1, ammonia concentrations remained below the detection limit.

Groundwater quality in proximity to the Phase 2 Basin confirms the hydraulic trap leachate collection system is effectively containing leachate north of Phase 2. Groundwater quality 100 m north of Phase 2 continued to show low concentrations of leachate indicator parameters, indicating groundwater quality is not affected by landfill leachate. The increase in nitrate and sulphate concentrations in groundwater is interpreted to be due to runoff from aggregate stockpiles and traffic corridors constructed with aggregate.

Operation of the Phase 1 North Purge Well System continued to mitigate leachate impacts north of the landfill.

Table 4 Compliance Groundwater Quality – North of the Landfill (2022/2023)

Well	Exceedances	# of Exceedances
20-1-1	Copper	1
20-1-2	none	-
21-1-1	none	-
21-1-2	none	-
21-2-1	none	-
28-1-0	none	-
29-1-1	none	-
29-1-2	none	-
30-1-1	none	-
30-1-2	none	-
31-1-1	none	-
31-1-2	none	-
39-1-1	none	-
39-2-1	none	-
53-1-1	none	-

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 all applicable CSR standards. Although ammonia concentrations in some wells south of the landfill were slightly elevated, they were within historical ranges and well below the applicable CSR standards.

Groundwater quality at several locations (e.g., sites 85, 60, and 71) showed no evidence of landfill leachate impacts. However, elevated nitrate and moderate sulphate concentrations reflect impacts from aggregate stockpiling and use, which may be related to runoff from the paved area and wind-blown or transported aggregate dust.

Groundwater quality is summarized in Table 5.

Table 5 Compliance Groundwater Quality – South of the Landfill (2022/2023)

Well	Exceedances	# of Exceedances
04-3-1	none	-
04-4-1	none	-
71-1-1	none	-
71-2-1	none	-
71-3-1	none	-
72-1-1	none	-
72-3-1	none	-
73-1-1	none	-
73-2-1	none	-
73-3-1	none	-

9.1.2.3 East of Phase 1

Water quality along the east boundary of the Phase 1 landfill was consistent with previous years, and concentrations of all parameters were below applicable CSR standards. However, elevated sulphate and nitrate concentrations were observed at Site 16 reflecting the influence of aggregate runoff from the Northeast Stockpile.

Groundwater quality is summarized in Table 6.

Table 6 Compliance Groundwater Quality – East of the Landfill (2022/2023)

Well	Exceedances	# of Exceedances
17-1-1	none	-
17-1-2	none	-
17-1-3	none	-
18-1-1	none	-
18-2-1	none	-
18-2-2	none	-

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 at the Hartland North Pad was slightly deteriorated, with elevated conductivity, nitrate, and sulphate concentrations observed in some wells (e.g., wells 44, 62, 77, 78, 87, 88), summarized in

Table 7. The concurrent increase in conductivity, sulphate, and nitrate concentrations suggests widespread impacts of aggregate runoff on shallow groundwater quality.

Groundwater quality in 91-1-1 and 92-1-1 was generally consistent with background conditions, except for elevated conductivity and sulphate concentrations. Nitrate concentrations remained low at both sites. The elevated sulphate may be associated with natural sulphide oxidation. Groundwater at location 94-1-1 was clearly impacted by aggregate runoff, indicating it cannot be considered a background station.

Table 7 Compliance Groundwater Quality – Hartland North Pad (2022/2023)

Well	Exceedances	# of Exceedances
41-1-1	none	-
42-1-1	none	-
55-1-1	none	-
56-1-1	none	-
57-1-1	none	-

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. Sixteen domestic wells were sampled in 2022 within a two-kilometre radius of the landfill.

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

The groundwater quality data was consistent with historic results, meeting all applicable federal and provincial drinking water quality guidelines (CDWQ and SDWQG). This indicates that offsite domestic water wells continue to remain unimpacted 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 surface water monitoring stations are considered boundary compliance stations, concentrated along the southern and northern property boundaries, downgradient of areas that have the potential to be impacted by leachate or landfill runoff. Water quality data collected from the Boundary Compliance stations are compared to BC Approved and Working Water Quality Short Term Acute Guidelines (BC WQG-STA) for Freshwater Aquatic Life.

Since November 2021, surface water at compliance monitoring station SW-N-05 (north end) has exhibited elevated and non-compliant nutrient concentrations. A multiphase assessment was completed during 2022 to determine the cause of elevated nutrient concentrations within and downstream of the Northwest Sedimentation Pond (NWSP) and Heal Creek. It was determined that water quality north of Phase 2 was being impacted by aggregate management activities and the Northwest Aggregate stockpile. Minor impacts related to landfill leachate were identified and mitigated through engineered controls in Quarter 3 2022. Remedial strategies and options for managing aggregate stockpiles have been implemented, with additional strategies planned for the next two years, including development of an Aggregate Management Plan and updates to the existing groundwater and surface water monitoring plan; additional design upgrades have also been incorporated into the Phase 4, 5 and 6 landfill design.

9.1.4.1 Results

Surface water quality data collected in 2022/2023 confirmed that nearby surface water bodies, including Tod Creek, Durrance Lake and Durrance Creek and Killarney Lake continue to be unimpacted by landfill leachate.

Some water quality impacts observed at the Boundary Compliance stations were caused by sources other than landfill leachate or aggregate runoff, including turbid samples collected under low-flow conditions and ongoing construction activities. In 2022/2023, surface water quality was slightly deteriorated, exhibiting widespread impacts related to aggregate production and stockpiling. Throughout the monitoring year, highly elevated conductivity, sulphate, nitrate and/or ammonia concentrations consistent with aggregate runoff were observed at Boundary Compliance stations SW-N-05, and SW-N-16.

Nitrate concentrations exceeded the BCWQG-STA at SW-N-05 during the May and November 2022 sampling events. Additionally, moderately elevated conductivity, sulphate, and nitrate concentrations at SW-N-41s1 and SW-N-42s1 indicate minor impacts from aggregate production, stockpiling and use. Ultimately, in 2022/2023, surface water quality at SW-N-05 was not compliant with the Landfill Operational Certificate. Table 8 summarizes BCWQG-STA exceedances observed at Hartland in 2022/2023.

Table 8 Surface Water Quality Compliance at Property Boundary Stations (2022/2023)

Location	Exceedances of BC Water Quality – Short-Term Acute Guidelines	# Samples with Exceedances	Comments
SW-N-05	Nitrate	2	Nitrate exceedances are associated with aggregate production and stockpiling at Hartland. The nitrate originates from leaching of ammonium nitrate / fuel oil (ANFO) residue left on the aggregate after blasting.
SW-N-16	Total iron	1	Exceedances are anticipated to be related to turbid flow conditions following a prolonged dry period. Continued monitoring to assess these anomalous results.
SW-S-04	Total iron, TSS	1	Exceedances are anticipated to be related to turbid flow conditions following a prolonged dry period. Continued monitoring to assess these anomalous results.

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 DOCP, 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 authorization 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 authorization 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 520,740 m^3, which is approximately 7.5% lower than the previous year's volume of 563,061 m^3, likely due to a lower volume of precipitation in 2022/2023 compared to 2021/2022. Leachate generation rates typically vary with annual precipitation and landfill construction-related activities (e.g., interim cover installation, final closures, etc.).

In 2022/2023, the leachate quality observed in the Hartland Valve Chamber followed the requirements of the Waste Discharge Authorization, except for Chemical Oxygen Demand (COD) exceedances on multiple sampling dates. Based on discussions with the analytical laboratory, the CRD confirmed that the noted COD exceedances were due to the use of compromised/expired preservatives that were provided to the CRD by the laboratory, and the exceedances likely do not reflect in-situ leachate quality. Overall, average annual leachate concentrations in 2022/2023 were comparable with those measured in 2021/2022.

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 a 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 2022, Hartland Landfill generated 7,283 tonnes/year 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 the annual calculation of collection efficiency and greenhouse gas emissions.

9.2.2 Gas Collection and Utilization

In 2022, the gas collection system consisted of 58 vertical wells and 86 horizontal wells, as well as 1 leachate horizontal gas well for a total of 145 wells. Gas collected by the well field averaged 5,864 tonnes/year for the year. The well field was balanced monthly in 2022, as recommended by the BC *Landfill Gas Management Facilities Design Guidelines*.

Total fugitive greenhouse gas emissions generated from the landfill for 2022 are estimated at 68,880 tonnes CO_2. Though not required under the regulation, alternative gas modeling using the UBCi model, shows CO_2e emissions (39,699 tonnes CO_2e) to be substantially less than the ENV model.

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 2022.

In 2022, collection efficiency using both the ENV model and UBCi model was calculated at 70% and 81% respectively. 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 2023.

The design and construction of Cells 4, 5 and 6 will require updating of the Landfill Gas Management Plan. This will be completed in 2024.

9.2.3 Gas Monitoring and Compliance Summary

Numerous monitoring programs are in place to evaluate the performance of the landfill gas system. Table 9 summarizes the results of these monitoring programs, compliance status, remedial actions, if any, and recommendations.

Table 9 Landfill Gas Compliance Summary 2022

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).	11 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 22 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 70%, based on the ENV gas generation model. Collection efficiency using an alternative model (UBCi) was estimated at 81%.	*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 helps to evaluate the effectiveness of leachate containment and collection systems, assess the potential impacts of landfill leachate and operational activities on groundwater and surface water quality, and assess temporal trends. The program supports landfill operations by providing information to staff, managers and committees; and confirms that regulatory requirements are met. Recommendations for 2023 are summarized below.

- Future landfill development planning (Cells 4, 5 and 6) 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.
- Recommendations from the upcoming monitoring program review should be implemented in order to continue monitoring landfill impacts effectively during landfill expansion activities. Groundwater wells to be removed should be decommissioned in accordance with provincial regulations.
- 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. Compliance with upcoming federal landfill gas regulations should guide future landfill gas sampling methodology.
- 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.
- Continue implementing additional engineered controls in the north end of Hartland to address known sources of diminished water quality related to aggregate management/quarrying.
- Recommendations from the Aggregate Management Plan should be implemented to ensure best practices for blasting, storage, and monitoring the environmental impacts from aggregate stockpiles at Hartland Landfill. Until the Aggregate Management Plan is ready, 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.

10.0 CONCLUSIONS

In 2022, Hartland Landfill received 201,981 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 2022/2023 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 (Appendix 1). Onsite aggregate management activities have resulted in a deterioration of surface water in the north. An aggregate management plan is underway to prevent and further mitigate impacts in these areas. Surface water quality data continues to confirm that nearby surface water bodies, including Tod Creek, Durrance Lake, Durrance Creek and Killarney Lake are not impacted by landfill leachate.

11.0 REPORT SIGNOFF

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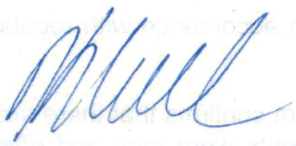

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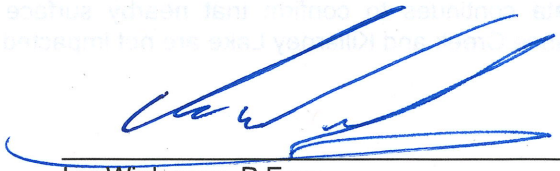

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