

Hartland Landfill – Landfill Gas Monitoring

2024 Report

Capital Regional District | Parks, Recreation & Environmental Services, Environmental Protection



Biogas Upgrading Facility at Hartland Landfill

Prepared by
GeoEnvironmental Programs

Capital Regional District

625 Fisgard Street
Victoria, BC V8W 2S6
T: 250.360.3000
www.crd.ca

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HARTLAND LANDFILL - LANDFILL GAS MONITORING 2024 REPORT

EXECUTIVE SUMMARY

Hartland Landfill provides solid waste disposal services for the Capital Regional District (CRD). The landfill is a multi-purpose facility providing collection services for recyclable materials, household hazardous waste, items covered by product stewardship, as well as disposal of municipal solid waste (MSW) and controlled waste. The site operates pursuant to an operational certificate under the *Environmental Management Act*, issued by the BC Ministry of Environment and Parks (ENV); and follows a Design, Operations and Closure Plan required under the operational certificate.

The landfill footprint (Phase 1 + Phase 2) occupies 42.9 hectares with an estimated 8.4 million tonnes of municipal solid waste in place in 2024. When the landfill reaches planned final filling elevations in Phase 2, it is estimated to contain approximately 18 million tonnes of municipal solid waste. This report fulfills annual reporting requirements set out in the BC *Operational Certificate 12659* and the BC *Landfill Gas Management Regulation*. Landfill gas (LFG) collection/management at Hartland (described below) includes collection and utilization infrastructure, generation modelling and monitoring (utilization, perimeter gas probes, and hotspot monitoring).

LFG collection and/or management at Hartland in 2024 included the following components:

- **Gas collection infrastructure** including cover systems, collection pipes, wells, and blowers to facilitate gas collection and utilization.
- **Flaring system** an enclosed flare and two blowers were in place in 2024 during the transition period through construction and commissioning of a new Biogas Upgrading Facility (BUF).
- **LFG monitoring system** including collection system, hotspot and subsurface monitoring programs.
- **Methane production and gas generation modelling** rates given landfill waste volumes and decomposition rates.

GAS GENERATION, COLLECTION AND UTILIZATION

In 2024, the gas collection system consisted of 58 vertical wells and 97 horizontal wells, for a total of 155 wells. The well field was balanced monthly in 2024, as recommended by the BC *Landfill Gas Management Facilities Design Guidelines*.

A fugitive emissions monitoring project was completed in 2020. The data were used to complete a comprehensive landfill gas mass balance for the site using three different landfill gas generation models. Report findings confirm that the current ENV model overestimates landfill gas generation and fugitive emissions at Hartland, while an alternative model (UBCi) more accurately estimates gas generation. Therefore, this model was used again in 2024, alongside the ENV model. Results of the UBCi model demonstrate a collection efficiency of 50%, whereas the ENV model reports 43% for the same period. In 2024, a new model provided by Environment and Climate Change Canada (ECCC) was also used, and the results indicated 49% collection efficiency. According to all three models, Hartland Landfill is under the 75% collection efficiency requirement set out in the *Landfill Gas Management Regulation*. The decrease in collection efficiency in 2024 was mainly due to infrastructure and installation challenges, including technical design considerations, delays in acquiring critical equipment, and coordination with other capital projects (Cell 4 construction), which affected the timely connection of gas wells. Construction began in late 2024 to align with Cell 4 timelines, with completion of new infrastructure and well connections expected in the first quarter (Q1) of 2025. Collection efficiency has improved significantly as of the date of this report.

Table ES1 Modelled Methane Generation and Collection Efficiency 2024

Year	Modelled Annual Methane Generated ENV (tonnes/year)	Modelled Annual Methane Generated UBCi (tonnes/year)	Modelled Annual Methane Generated ECCC (tonnes/year)	Measured Annual Gas Capture (tonnes/year)	Collection Efficiency (%) ENV Model	Collection Efficiency (%) UBCi Model	Collection Efficiency (%) ECCC Model
2024	8,531.6	7,362.9	7,443	3,648	43%	50%	49%

MONITORING

Hartland Landfill has several monitoring programs to assess the effectiveness of the LFG collection infrastructure. The following summarizes the components of the program:

1. **Collection and flaring system monitoring** to evaluate changes in gas quality over time and to document data for gas collection and gas flaring to assess collection efficiency and total emissions from the landfill.
2. **Monitoring of subsurface perimeter and building foundation probes** to assess the potential for subsurface LFG migration at the eastern landfill boundary and at on-site buildings for compliance with BC *Landfill Criteria*, and for worker and public health and safety.
3. **Surface emissions and hotspot monitoring** to verify the effectiveness of cover and the LFG collection system in order to identify health and safety risks associated with fugitive LFG emissions.

COMPLIANCE SUMMARY

Table ES2 has been prepared to summarize the results of LFG monitoring programs, whether the results comply with requirements, actions taken to address non-compliance, and recommendations.

Table ES2 LFG Compliance Summary 2024

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 (<i>BC Landfill Criteria for Municipal Solid Waste & BC Landfill Gas Management Facilities Design Guidelines</i>)	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, 17A and 18A	Maximum 1% methane in any on-site facility (<i>BC Landfill Criteria for Municipal Solid Waste & BC Landfill Gas Management Facilities Design Guidelines</i>)	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)	4 grid locations >100 ppm No cover system failures suspected in the closed area of Phase 1	Investigated hotspots and mitigated, where possible.	Continue annual monitoring.
Hotspot Monitoring	N/A	1,000 ppm THC (CRD internal guideline)	No new hotspots (Z-points) >1,000 ppm were identified. Currently 20 locations for hotspot investigation	Added new locations of hotspots 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 (<i>BC Landfill Gas Management Facilities Design Guidelines</i>)	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 <i>Landfill Gas Management Plan</i>	Site specific model (UBCi) estimated collection efficiency at 50%. ENV model estimated collection efficiency at 43%. ECCC model estimated the collection efficiency at 49%.	<i>Landfill Gas Management Plan</i> submitted to ENV.	Continue to implement the gas management plan and optimize gas concentrations in the well field.

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List of Acronyms and Units of Measurement

%	Percent	GJ	Gigajoule
<	Less than	H ₂ S	Hydrogen sulfide
≤	Less than or equal to	LEL	Lower explosive limit
=	Equal to	LFG	Landfill gas
>	Greater than	m	Meter
BC	British Columbia	m ³	Cubic meter
BGM	Biosolids growing medium	mASL	Meters above sea level
BUF	Biogas Upgrading Facility	mm	Millimeters
CH ₄	Methane	MSW	Municipal solid waste
CO ₂	Carbon dioxide	O ₂	Oxygen
CO ₂ e	Carbon dioxide equivalent	ppm	Parts per million
CRD	Capital Regional District	Q1-4	Four quarters of the year
ECCC	Environment and Climate Change Canada	RNG	Renewable natural gas
ENV	Ministry of Environment and Parks	scfm	Standard cubic feet per minute
ENV model	Ministry of Environment and Parks model	THC	Total hydrocarbon
EPro	Environmental Protection	UBCi model	University of British Columbia integrated Model
GHG	Greenhouse gas	VOC	Volatile organic content
		Z-points	New hotspots

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1.0 INTRODUCTION

Hartland Landfill provides solid waste disposal services for the Capital Regional District (CRD). The landfill is a multi-purpose facility providing collection services for recyclable materials, household hazardous waste, extended producer responsibility products, salvageable items, as well as disposal services for municipal solid waste and controlled waste. Landfill operations are guided by the *Hartland Landfill Design, Operations and Closure Plan (updated 2023)*, the *BC Operational Certificate 12659* issued by the BC Ministry of Environment and Parks (ENV), and the CRD's *Solid Waste Management Plan (approved in 2022)*.

Landfill gas (LFG) is primarily composed of methane, carbon dioxide and nitrogen, with small amounts of water vapour, oxygen and trace gases. Trace gases include hydrogen sulphide, ammonia, nitrous oxide, volatile organic compounds and chlorofluorocarbons. Risks associated with LFG include asphyxiation, flammability (between 5% and 15% methane by volume), toxicity, odour, and greenhouse gas (GHG) emissions.

The objective of an LFG collection system is to reduce GHGs through the destruction of collected methane, mitigate fugitive emissions, and reduce the potential for subsurface, lateral gas migration. Ongoing monitoring is conducted at the landfill to assess the effectiveness of these controls, and includes gas generation modelling, gas capture assessment, and ambient and subsurface monitoring.

This report is prepared to assess operational needs and performance, meet regulatory reporting requirements and to inform the public regarding LFG management at Hartland Landfill. This report meets the reporting requirements specified in the *BC Operational Certificate 12659* and the *BC Landfill Gas Management Regulation* for annual reporting of gas collection and management.

2.0 SITE DESCRIPTION

The Hartland Landfill is situated on 320 hectares within the District of Saanich. Mount Work Regional Park is located to the west, parkland and the Heal's Rifle Range lies to the north, residential properties lie to the east, and undeveloped CRD property is located to the south.

The climate in the area is classified as "cool mediterranean" due to warm, dry summers and cool, wet winters. Annual precipitation is around 800-1,000 mm per year. The site is surrounded by bedrock; discontinuous bedrock fractures have been identified.

The CRD took over operation of the landfill site in 1985. Prior to that, it was privately owned and operated. The landfill footprint (Phase 1 + Phase 2) occupies 42.9 hectares with an estimated 8.4 million tonnes of MSW in place. The average annual disposal rate for the last five years is approximately 186,525 tonnes which comprises residential, commercial and industrial wastes as well as controlled waste and asbestos containing material.

The landfill has two operational areas: Phase 1 was operational between the 1950s and 1997 and has final cover. Phase 2 comprises the current active area of the landfill, which began in 1997. Phase 1 is unlined and covered with a combination geomembrane/clay cap. Phase 2 was constructed within a former lake basin (now referred to as the Phase 2 basin); it is partially lined and relies on hydraulic gradients to contain leachate. Development of the Hartland Landfill is guided conceptually by the cell development and filling plan, updated in 2022.

3.0 REGULATORY FRAMEWORK

There are a number of provincial and federal regulations that apply to LFG management, emissions management and reporting. Key regulations are listed below.

3.1 LFG Management Regulation

The BC *Landfill Gas Management Regulation* requires landfills that produce 1,000 tonnes of methane per year to have a qualified professional prepare an LFG management plan. According to the regulation, the *Landfill Gas Management Plan* must be prepared in accordance with the BC *Landfill Gas Management Facilities Design Guidelines*, 2010 ('the Guidelines') and include:

- a description of existing or planned methods or maintenance practices and processes for LFG management on the site;
- a plan for installation, operation and maintenance of LFG management facilities (including contingencies for planned or emergency shutdowns); and
- recommendations for optimizing LFG collection to meet a 75% collection efficiency target four years after implementation.

The Guidelines specify a set of design and performance objectives/standards regarding LFG management and operations including gas collection and composition, extraction and destruction infrastructure, and gas migration and assessment.

3.2 WorkSafeBC

Many of the compounds in LFG, particularly methane, hydrogen sulphide and individual volatile organic compounds, have worker exposure limits set out within WorkSafeBC regulations. The Hartland Landfill must comply with these limits.

3.3 BC Landfill Criteria for Municipal Solid Waste

The BC *Landfill Criteria for Municipal Solid Waste* (2016) stipulates compliance with the *Landfill Gas Management Regulation* and the Guidelines described above. As well, the landfill must be managed to ensure there is no public threat or nuisance/odour. Annual reporting and compliance review is a requirement under Hartland Landfill's *Operational Certificate 12659*. A full compliance report for all Operational Certificate requirements is provided in the 2022 Hartland Landfill Annual Operations Report.

4.0 HEALTH AND SAFETY

LFG is flammable, toxic and poses an asphyxiation risk to landfill employees and contractors on site. Specifically:

- LFG can accumulate in confined spaces or low-lying areas with poor air circulation, which can pose an asphyxiation risk due to the displacement of oxygen.
- Both trace gases and major gas constituents can result in acute toxicity if exposure occurs at high enough concentrations.
- Trace gases, usually associated with sulphur compounds, can create odours.
- Methane is explosive at concentrations between 5 and 15%. It is also a GHG with 25 times the global warming potential of carbon dioxide.

There is also potential for gas to laterally migrate off-site. When gas pressure builds up in a landfill, gas migrates via cracks, soil pores, and/or fractures to equalize with the surrounding atmosphere. This includes migrating through permeable cover systems or subsurface migration toward adjacent properties. The main objective of an LFG collection system is to mitigate the above risks and reduce the potential for subsurface, lateral gas migration. However, while lateral movement can be mitigated with LFG collection and control, there will still be fugitive LFG emissions on site. A number of factors influence this, such as atmospheric pressure, groundwater level, gas pressure in the refuse mass, and permeability of cover systems. Gas

collection system operation and utilization is discussed in Sections 6.0 and 7.0, and monitoring programs are discussed in Section 9.0.

5.0 LFG GENERATION

Decomposition of refuse creates LFG; 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 temperature and moisture content. LFG composition and generation rates are discussed in Sections 7.0 and 9.0.

Peak gas generation occurs during the first one to three years after disposal. Initially, decomposition of waste is an aerobic process and produces mainly carbon dioxide. As oxygen is depleted, the decomposition occurs under anaerobic conditions. The total waste input and waste composition affects overall gas generation rates. For clarity, it is important to note that gas production is the total amount of gas predicted to be produced by the landfill given waste composition, volume of existing waste in place and site-specific, meteorological conditions.

5.1 Waste Quantity

The quantity of LFG production is dependent on the amount and type of waste received. In 2024, the Hartland Landfill received 186,525 tonnes of waste, which included 161,540 tonnes of general refuse (including biosolids mixed with sand), 22,671 tonnes of controlled waste and 2,314 tonnes of asbestos.

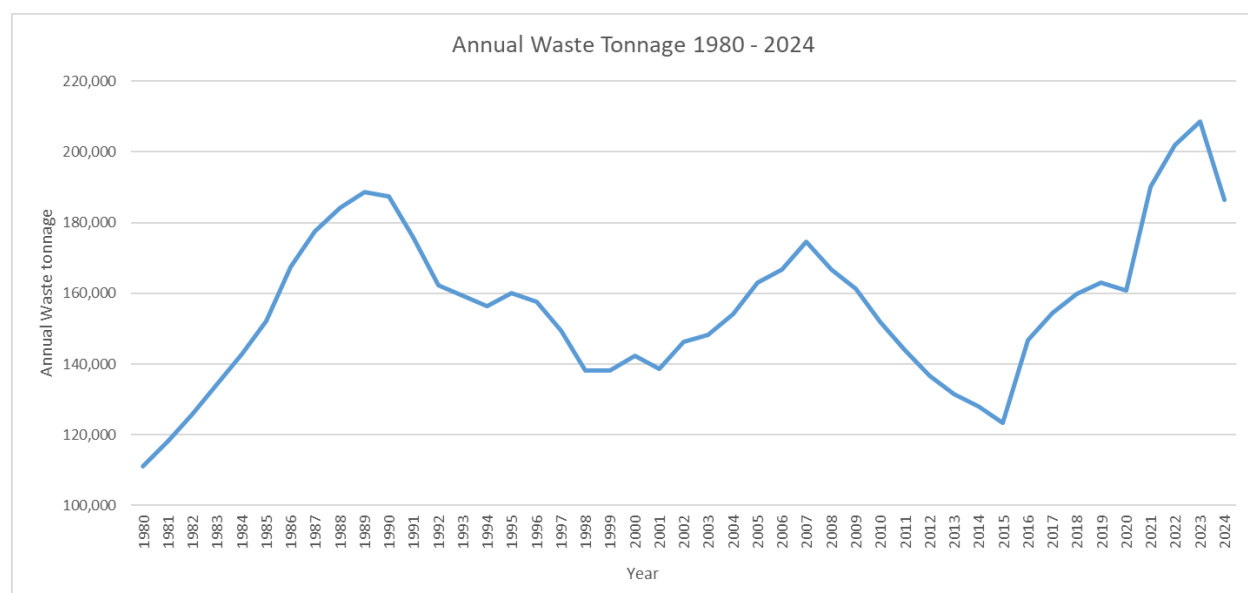


Figure 1 Annual Waste Tonnages Received or Estimated for Hartland Landfill from 1980-2024

5.2 Waste Composition

Waste composition is used to calculate methane generation rates in order to estimate overall LFG generation. Waste composition study results are included in Table 1 and with the gas generation data in Appendix A, including methane generation potential and a summary of waste sources and diversion, as required under the BC *Landfill Gas Management Regulation*.

The Waste Composition Study conducted by Tetrtech (2022) does not quantify controlled waste. Controlled waste is classified by the CRD as wastes that, due to environmental or health and safety considerations, require special handling. Controlled waste deposited at the site is measured by scale and classified by type. For the modelling purposes by using UBCi model, controlled waste data is categorized as described below. Based on the consultant's recommendation, the following assumptions were applied

to categorize controlled waste decomposability:

- All asbestos and demolition wastes are relatively inert.
- Anything with a rock/sand nature or contaminated soil is relatively inert.
- Anything with unknown composition is categorized as Miscellaneous (50% moderately decomposable and 50% relatively inert).
- Waste sludge and pumping from sewage treatment are decomposable.

In 2024, the general refuse total tonnage (184,566) was inclusive of approximately 918 tonnes of biosolids. Based on consultant feedback, this volume of landfilled biosolids is not expected to have any appreciable impact on the reported collection efficiency. Staff will continue to review this and make adjustments to the methodologies as necessary.

Controlled waste composition is attributed to each of the waste composition categories (relatively inert, moderately decomposable and decomposable waste) in the models. Table 1 indicates the waste composition used since 1981.

Table 1 Waste Composition 1981 to Present; and Projection to 2027

Year	Relatively Inert	Moderately Decomposable	Decomposable
1981 - 2013	35.1%	37.2%	27.7%
2014	35.3%	40.9%	23.9%
2015	35.1%	41.3%	23.6%
2016	36.0%	43.4%	20.6%
2017	36.0%	43.4%	20.6%
2018	36.0%	43.4%	20.6%
2019	35.9%	43.5%	20.6%
2020	35.2%	45.6%	19.1%
2021	34.5%	46.9%	18.6%
2022	39.6%	45.4%	15.0%
2023	38.9%	46.2%	14.9%
2024-end	38.8%	46.6%	14.6%

5.3 Gas Generation Modelling

LFG generation rates are estimated using the ENV model stipulated by the BC *Landfill Gas Management Regulation*. Additional modelling was completed in 2020 after a comprehensive landfill gas quantification project supported the use of the UBCi model as a more accurate representation of gas generation for Hartland Landfill.

Table 2 Estimated Methane Generation by Year at Hartland Landfill

Year	Annual Methane Generation (tonnes/year) UBCi model	Annual Methane Generation (tonnes/year) ENV model
2021	7,167	8,192
2022	7,283	8,325
2023	7,307	8,418
2024	7,363	8,532

6.0 LFG COLLECTION AND MONITORING INFRASTRUCTURE

Systems to control and monitor fugitive LFG emissions have been implemented at Hartland Landfill. The objective of these controls is to:

- protect employee and public health and safety
- prevent migration of gas off-property or into on-site buildings
- reduce GHG
- capture gas for energy recovery
- control odour

The original LFG management system was installed in 1990 and upgraded in 1996. Under this early LFG system, collected methane was destroyed via candlestick flare. Since 2004, LFG has been used to generate electricity. The electricity generation function of the old gas plant ceased on December 31, 2023. A new enclosed flare and blowers were installed in 2024. A Biogas Upgrading Facility (BUF) was under construction throughout 2024 that uses cutting-edge technologies with a complex design to produce Renewable Natural Gas (RNG) for sale to FortisBC. During construction of the BUF, the landfill gas was flared continuously in 2024.

The current LFG management system consists of:

- An extraction well network, including vertical and horizontal wells
- A collection system incorporating branch, lateral and header pipes to convey the collected LFG from the extraction network to the LFG utilization facility or flares.
- A new flare system that consists of two blowers, an enclosed flare, flame arrestor, condensate knock-out, analyzers, valves, controls, interconnected piping and electrical system.
- The Biogas Upgrading Facility (under construction in 2024)
- An LFG monitoring program
- A subsurface gas migration monitoring network that includes gas monitoring probes located adjacent to the eastern property boundary and the perimeter of on-site building foundations.

6.1 Gas Extraction Wells

Table 3 shows the number and type of gas wells installed and operating over the last six years.

Table 3 Number and Type of Gas Wells Installed or Operating (2018-2024)

Type of Gas Well	2018	2019	2020	2021	2022	2023	2024
Vertical gas wells operating	63	60	60	58	58	58	58
Horizontal gas wells operating	69	78	78	84	86	94	97
Leachate horizontal gas wells operating	9	8	6	6	1	1	1
Leachate gas trench operating	0	0	0	0	0	0	0
Wells installed, but not connected ¹	15	7	15	7	25	33*	33
Totals	141	146	144	148	145	152	155

The total number of wells does count wells currently installed, but not connected the gas collection system yet

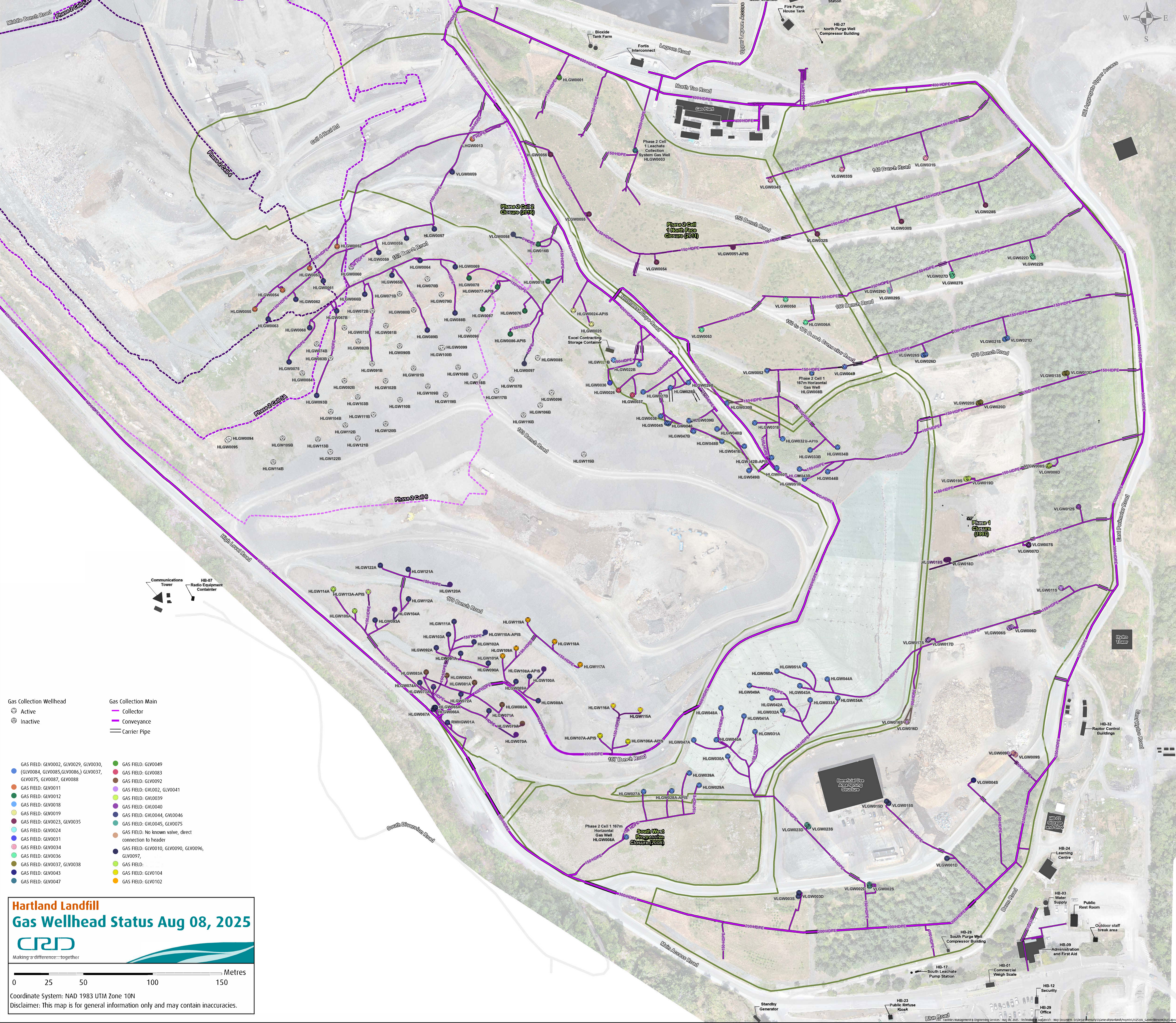
* LFG collectors can be connected to well heads on either end (north and/or south). There are currently 33 collectors installed in Cell 3 that are not connected on either north or south ends. This would account for 66 total well heads.

See Figure 2 for the general location and layout of the LFG infrastructure.

Since 2011, the density of horizontal wells has increased from 45-50 m to 20 m on center. Wells are placed on each vertical lift, approximately every 4 m, with each offset from the lower trench alignment. All new horizontal wells over 150 m in length are connected to laterals at both ends (where feasible).

Current vertical well design includes dual zone shallow and deep wells extending approximately 16 m and 30 m into the waste, respectively. Vertical well saturation with leachate has complicated gas extraction and, as a result, no further vertical wells have been installed since the 2012 implementation of the *Landfill Gas Management Plan*.

Figure 2 Hartland LFG Collection Infrastructure



6.2 Gas Well Field Operation and Monitoring

CRD staff monitor gas wells for methane, carbon dioxide, carbon monoxide, oxygen, balance gas, static pressure, differential pressure, temperature and flow on a monthly basis. The well field must be measured and balanced at least once per month and more often if there are changes in gas composition, or if there are fluctuations in the system vacuum. There are many factors that impact gas generation, so frequent well adjustments are critical to minimize oxygen, and optimize flow and methane content. Ideally, constant vacuum is applied at a well so that gas is drawn at approximately the same rate that it is being generated (a target of approximately 50% methane and <3% oxygen is desirable).

The well field was balanced 12 times in 2024 on a monthly basis (specific wells are checked more often to optimize gas extraction), as recommended by the BC *Landfill Gas Management Facilities Design Guidelines*.

Table 4 shows that eleven most productive wells contribute approximately 50% of the total gas volume. Figure 3 depicts gas collection by well as it contributes to the total gas collected.

Table 4 Gas Wells with the Highest Collection 2024

Name	Refuse Lift (mASL)	Year Activated	Average Methane (% by vol)	Average Flow (scfm)	Months in Operation	Methane Annual Flow (scfm)	Methane Flow (m ³)	Energy (GJ)	Well Production (% of Total)	Cumulative Total (%)
HLGW016B	163	2012	52.2	109.7	12.0	30,104,933	852,481	30,604	12.21	12.21
HLGW028A	171	2017	53.5	34.6	12.0	9,731,211	275,559	9,893	7.16	19.37
HLGW073A	163	2019	53.1	32.7	12.0	9,114,742	258,102	9,266	7.68	27.05
HLGW081A	167	2019	53.3	28.0	12.0	7,839,517	221,992	7,969	4.14	31.19
HLGW0018	165	2013	53.1	26.6	12.0	7,408,191	209,778	7,531	3.32	34.51
HLGW067A	159 (3)	2018	53.0	21.8	12.0	6,070,683	171,904	6,171	3.81	38.32
HLGW079A	167	2019	54.8	20.1	12.0	5,773,737	163,495	5,869	2.74	41.06
HLGW070A	163	2019	55.1	19.0	12.0	5,489,167	155,437	5,580	2.91	43.97
HLGW072A	163	2019	52.2	20.8	11.0	5,236,092	148,270	5,323	2.35	46.32
HLGW080A	167	2019	56.0	17.1	12.0	5,038,693	142,681	5,122	2.05	48.37
HLGW0061	155(3)	2019	52.3	15.8	11.0	3,983,490	112,800	4,050	2.2	50.57
HLGW042B	175	2017	53.4	14.2	12.0	3,966,832	112,329	4,033	1.9	52.47
HLGW082A	167	2019	55.5	13.6	12.0	3,955,389	112,005	4,021	2.0	54.47

If a gas well does not produce enough methane, the valve is often turned down or off. Well production is reviewed monthly during well field balancing events. Wells with poor quality or low/no gas may be monitored over time for improvements before being removed from the program. It is recommended that older, non-producing wells be removed from the monitoring program and labelled as 'inactive' after 18 months.

7.0 LFG UTILIZATION AND COLLECTION EFFICIENCY

The volume of collected LFG for 2024 was measured by flow meters at the temporary flaring system designed to flare the gas during the transition time to construct and commission the Biogas Upgrading Facility (BUF). This data is provided by WAGA Energy on a live data platform and the weighted average data is summarized in Appendix A. The data is compiled to determine collection rates and then compared to the generation model to estimate the collection efficiency of the system.

Table 5 and Table 6 show a summary of gas collection, utilization and overall collection efficiency based on ENV and UBCi models respectively. Figures in the following section illustrate the collection efficiency for the last several years (2010-2024) and the full set of collected data in 2024 is provided in Appendix A.

Construction to replace the existing landfill gas-to-energy facility began in Q3 of 2023 and continued through 2024. A phasing plan was developed and followed during decommissioning and construction to ensure ongoing gas destruction in accordance with the Landfill Gas Management Regulation. A new enclosed flare and blowers were installed in 2024. Until the new equipment was commissioned, the existing ground flare operated continuously. The new flare system consists of two blowers, an enclosed flare, flame arrestor, condensate knock-out, analyzers, valves, controls, interconnected piping and electrical system.

The BUF is anticipated to start producing Renewable Natural Gas (RNG) for sale to FortisBC in 2025. The BUF uses cutting edge, proprietary technologies and has a complex design. Further details of the system and the process flow diagram is included in Section 7.1.4.

Table 5 LFG System Collection Efficiency 2010-2024 ENV Model

Year	Modelled Methane generation (tonnes/year)	Measured Methane (tonnes/year)	Collection Efficiency (%) ENV Model	GHG Emission (tonnes/year CO ₂ e)	GHG Emission (tonnes/year CO ₂ e) ¹ with biological oxidation
2010	8,054	2,664	32.4	155,829	116,872
2011	8,125	2,835	34.3	152,379	114,284
2012	8,163	4,045	48.8	118,945	89,208
2013	8,170	4,817	58.2	97,019	72,764
2014	8,158	4,596	56.4	100,211	75,158
2015	8,103	5,294	65.6	77,722	58,292
2016	8,038	4,923	61.8	85,064	63,798
2017	8,032	5,377	67.7	71,868	53,901
2018	8,056	5,060	64.0	79,780	59,835
2019	8,101	5,182	65.5	76,532	57,399
2020	8,157	5,289	66.7	74,060	55,545
2021	8,192	5,611	68.5	72,268	54,201
2022	8,325	5,865	70.5	68,880	51,660
2023	8,418	5,422	64	83,888	62,916
2024	8,532	3,648	43	136,739	102,555

¹ Assuming 25% biological oxidation. Appendix A6 includes US EPA Oxidation Table Reference for Cover System Capture

Table 6 LFG Collection System Efficiency 2015-2024 UBCi Model

Year	Modelled Methane generation (tonnes/year)	Measured Methane (tonnes/year)	Collection Efficiency (%) UBCi Model	GHG Emission (tonnes/year CO ₂ e)	GHG Emission (tonnes/year CO ₂ e) ¹ with biological oxidation
2015	7,239	5,294	73	54,440	40,830
2016	7,135	4,923	69	61,919	46,439
2017	7,100	5,377	76	48,250	36,187
2018	7,101	5,060	71	57,139	42,855
2019	7,123	5,182	73	54,337	40,753
2020	7,151	5,289	74	52,135	39,102
2021	7,167	5,611	78	43,545	32,659
2022	7,283	5,865	81	39,699	29,774
2023	7,307	5,422	74	52,780	39,585
2024	7,363	3,648	50	104,017	78,013

¹ Assuming 25% biological oxidation.

The data above present collection efficiency using the ENV gas generation model (Table 5), as stipulated in the *Landfill Gas Management Facilities Design Guidelines*, and the UBCi model (

Table 6). In 2020, landfill gas emissions were quantified 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 to retroactively calculate collection efficiency back to 2014.

In 2024, collection efficiency using the ENV model and UBCi model was calculated at 43% and 50%, with total uncollected (fugitive) GHG emissions after biological oxidation estimated at 102,555 and 78,013 tonnes CO₂e, respectively (Figure 4 and Figure 5). Gas collection varies as a result of refuse age, well installation/operation, and well balancing activity. In 2024, the Environment and Climate Change Canada (ECCC) model was introduced and subsequently used as a complementary tool to compare results with the other two models. Collection efficiency using the ECCC model was calculated at 49%, with total uncollected (fugitive) GHG emissions resulting in 79,695 tonnes CO₂e following biological oxidation. The landfill gas generation estimate projections for future years is included in Appendix B.

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 Cell 2, Phase 2, which is expected due to age of refuse and advanced methanogenic processes.
- Much of the gas production is now in Cell 3, Phase 2 due to the age of the refuse (landfill began in 2016).

Figure 4 Fugitive GHG Emission After Biological Oxidation at Hartland Landfill 2015-2024 (UBCi model)

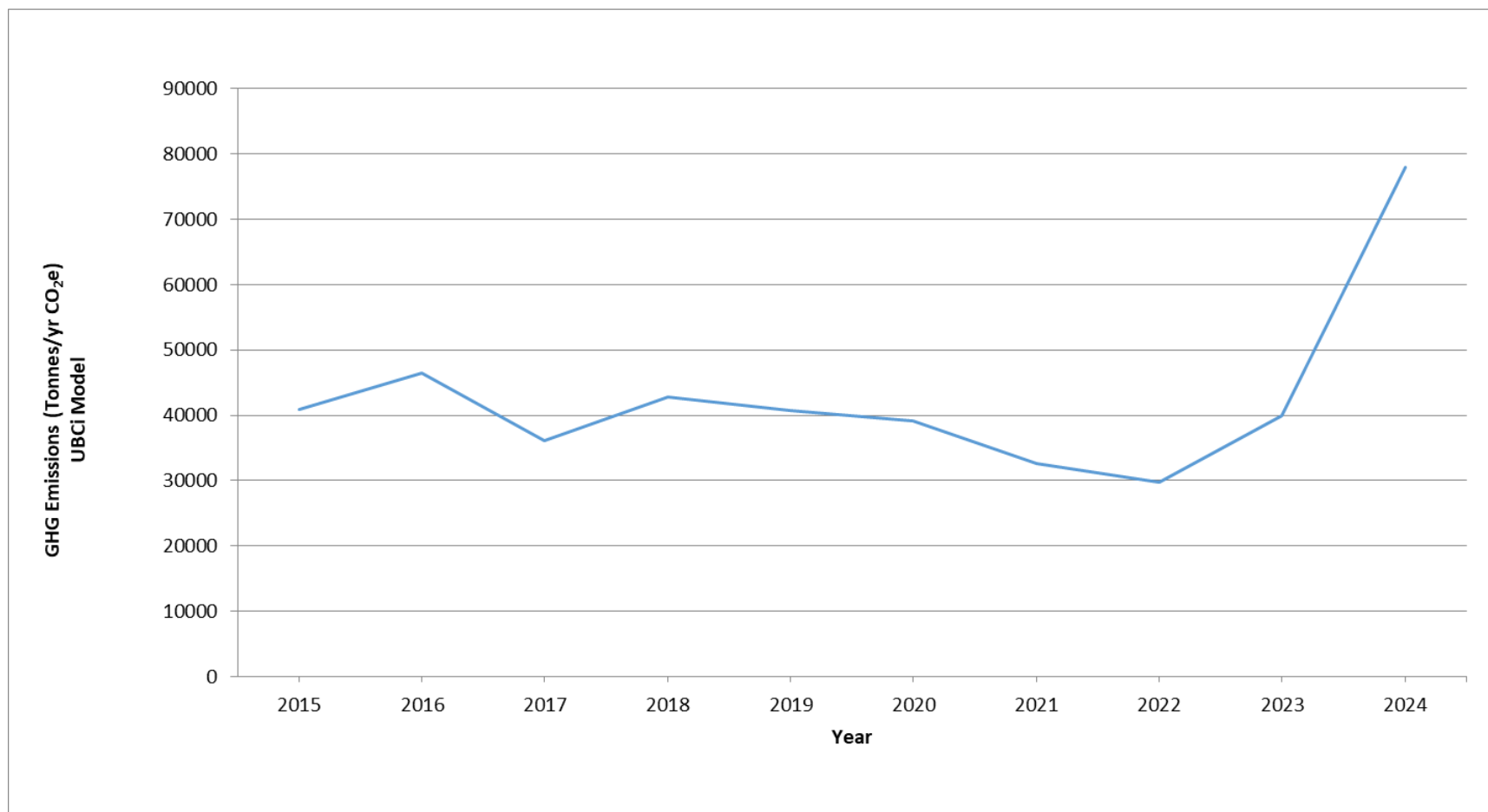
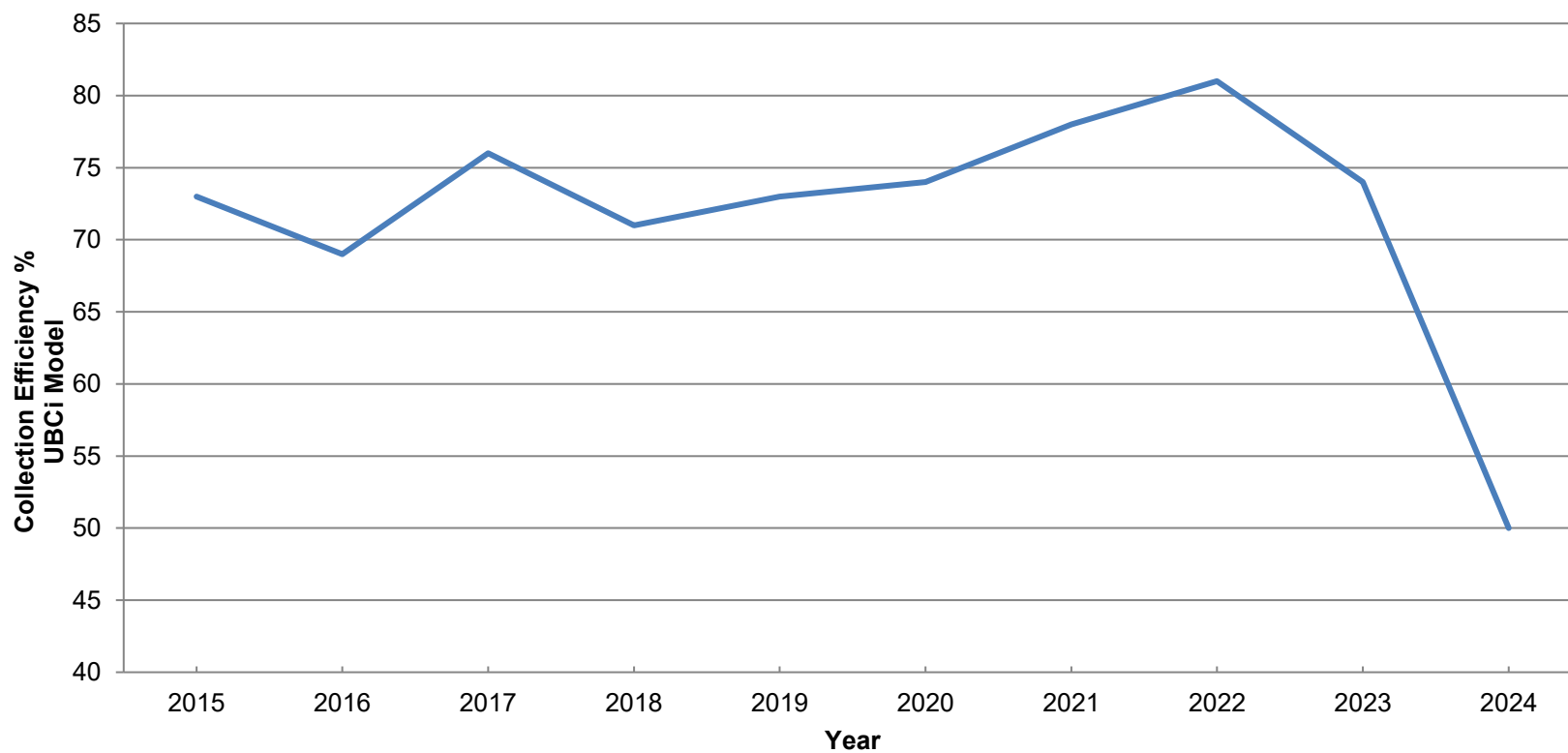


Figure 5 Collection Efficiency Estimates 2015-2024 (UBCi model)



7.1.1 Fugitive Emissions

Fugitive emissions at Hartland Landfill were empirically measured during two field events in 2020 (June and October). The data were used to complete a comprehensive landfill gas mass balance for the site across three different landfill gas generation models. Report findings confirm that the current ENV model overestimates landfill gas generation and fugitive emissions at Hartland, while the UBCi model more accurately estimates gas generation. Consequently, the calculated gas collection efficiency is higher for the UBCi model. In 2024, according to the UBCi model, supported by empirical, mass balance data, Hartland Landfill is under the 75% collection efficiency requirement set out in the *BC Landfill Gas Management Regulation*. The analysis also found that current landfill cover systems were estimated to biologically oxidize 29% of the total fugitive emissions in 2020. For the 2024 report, based on the advice of our consultant, we are assuming 25% biological oxidation through the landfill cover based on the US EPA Oxidation Table and the advice of our consultant.

The report also identified additional strategies that can be taken by the CRD to increase collection efficiency and biological oxidization, including enhancements to the existing landfill gas collection system and application of an engineered biocover system on both closed and operational phases of the landfill. In July 2023, approximately two hectares of fabricated biocover were installed on both the south and north slopes of the Cell 3 disposal area. The biocover blend was designed by consultants using biosolids mixed with additional feedstocks (wood and sand) to create biosolids growing medium (BGM). Following the land application, consultants were retained to:

- establish baseline data for methane emission rates from the targeted areas,
- gauge the levels of methane emissions from the biocover system immediately following its installation (understanding that methanotrophic activities might not yet be fully developed), and
- perform a technical inspection and provide commentary on the design and construction of the biocover test pads.

The methane emission rates from final surface and the biocover areas at the Hartland Landfill were quantified using field measurements. The results of this initial study indicated potential for additional fugitive methane reduction through biocover; however, since this investigation was completed closely following the biocover installation, it was recommended by the consultant to repeat the investigation after approximately one year. This would allow sufficient time for the methanotrophic bacteria responsible for methane biological oxidation to be established within the medium. In addition, a modification in the installation design and configurations was recommended to minimize the upward migration of gas through the underlying aggregate drainage layer. Implementation of the recommendations associated with the installations would potentially considerably reduce the observed hotspots at the edges of the biocover area and it would result in higher efficacy rates for reducing methane emissions through biocover in the future. In 2024, due to the continuing construction and multiple operations at Hartland Landfill in several projects, the recommendations regarding the biocover optimization were on pause; and Hartland staff are planning to implement these changes and schedule a follow up assessment on the biocover areas in 2025.

In 2025, CRD staff and consultant(s) will be working on improving or designing alternative ways to address fugitive emissions across the landfill.

7.1.2 Destruction Devices and Usage

Upon the decommissioning of the old landfill gas plant in December 2023, the landfill gas was continuously flared by a new system including enclosed flare and blowers in 2024. Until this new equipment was commissioned, the old ground flare operated continuously.

7.1.3 LFG Management Plan Implementation Status

The CRD has implemented the conceptual design in the *Landfill Gas Management Plan*. However, since the plan was prepared, some operational changes have occurred, which are summarized below:

2012	Per the <i>Landfill Gas Management Plan</i> , alignment of horizontal wells changed from east-west to north-south due to the master fill plan cell phasing and progression.
2012/2013	Relocation and reconfiguration of controlled waste disposal areas. Controlled waste, initially landfilled in clay-lined cells, is now trenched into refuse. Landfilling was conducted over the controlled waste area expanding the available footprint for Cell 2. This benefits overall collection in that it allows gas wells to be installed in controlled waste areas that would otherwise be inappropriate due to clay.
2014	Installation of vertical gas wells has been delayed pending further review of efficacy due to leachate inundation or minimal gas production. Vertical gas wells installed in recent closed areas (2012) were not productive due to density of horizontal wells and overlapping areas-of-influence.
2014	Since implementation of the <i>Landfill Gas Management Plan</i> , horizontal well installation depths have been reduced (made shallower). The proposed deeper wells were intended to accelerate activation; however, this was not actualized, and the deeper wells triggered odour and safety issues during installation. As a result, this part of the <i>Landfill Gas Management Plan</i> was revised to allow for shallow wells. The shallow wells have fewer health and safety considerations, are less expensive to install, and can be activated in the same timeframe as deeper wells specified in the plan.
2015/2016	Filling plan sequencing has changed since the plan was prepared. These changes represent schedule variations rather than whole scale deviations from the <i>Landfill Gas Management Plan</i> . Changes include: Phase 2, Cell 2 vertical extension by two lifts to allow time for completion of the cliff quarry and construction of Cell 3.
2017	A bypass line valve was opened at the gas plant to reduce backpressure on the well field and increase gas flows to the plant. As a result, flows increased by 50-100 scfm.
2018	No significant changes to the system were made in 2018.
2019	No significant changes to the system were made, but additional Cell 3 wells are now coming online, which is consistent with the <i>Landfill Gas Management Plan</i> prediction that Cell 3 well activation may take up to five years.
2020	No significant changes to the system were made. LFG generation and emissions study was completed to confirm the effectiveness of the current collection infrastructure and well field balancing programs. Additional well field optimization projects are planned for 2021.
2021	CRD staff continue the well balancing efforts several times a month to optimize the methane generation in each well and subsequently improve the well field gas production (i.e., reducing nitrogen and oxygen content and increasing the methane production).
2022	No significant changes to the system were made. Additional well field optimization and biocover projects are planned for 2023. CRD staff will continue the well balancing efforts several times a month to optimize the methane generation in each well and subsequently improve the well field gas production (i.e., reducing nitrogen and oxygen content and increasing the methane production). Due to the current design and development of Cells 4, 5 and 6 in Phase 2, connection has been delayed for a number of collection wells already installed on the north slope of Cell 3.

2023	Approximately 2 hectares of fabricated biocover was installed on both the south and north slopes of the Cell 3 disposal area and a follow-up field measurement on the biocover areas is planned for 2024. While the biocover is not an approved LFG mitigation/destruction method under the regulation, it is expected to reduce localized fugitive methane emissions in areas without tarps or permanent closures. Results of the follow-up monitoring will be presented in a future annual report. In 2023, the construction of Cell 4 in Phase 2 was initiated, resulting in delayed connection of 33 collection wells already installed in the upper lifts of Cell 3. These wells will be connected to a collection system at both ends (north and south) but south connections require the extension of a main gas header on top of Cell 3, which is scheduled for construction in the third and fourth quarters (Q3/Q4) of 2024. The final north connection will not be completed until Cell 4 construction and subsequent LFG collection design is completed (2025). Gas collection is expected to decline in 2024 until the wells are connected. CRD staff will continue wellfield balancing each month to optimize LFG collection in each well and improve the quality of collected gas (i.e., reduce nitrogen and oxygen content and increase methane production). To reduce staff workload and improve data collection and wellfield balancing efforts, the CRD plans to install and pilot automated gas well tuning devices in 2024 at key collection wells. The existing gas-to-energy facility (generator) was formally decommissioned to enable construction of the Biogas Upgrading Facility on December 31, 2023. More detail in Section 7.1.4.
2024	The final Cell 3 split header design in the CRD's 2011 LFG Management Plan was reconfigured to a loop header to improve vacuum and collection efficiency needed to facilitate the connection of new wells. Additionally, loop headers have historically been the norm at Hartland. As a result, the CRD altered the Cell 3 header design in 2024, in partnership with a consultant, to a loop configuration. This header was completed in Q4 of 2024 and will enable the south side connection of 33 gas wells in the upper lifts of Cell 3 in early 2025. Final redundant north-side connection of these wells is anticipated after final closure of Cell 2 & 3 (anticipated 2027-2028). While gas collection continued to decline in 2024, a significant increase is expected in 2025 once these wells are connected to the new LFG loop-header collection system. CRD staff will continue wellfield balancing each month to optimize LFG collection in each well and improve the quality of collected gas (i.e., reduce nitrogen and oxygen content and increase methane production). To reduce staff workload and improve data collection and wellfield balancing efforts, the CRD plans to install and pilot automated gas well tuning devices in 2025 at key collection wells. The construction of the Biogas Upgrading Facility continued throughout 2024. Landfill gas was continuously flared during this time. The facility is expected to be fully commissioned in early to mid- 2025.

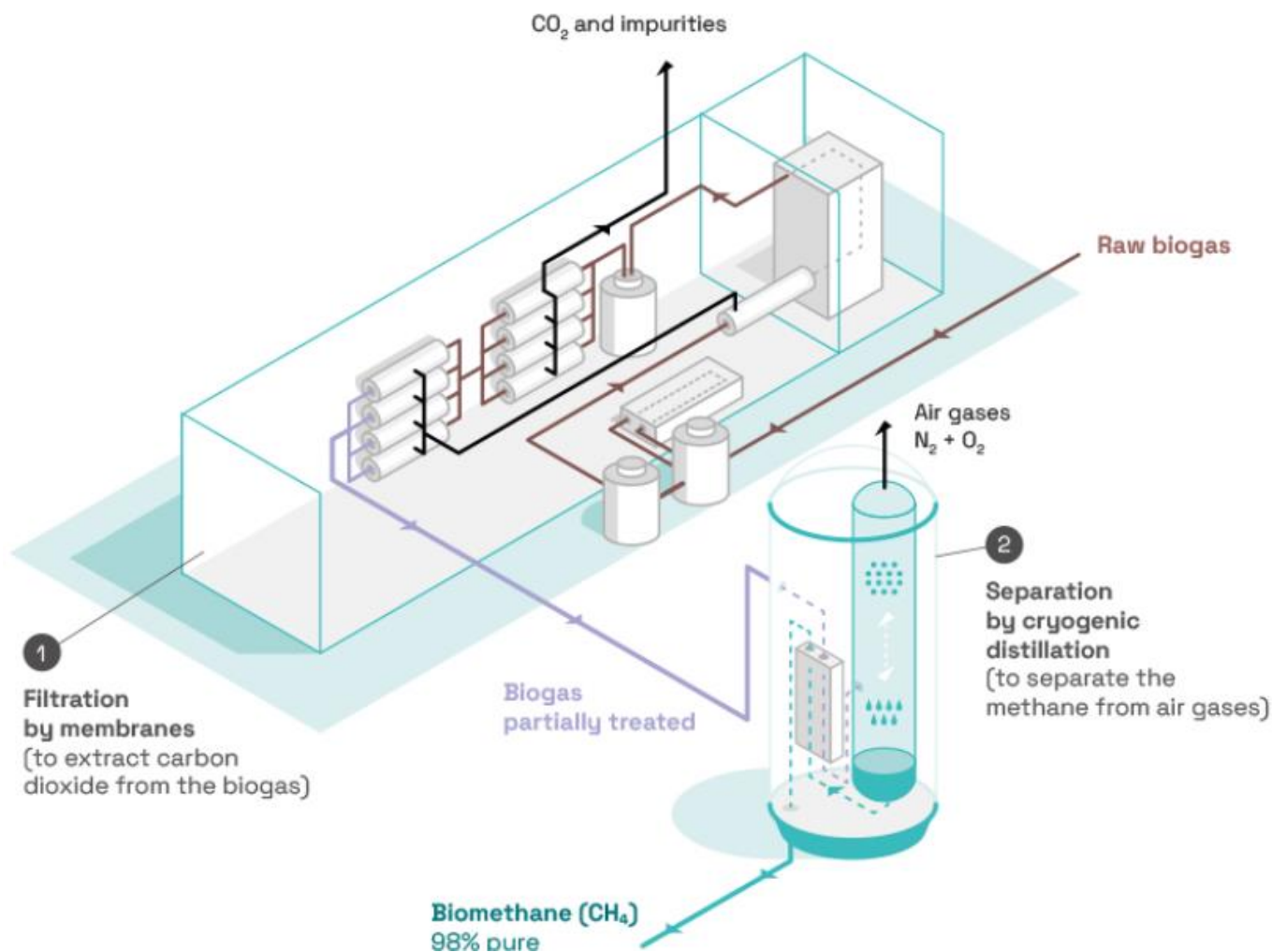
7.1.4 System Upgrades and Innovation

Renewable Natural Gas Project

Construction to replace the existing landfill gas-to-energy facility began in Q3 of 2023 and continued through 2024. A phasing plan was followed during decommissioning and construction to ensure ongoing gas destruction in accordance with the Landfill Gas Management Regulation. The new flare system consists of two blowers, an enclosed flare, flame arrestor, condensate knock-out, analyzers, valves, controls, interconnected piping and electrical system.

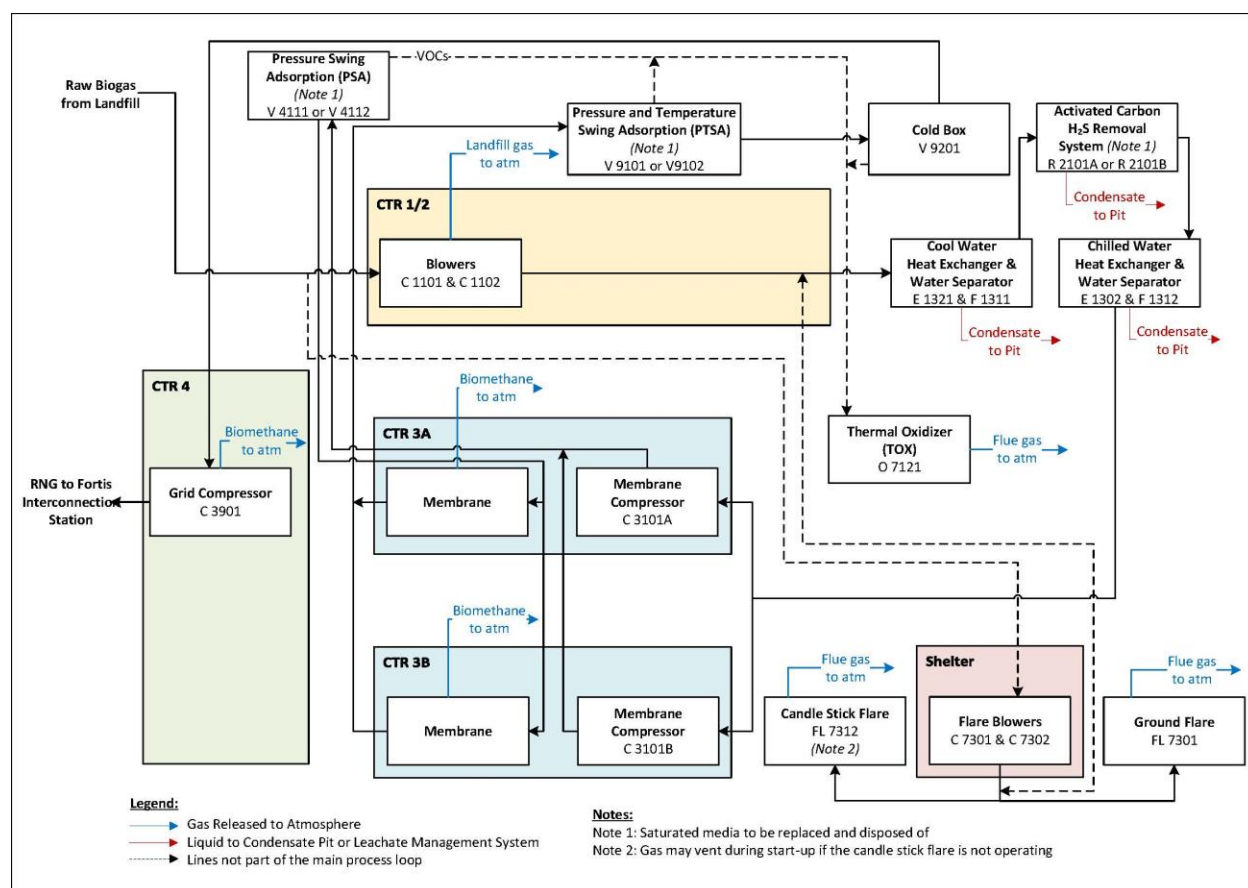
The BUF is anticipated to start producing Renewable Natural Gas (RNG) for sale to FortisBC in 2025. The BUF uses cutting edge, proprietary technologies and has a complex design. A high-level process is indicated in Figure 6; and a detailed process flow diagram is included in Figure 7. As the raw biogas enters the system, the carbon dioxide and other impurities are filtered out by the membranes. The partially treated biogas then goes through a secondary treatment where the methane is separated from other gases like oxygen and nitrogen through cryogenic distillation. The BUF expected design capacity is maximum 2,000 scfm, and the output is delivered to the Fortis Injection Station for distribution as RNG into the Fortis Intermediate Pressure piping network.

Figure 6 Overview of process design for the Biogas Upgrading Facility



Note: The complete details of this technology are proprietary information and can be provided to the regulator upon request.
Figure Source: [Renewable natural gas for all - Waga Energy \(waga-energy.com\)](https://waga-energy.com)

Figure 7 Process Flow Diagram for Biogas Upgrading Facility at Hartland Landfill



Landfill Gas Management in Cells 3 to 6

The construction of Cell 4 was completed in Q4 of 2024. The final Cell 4 landfill gas collection system design is expected in 2025 and the draft design is included in Appendix C.

Installation of Well Auto Tuning Devices

In 2025, the CRD intends to initiate a pilot project testing the feasibility of automated well head tuning devices at Hartland. Automated well tuning devices monitor and adjust gas well extraction rate at a higher frequency than a field technician (e.g., multiple times a day – depending on the device and the design). These devices measure vacuum, gas concentrations and flow rate at each well, and then adjust the extraction rate of each well to achieve optimal performance. When deployed at multiple locations, the devices are anticipated to improve LFG collection efficiency and reduced overall fugitive emissions. The deployment of these devices is expected in Q2 of 2025.

Installation of Continuous Surface Emission Monitoring Devices

The CRD is currently partnering with a vendor to install continuous methane surface emission measurement devices at different locations of Hartland Landfill. This will be a pilot project to apply an alternative method for surface emissions monitoring and leak detection on the site. Each device will be equipped with methane sensors and the default ability to monitor meteorological data using anemometer, temperature, pressure and humidity sensors. This initiative is a partnership partially funded through a federal grant administered by the vendor, Qube Technologies. As part of the collaboration, the CRD will contribute in-kind support, including staff time, technical feedback, and access to site data. The project will allow the CRD to evaluate the technology as a potential tool to meet upcoming federal landfill methane regulations issued by

Environment and Climate Change Canada, while also helping to identify and mitigate health and safety risks associated with fugitive emissions in operational areas.

8.0 OPERATIONAL PERFORMANCE

Detailed landfill operational updates and changes are outlined in the Hartland Landfill 2024 Operations Report. The gas collection system operated continuously, except when there was a power failure or when shutdowns were required during the construction/maintenance of the RNG Facility.

Table 7 summarizes collection system downtime (i.e., gas was not being flared), for approximately two days.

Table 7 Summary of 2024 Blower Downtime by Date

Date	Shutdown time	Restart time	Shutdown duration (hours)
17-Dec-24	11:30	13:10	1.67
16-Dec-24	6:25	6:35	0.17
26-Nov-24	9:00	15:10	6.17
25-Nov-24	8:14	8:27	0.22
11-Nov-24	13:43	14:00	0.28
18-Nov-24	11:20	13:50	2.5
09-Nov-24	9:00	12:47	3.78
30-Oct-24	13:22	13:55	0.55
29-Oct-24	11:40	12:05	0.42
10-Oct-24	15:25	15:40	0.25
02-Oct-24	13:55	14:30	0.58
26-Sep-24	12:48	15:22	2.57
25-Sep-24	13:55	14:25	0.5
18-Sep-24	13:00	13:40	0.67
10-Sep-24	8:30	10:15	1.75
05-Sep-24	7:00	12:30	5.5
28-Aug-24	12:20	14:09	1.82
27-Jul-24	8:13	9:05	0.87
26-Jul-24	13:34	14:20	0.77
25-Jul-24	14:28	15:10	0.7
09-May-24	10:50	11:33	0.72
08-May-24	11:52	13:35	1.72
01-May-24	7:15	19:00	11.75
25-Apr-24	7:45	8:36	0.85
03-Apr-24	14:10	14:50	0.67
Total (Hours)			47.42
Days:			2.0

9.0 MONITORING PROGRAMS

Annual monitoring is conducted to evaluate LFG collection and control system performance. Monitoring includes both operational monitoring, generator performance monitoring and environmental monitoring (e.g., gas quality in surface probes). This section and Table 8 summarize the LFG monitoring activities.

Table 8 Summary of LFG Monitoring Programs

Task & Objectives	Frequency	Primary Parameters	Criteria	Action if Criteria Exceeded	Monitoring By
1. Perimeter subsurface probe monitoring					
To detect potential subsurface LFG migrating off-site	Quarterly at perimeter probes	CH ₄ , CO ₂ , O ₂ , pressure and/or vacuum	LEL for methane (5.0%)	Increase sampling frequency. Initiate off-site sampling (see Task 7 below). Evaluate effectiveness of remedial measures.	EPro staff
2. Building foundation probes					
To detect potential subsurface LFG migration into on-site building foundations	Quarterly at foundation probes	CH ₄ , CO ₂ , O ₂ , pressure and/or vacuum	20% of LEL 10% of LEL – CRD internal standard	Initiate appropriate remedial action.	EPro staff
3. On-site ambient grid sampling					
To assess on-site LFG concentrations at known grid locations across the landfill surface	Once per year	THC as methane and H ₂ S	100 ppm as THC (methane)	Initiate investigation of remedial measures. Identify locations >100 ppm THC for Task 4.	EPro staff
4. On-site ambient hotspot monitoring					
To identify localized sources of LFG, or releases that could create potential health, safety, environmental or operational problems	Once per year	THC as methane and H ₂ S	12,500 ppm/1.25% THC (25% of the LEL) 5 ppm H ₂ S	Initiate investigation of remedial measures. Identify locations with THC >1,000 ppm or H ₂ S >5 ppm as Z points (hotspots). Personal gas detectors required in high-risk areas.	EPro staff

Task & Objectives	Frequency	Primary Parameters	Criteria	Action if Criteria Exceeded	Monitoring By
5. Gas well field monitoring					
Monitor the concentrations and gas flows from all the wells connected to the gas collection system	Minimum of monthly	Temperature, vacuum, flow rate, CH ₄ , CO ₂ , O ₂	Maintain gas flow and methane content, control oxygen intake	Adjust wellhead vacuum.	Hartland staff
6. Blower, flare and generator station monitoring					
Monitor the performance of the moisture separators, blowers and flare and/or generation station	Continuous	Temperature, pressure, gas flow rate, CH ₄ , O ₂	Operational	Adjust well field if outside operational criteria.	Hartland staff
7. Off-site properties					
To measure concentrations of gases in the event of LFG migrating off-site	Task 1 exceedance	THC and H ₂ S	Detectable above air quality guidelines and WorkSafeBC criteria	Initiate appropriate remedial action.	Hartland staff
8. On-site building gas monitoring					
To monitor methane and H ₂ S levels to protect workers in on-site buildings	Task 2 exceedance	Methane and H ₂ S	20% of the LEL (1% CH ₄) – the Guidelines 10 ppm H ₂ S – WorkSafeBC	Initiate appropriate remedial action.	Hartland staff
9. LFG speciation					
To measure concentrations of compounds in the LFG at the inlet to the gas conditioning skid and power generation station	Once every two years	VOC and H ₂ S	WorkSafeBC criteria for individual compounds in ambient air	Initiate Task 10 if calculated ambient concentrations exceed WorkSafeBC limits.	EPro staff
10. On-site ambient air quality measurement					
Measure ambient VOC	Task 9 exceedance	VOC and H ₂ S	WorkSafeBC criteria for individual compounds in ambient air	Initiate remedial action.	EPro staff

Notes:

EPro staff = Environmental Protection staff

LEL = lower explosive limit

THC = total hydrocarbons

VOC = volatile organic content

9.1 Subsurface Gas Monitoring - Perimeter and Foundation Probes

Perimeter probes and foundation/trench probes have been used at Hartland Landfill to monitor for subsurface gas migration since 1996. Perimeter and foundation probes are required in the BC *Landfill Criteria for Municipal Solid Waste* (2016). Quarterly monitoring is conducted in five eastern perimeter monitoring probes and 12 foundation monitoring probes (Figure 8). Through long-term improvements to the LFG collection system, LFG migration potential has been mitigated and there is no indication of gas migration off-site. Although the risk is minimal, ongoing monitoring is required to meet regulatory requirements and to confirm worker and public health and safety. A complete monitoring methodology, probe locations, details, and data from the perimeter and building foundation probes are provided in Appendix D.

9.1.1 Perimeter Probes

All probes were monitored according to the standard operating procedures four times in 2024; data is presented in Table 9 and Table 10. There was no detectable methane recorded in 2024. Consistent with historical data, CO₂ levels are slightly higher in the shallower 'B' probes than the deeper 'A' probes. Elevated CO₂ levels may give an early indication of the presence of LFG; however, no unusually high CO₂ levels were observed. Ongoing monitoring will continue to determine if any trends develop.

9.1.2 Foundation Probes

Foundation probes were monitored four times in 2024, which is in compliance with ENV requirements (see Table 11 and Table 12). Carbon dioxide levels were similar to previous years. There were no recorded exceedances of the ENV limit of 1.0% methane during the reporting period. Monitoring will continue to satisfy regulatory requirements and to determine if any trends develop.

Perimeter and foundation probe monitoring results for 2024 were in compliance with the ENV requirements. Methane was not detected. The data indicates minimal risk of subsurface methane migration to adjacent properties or buildings. Quarterly monitoring should continue, to meet regulatory requirements and to evaluate health and safety risks.

Table 9 Average Gas Concentrations in Subsurface Perimeter Probes 2018-2024

Probe	CH ₄ (%)							Probe	CO ₂ (%)							Probe	O ₂ (%)						
	2018	2019	2020	2021	2022	2023	2024		2018	2019	2020	2021	2022	2023	2024		2018	2019	2020	2021	2022	2023	2024
GP-01A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-01A	0.00	0.00	0.03	0.05	0.20	0.10	0.05	GP-01A	20.3	20.8	20.8	21.5	20.2	21.1	21.2
GP-01B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-01B	0.80	1.53	2.48	2.98	3.05	1.90	1.70	GP-01B	19.4	19.1	19.1	16.1	15.4	17.7	17.8
GP-02A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-02A	0.00	0.00	0.03	0.05	0.20	0.13	0.05	GP-02A	20.2	20.6	20.8	21.6	20.1	21.2	21.4
GP-02B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-02B	3.05	3.78	4.33	2.23	4.70	2.73	4.55	GP-02B	13.9	12.5	15.7	16.8	9.7	16.6	7.3
GP-03A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-03A	1.38	1.88	1.45	1.88	1.75	0.70	0.55	GP-03A	14.7	13.8	15.5	18.5	13.0	18.5	19.0
GP-03B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-03B	3.93	5.85	6.08	4.98	3.75	0.77	7.25	GP-03B	15.4	15.5	15.3	14.9	15.4	20.5	14.6
GP-11A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-11A	0.00	0.00	0.03	0.13	0.20	0.13	0.20	GP-11A	20.3	20.8	20.9	21.5	20.4	21.2	21.1
GP-11B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-11B	1.05	1.37	2.10	1.98	11.00	1.83	1.25	GP-11B	19.5	19.8	18.6	19.5	18.4	19.3	20.0
GP-12A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-12A	1.95	1.25	2.33	1.80	11.70	1.63	0.30	GP-12A	13.6	16.4	13.5	15.3	14.2	16.6	20.1
GP-12B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-12B	4.93	7.25	7.03	5.23	8.25	4.63	2.45	GP-12B	12.9	9.0	10.5	12.9	8.2	14.6	14.7

Table 10 Maximum Gas Concentrations in Perimeter Probes (2024)

Probe	CH ₄ (%)	CO ₂ (%)
GP-01A	0.20	1.60
GP-01B	0.30	4.90
GP-02A	0.20	20.70
GP-02B	0.30	53.00
GP-03A	9.90	6.00
GP-03B	24.70	19.70
GP-11A	0.20	0.80
GP-11B	0.20	19.00
GP-12A	0.20	20.80
GP-12B	0.20	13.00

Figure 8 Location of Gas Probes



Table 11 Average Gas Concentrations in Subsurface Foundation Probes 2018-2024

Probe	CH ₄ (%)							Probe	CO ₂ (%)							Probe	O ₂ (%)						
	2018	2019	2020	2021	2022	2023	2024		2018	2019	2020	2021	2022	2023	2024		2018	2019	2020	2021	2022	2023	2024
GP-04A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-04A	0.05	0.00	2.90	1.08	2.10	1.50	1.65	GP-04A	20.8	21.0	18.3	20.8	18.4	18.8	19.9
GP-05A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-05A	0.65	0.58	0.83	0.80	0.60	0.87	0.40	GP-05A	19.7	20.2	19.9	21.0	20.0	20.2	20.8
GP-06A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-06A	1.00	0.78	0.75	1.33	0.40	1.17	2.00	GP-06A	19.4	20.0	20.0	20.3	20.1	19.6	19.0
GP-06B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-06B	0.68	0.53	0.85	1.50	0.75	1.07	1.85	GP-06B	19.6	20.3	19.8	20.2	19.8	19.9	19.0
GP-07A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-07A	0.30	0.25	0.23	0.53	0.25	0.37	0.60	GP-07A	20.1	20.6	20.6	16.8	20.6	20.8	20.2
GP-07B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-07B	0.13	0.15	0.15	0.33	0.15	0.23	0.25	GP-07B	20.3	20.7	20.7	21.6	20.7	20.9	20.8
GP-08A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-08A	0.13	0.20	0.15	0.25	0.20	0.20	0.30	GP-08A	20.4	20.6	20.7	21.7	20.7	21.1	20.8
GP-09A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-09A	0.10	0.18	0.15	0.20	0.20	0.27	0.25	GP-09A	20.3	20.7	20.7	21.7	20.6	21.0	20.3
GP-13A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-13A	2.77	2.43	2.78	2.35	11.80	2.63	4.15	GP-13A	17.3	18.5	17.6	19.0	16.0	18.3	17.4
GP-17A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-17A	0.20	0.05	0.15	0.15	10.90	0.13	0.15	GP-17A	20.0	20.6	20.7	21.7	20.0	21.1	21.2
GP-18A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	GP-18A	0.33	0.25	0.18	0.18	10.65	0.20	0.30	GP-18A	19.2	20.0	20.2	21.0	20.5	20.8	21.2

Notes:
GP-17A: probe for Hartland Learning Centre (constructed in 2011)
GP-18A: probe for new contractors workshop (constructed in 2011)

Table 12 Maximum Gas Concentrations in Foundation Probes (2024)

Probe	CH ₄ (%)	CO ₂ (%)
GP-04A	0.0	0.75
GP-05A	0.0	0.90
GP-06A	0.0	0.95
GP-06B	0.0	0.55
GP-07A	0.0	0.35
GP-07B	0.0	0.25
GP-08A	0.0	0.25
GP-09A	0.0	0.35
GP-13A	0.0	2.65
GP-17A	0.0	0.15
GP-18A	0.0	0.10

9.2 Surface Emissions and Hotspot Monitoring

Fugitive emissions can occur from advection and/or diffusion via soil pores, gaps and defective cover materials and are monitored routinely through surface monitoring. This monitoring assesses landfill closure integrity, supports worker health and safety, informs operational or capital planning, and supports optimal LFG collection. This monitoring is a simple and low cost means to assess methane and non-methane emissions. Although hotspot locations (also known as Z-points) change over time, they are usually located at breaks or seams of cover systems and near side slopes in Phase 2, where gas collection is a challenge. The locations of all grid points and hotspots as are shown in Figure 9 and historical hotspots at Hartland are included in Figure 10. A summary of the results are shown in Table 13 and Table 14.

In 2024, a total of 21 Z-points were identified. There were no elevated hydrogen sulphide concentrations. The absence of hotspots in Phase 1 indicates that the cover and gas collection system in the permanent closure is functioning. Annual monitoring should continue. Hotspots have decreased significantly since the implementation of the *Landfill Gas Management Plan* in 2012.

Table 13 Summary of Grid Sampling Results 2024

Survey date	August
Grid points monitored	196
# Grid points >100 ppm THC	4

Note: Does not include discontinued and grid points in Active Face and Controlled Waste areas, where the waypoints could not be accessed at the time of the survey

Table 14 Summary of Hotspot Results 2024

Survey date	August
Total # hotspots ¹	21
New hotspots at end of survey	0
Hotspots discontinued ²	0
Maximum CH ₄ (ppm)	1,000

¹ Total number of hotspots at the end of the survey date

² Hotspots discontinued at the end of the survey date

Figure 9 Hartland Landfill Ambient Air Monitoring Results, August 2024



Figure 10 Historical Hotspot Locations



The following table summarizes LFG monitoring results, compliance, mitigation actions and recommendations.

Table 15 LFG Compliance Summary

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 <i>Landfill Criteria for Municipal Solid Waste & BC Landfill Gas Management Facilities Design Guidelines</i>)	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, 17A and 18A	Maximum 1% methane in any on-site facility (BC <i>Landfill Criteria for Municipal Solid Waste & BC Landfill Gas Management Facilities Design Guidelines</i>)	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)	4 grid locations >100 ppm No cover system failures suspected in the Phase 1 closure	Investigated hotspots and mitigated, where possible.	Continue annual monitoring.
Hotspot Monitoring	N/A	1,000 ppm THC (CRD internal guideline)	No new hotspots (Z-points) >1,000 ppm were identified. Currently 20 locations for hotspot investigation	Added new locations of hotspots 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 <i>Landfill Gas Management Facilities Design Guidelines</i>)	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 <i>Landfill Gas Management Plan</i>	Site specific model (UBCi) estimated collection efficiency at 50%. ENV model estimated collection efficiency at 43%.	<i>Landfill Gas Management Plan</i> submitted to ENV.	Continue to implement the gas management plan and optimize methane and nitrogen, oxygen levels in the well field.

10.0 CONCLUSIONS AND RECOMMENDATIONS

The following section presents the key findings and recommendations developed from the 2024 LFG monitoring programs at the Hartland Landfill.

GAS GENERATION

Hartland Landfill generates more than 1,000 tonnes of methane per year and is subject to the BC *Landfill Gas Management Regulation*. In 2024, according to the ENV model, the Hartland Landfill is estimated to have generated 8,532 of methane tonnes/year or the equivalent of approximately 136,739 tonnes CO₂e. Of this total, 102,555 tonnes of CO₂e were uncaptured (fugitive emissions). Though not recognized under the regulation, alternative gas modeling using the UBCi model, shows uncaptured CO₂e emissions (78,013 tonnes CO₂e); and ECCC model accounts for 79,695 tonnes CO₂e uncaptured emissions, both to be substantially less than the ENV model.

GAS GENERATION, COLLECTION AND UTILIZATION

In 2024, the gas extraction network consisted of 155 wells that captured an average of 748 scfm of LFG. Well field balancing was completed at least monthly to optimize collection. Well field monitoring and balancing should continue at least monthly, as recommended by the BC *Landfill Gas Management Facilities Design Guidelines*.

At the end of 2024, the efficiency was 43% according to the ENV model. Empirical data and methane mass balance indicates that an alternative gas generation (UBCi) more accurately estimates overall gas production for Hartland. Using this model, collection efficiency in 2024 is estimated to be 50%; and according to the new ECCC model, it was 49%. The decrease in collection efficiency is mainly due to infrastructure and installation challenges, including technical design considerations, delays in acquiring critical equipment, and coordination with other capital projects (Cell 4 construction), which affected the timely connection of gas wells. Construction began in late 2024 to align with Cell 4 timelines, with completion of new infrastructure and well connections expected in Q1 2025. Collection efficiency is expected to improve thereafter. These wells are planned to be connected initially at the south end (early 2025), followed by the north end after final closure of Cell 2 & 3 (anticipated 2027-2028).

The CRD continues to follow the *Landfill Gas Management Plan* design specifications for reaching 75% collection efficiency. Staff continue to monitor and adjust the well field to maximize collection and optimize key gas constituents (methane and nitrogen) in accordance with the Guidelines.

OPERATIONAL PERFORMANCE

The Hartland Landfill 2024 Operations Report provides detailed updates and changes related to landfill operations. The gas collection system remained in continuous operation throughout the year, except during power outages or planned shutdowns required for the construction and maintenance of the Renewable Natural Gas (RNG) Facility. The total time period during which gas was not being flared amounted to approximately two days.

MONITORING

No methane concentrations were observed during foundation and perimeter probe monitoring and, as a result, there is little risk of lateral LFG migration. This monitoring is a regulatory requirement and should continue on a quarterly schedule.

During the 2024 surface emissions grid monitoring, four grid locations with methane concentrations >100 ppm were identified. Currently there are 20 locations monitored for hotspot investigation.

UPCOMING PROJECTS IN 2025

Full commissioning of the Biogas Upgrading Facility (BUF), converting the landfill gas to RNG, and distribution through FortisBC pipelines is expected in 2025. Concurrently, construction of landfill gas collection in Cells 4 and 5 is underway, with completion expected in 2025. An updated Cell 3 header installation on the north side of Cell 3 is planned for 2025. Additionally, pilot projects for automated well head tuning devices and continuous methane surface emission monitoring devices are set to begin in 2025, aiming to further improve gas collection efficiency and reduce emissions.

11.0 REFERENCES

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Declaration of Competency

The Ministry of Environment and Climate Change Strategy relies on the work, advice, recommendations and in some cases decision making of qualified professionals¹, under government's professional reliance regime. With this comes an assumption that professionals who undertake work in relation to ministry legislation, regulations and codes of practice have the knowledge, experience and objectivity necessary to fulfill this role.

1. Name of Qualified Professional Kelly Tradewell
Title Supervisor, GeoEnvironmental Programs

2. Are you a registered member of a professional association in B.C.? ☒ Yes ☐ No

Name of Association: BC Institute of Agrologists Registration # 4409

3. Brief description of professional services:
Oversight and senior review of the data analysis, interpretation and compliance summary of the
2024 Hartland Landfill Gas Annual Report

This declaration of competency is collected under section 26(c) of the *Freedom of Information and Protection of Privacy Act* for the purposes of increasing government transparency and ensuring professional ethics and accountability. By signing and submitting this statement you consent to its publication and its disclosure outside of Canada. This consent is valid from the date submitted and cannot be revoked. If you have any questions about the collection, use or disclosure of your personal information please contact the Ministry of Environment and Climate Change Strategy Headquarters Office at 1-800-663-7867.

Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

X

Print Name: Kelly Tradewell

Witnessed by:

X

Print Name: Chris Lowe

Date signed: November 20, 2025

¹Qualified Professional, in relation to a duty or function under ministry legislation, means an individual who

- a) is registered in British Columbia with a professional association, is acting under that organization's code of ethics, and is subject to disciplinary action by that association, and
- b) through suitable education, experience, accreditation and knowledge, may reasonably be relied on to provide advice within his or her area of expertise, which area of expertise is applicable to the duty or function.

12.0 REPORT SIGNOFF

Prepared by:

Arma Attar, M.Sc.
Environmental Contaminants Officer



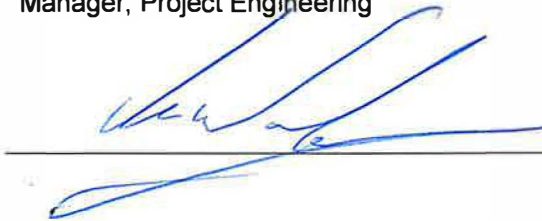
Approved by:

Kelly Tradewell, P.Ag
Supervisor, GeoEnvironmental Programs



Approved by:

Ian Wiebenga, P.Eng.
Manager, Project Engineering



APPENDIX A

Hartland Landfill Gas Collection Data

Appendix A
Hartland Landfill Gas Collection Data

Date	Methane Daily Avg	Oxygen Daily Avg	Field Pressure ("H2O)	Flare 1 Temp Avg	Flare 2 Temp Avg	Groundflare Daily Flow	Candlestick Flare 2 Daily Flow	Gen Flow	TotalFlow	Comments
1-Jan-24	43.18	0.31	-32.04	1,548.46	34.68	1,385,034	-	33,570	1,418,604	For January until February 22, the data is from gas flared through the old groundflare
2-Jan-24	49.90	0.30	-32.03	1,545.77	34.10	1,378,430	-	41,606	1,420,036	
3-Jan-24	49.60	0.31	-28.36	1,225.19	116.68	1,202,009	120,942	42,730	1,365,681	
4-Jan-24	48.10	0.20	-27.82	1,188.06	101.03	1,281,995	12,994	20,318	1,315,307	
5-Jan-24	46.40	0.40	-30.30	1,234.31	42.97	1,394,740	1,081	-	1,395,821	
6-Jan-24	44.30	0.80	-31.48	1,546.18	29.92	1,538,732	-	-	1,538,732	
7-Jan-24	---	---	-31.50	1,543.27	34.29	1,526,042	-	-	1,526,042	
8-Jan-24	49.90	0.20	-30.73	1,311.44	34.73	1,367,569	-	-	1,367,569	
9-Jan-24	50.60	0.30	-29.67	1,415.42	127.94	1,253,660	60,978	-	1,314,638	
10-Jan-24	48.50	0.10	-31.69	1,542.28	32.54	1,286,320	-	-	1,286,320	
11-Jan-24	51.10	0.10	-31.17	1,100.88	281.33	572,426	631,470	-	1,203,896	
12-Jan-24	45.70	0.40	-32.48	82.25	321.30	0	1,273,931	-	1,273,931	
13-Jan-24	48.10	0.50	-32.49	88.56	305.10	0	1,207,335	-	1,207,335	
14-Jan-24	---	---	-32.49	88.80	247.57	0	1,205,910	-	1,205,910	
15-Jan-24	47.80	0.50	-32.48	87.28	248.85	0	1,207,592	-	1,207,592	
16-Jan-24	49.10	0.10	-32.48	94.19	237.85	0	1,235,943	-	1,235,943	
17-Jan-24	48.00	0.20	-31.10	1,269.18	223.68	641,819	604,428	-	1,246,247	
18-Jan-24	46.00	0.70	-32.49	1,563.04	32.93	1,307,445	-	-	1,307,445	
19-Jan-24	47.80	0.30	-31.91	1,412.70	33.32	1,292,225	-	-	1,292,225	
20-Jan-24	48.80	0.40	-32.50	1,546.13	34.16	1,310,336	-	-	1,310,336	
21-Jan-24	---	---	-32.49	1,547.81	33.77	1,310,429	-	-	1,310,429	
22-Jan-24	48.60	0.50	-32.47	1,545.73	33.56	1,287,629	-	-	1,287,629	
23-Jan-24	46.60	1.00	-32.49	1,547.35	32.70	1,308,008	-	-	1,308,008	
24-Jan-24	47.50	0.90	-32.49	1,549.96	32.93	1,310,056	-	-	1,310,056	
25-Jan-24	48.30	0.40	-32.49	1,548.56	33.26	1,282,031	-	-	1,282,031	
26-Jan-24	49.70	0.30	-31.12	1,333.16	32.50	1,167,702	-	-	1,167,702	
27-Jan-24	48.70	0.20	-32.49	1,550.91	33.34	1,313,161	-	-	1,313,161	
28-Jan-24	---	---	-32.50	1,547.80	33.32	1,323,216	-	-	1,323,216	
29-Jan-24	48.80	0.40	-32.47	1,550.87	34.17	1,304,974	-	-	1,304,974	
30-Jan-24	47.70	0.60	-32.48	1,550.13	33.69	1,324,238	-	-	1,324,238	
31-Jan-24	47.30	0.70	-32.50	1,547.60	33.80	1,343,081	-	-	1,343,081	
1-Feb-24	48.00	0.80	-32.48	1,543.67	32.41	1,333,682	-	-	1,333,682	
2-Feb-24	47.80	0.60	-30.89	1,277.99	47.82	1,174,943	686	-	1,175,629	
3-Feb-24	45.20	0.90	-31.56	1,332.17	30.92	1,319,561	-	-	1,319,561	
4-Feb-24	---	---	-32.47	1,547.34	29.21	1,347,544	-	-	1,347,544	
5-Feb-24	46.90	0.90	-32.47	1,546.58	33.62	1,323,509	-	-	1,323,509	

Appendix A, continued

Date	Methane Daily Avg	Oxygen Daily Avg	Field Pressure ("H2O)	Flare 1 Temp Avg	Flare 2 Temp Avg	Groundflare Daily Flow	Candlestick Flare 2 Daily Flow	Gen Flow	TotalFlow	Comments
6-Feb-24	45.30	1.00	-32.48	1,549.41	30.73	1,333,222	-	-	1,333,222	
7-Feb-24	45.80	1.00	-32.48	1,547.28	31.64	1,310,785	-	-	1,310,785	
8-Feb-24	---	---	-32.49	1,548.71	32.63	1,317,436	-	-	1,317,436	
9-Feb-24	---	---	-32.48	1,549.44	30.60	1,331,771	-	-	1,331,771	
10-Feb-24	---	---	-32.48	1,550.67	33.50	1,340,443	-	-	1,340,443	
11-Feb-24	---	---	-32.49	1,555.56	33.73	1,332,831	-	-	1,332,831	
12-Feb-24	46.50	0.80	-32.48	1,546.03	29.79	1,342,175	-	-	1,342,175	
13-Feb-24	46.20	0.90	-28.99	1,310.40	29.66	1,190,121	-	-	1,190,121	
14-Feb-24	---	---	-26.37	933.47	34.10	825,488	-	-	825,488	
15-Feb-24	46.00	1.00	-32.48	1,542.61	34.14	1,429,013	-	-	1,429,013	
16-Feb-24	---	---	-32.48	1,547.33	30.64	1,466,143	-	-	1,466,143	
17-Feb-24	---	---	-32.49	1,550.67	34.40	1,460,163	-	-	1,460,163	
18-Feb-24	---	---	-32.49	1,543.18	32.84	1,450,387	-	-	1,450,387	
19-Feb-24	---	---	-32.48	1,545.96	32.52	1,446,692	-	-	1,446,692	
20-Feb-24	48.00	0.70	-29.18	1,278.42	32.85	1,086,367	-	-	1,086,367	
21-Feb-24	45.80	1.00	-30.41	1,017.19	32.11	657,935	-	-	657,935	
22-Feb-24	51.30	0.70	-29.50	82.78	29.66		-	-	0	
23-Feb-24	47.66	0.55	-31.65	1,296.23		1,150,644.58			1,150,645	Average data from Jan and Feb
24-Feb-24	47.78	0.56	-31.64	1,291.47		1,150,644.58			1,150,645	Average data from Jan and Feb
25-Feb-24	47.78	0.56	-31.64	1,291.47		1,150,644.58			1,150,645	Average data from Jan and Feb
26-Feb-24	47.78	0.56	-31.64	1,291.47		1,150,644.58			1,150,645	Average data from Jan and Feb
27-Feb-24	47.78	0.56	-31.64	1,291.47		1,150,644.58			1,150,645	Average data from Jan and Feb
28-Feb-24	47.78	0.56	-31.64	1,291.47		1,150,644.58			1,150,645	Average data from Jan and Feb
29-Feb-24	47.78	0.56	-31.64	1,291.47		1,150,644.58			1,150,645	Average data from Jan and Feb
1-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	For March and April, no flow data available from WAGA, therefore the average for May and June is used here
1-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
3-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
4-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
5-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
6-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
7-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
8-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
9-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
10-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
11-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
12-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	

Appendix A, continued

Date	Methane Daily Avg	Oxygen Daily Avg	Field Pressure ("H2O)	Flare 1 Temp Avg	Flare 2 Temp Avg	Groundflare Daily Flow	Candlestick Flare 2 Daily Flow	Gen Flow	TotalFlow	Comments
13-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
14-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
15-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
16-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
17-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
18-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
19-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
20-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
21-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
22-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
23-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
24-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
25-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
26-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
27-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
28-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
29-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
30-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
31-Mar-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
1-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	For April, no flow data available from WAGA, therefore the average for May and June is used here
2-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
3-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
4-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
5-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
6-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
7-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
8-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
9-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
10-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
11-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
12-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
13-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
14-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
15-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
16-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
17-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	

Appendix A, continued

Date	Methane Daily Avg	Oxygen Daily Avg	Field Pressure ("H2O)	Flare 1 Temp Avg	Flare 2 Temp Avg	Groundflare Daily Flow	Candlestick Flare 2 Daily Flow	Gen Flow	TotalFlow	Comments
18-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
19-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
20-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
21-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
22-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
23-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
24-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
25-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
26-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
27-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
28-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
29-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
30-Apr-24	49.65	0.48	-31.73	1,599.08		746.32			1,075,938	
1-May-24	---	2.66	-21.08	903.87		404.58			582,589	For May, due to the challenges with WAGA methane sensor, Methane data from the CRD staff GEM reading is used. The data is averaged per multiple readings for each day when available. The rest of the data is from WAGA.
2-May-24	50.15	0.33	-32.15	1,627.03		797.48			1,148,373	
3-May-24	---	1.13	-32.16	1,622.83		822.00			1,183,679	
4-May-24	---	1.27	-32.16	1,622.94		813.12			1,170,896	
5-May-24	---	1.41	-32.18	1,606.97		812.02			1,169,304	
6-May-24	49.00	0.89	-32.17	1,595.51		790.95			1,138,972	
7-May-24	48.30	0.52	-32.17	1,598.86		782.81			1,127,243	
8-May-24	47.80	1.74	-30.70	1,511.14		841.14			1,211,244	
9-May-24	49.50	0.61	-31.40	1,589.52		969.02			1,395,382	
10-May-24	50.30	0.27	-32.14	1,629.47		889.12			1,280,337	
11-May-24	50.65	0.23	-32.14	1,632.62		795.47			1,145,472	
12-May-24	---	0.23	-32.14	1,634.38		830.51			1,195,941	
13-May-24	48.35	0.31	-32.13	1,630.03		831.30			1,197,078	
14-May-24	47.20	0.34	-32.13	1,625.99		820.92			1,182,119	
15-May-24	48.80	0.25	-32.11	1,624.08		798.23			1,149,450	
16-May-24	50.40	0.21	-32.09	1,610.98		784.15			1,129,170	
17-May-24	49.90	0.24	-32.09	1,587.94		786.08			1,131,952	
18-May-24	51.10	0.22	-32.08	1,598.58		787.43			1,133,895	
19-May-24	50.85	0.26	-32.07	1,583.11		783.54			1,128,304	
20-May-24	---	0.21	-32.06	1,581.21		781.79			1,125,778	

Appendix A, continued

Date	Methane Daily Avg	Oxygen Daily Avg	Field Pressure ("H2O)	Flare 1 Temp Avg	Flare 2 Temp Avg	Groundflare Daily Flow	Candlestick Flare 2 Daily Flow	Gen Flow	TotalFlow	Comments
21-May-24	50.85	0.18	-32.08	1,604.50		786.13			1,132,024	
22-May-24	49.20	0.49	-30.65	1,562.67		757.61			1,090,955	
23-May-24	48.20	0.47	-32.05	1,617.74		794.31			1,143,808	
24-May-24	49.00	0.18	-32.04	1,619.68		770.36			1,109,325	
25-May-24	48.80	0.24	-32.02	1,605.77		765.47			1,102,278	
26-May-24	---	0.26	-32.01	1,592.07		765.42			1,102,203	
27-May-24	48.40	0.30	-31.99	1,605.74		767.60			1,105,337	
28-May-24	45.70	0.78	-31.98	1,612.73		811.49			1,168,551	
29-May-24	46.15	0.64	-31.98	1,588.46		746.70			1,075,248	
30-May-24	48.10	0.73	-31.97	1,611.42		736.09			1,059,977	
31-May-24	---	0.66	-31.96	1,624.37		751.61			1,082,313	
1-Jun-24	49.80	0.37	-31.90	1,629.60		706.78			1,017,768	For June, due to the challenges with WAGA methane sensor, Methane data from the CRD staff GEM reading is used. The data is averaged per multiple readings for each day when available. The rest of the data is from WAGA.
2-Jun-24	---	0.37	-31.89	1,632.69		706.58			1,017,768	
3-Jun-24	46.90	0.83	-31.93	1,595.31		722.03			1,039,728	
4-Jun-24	48.90	0.64	-31.92	1,596.13		703.94			1,013,671	
5-Jun-24	49.30	0.67	-31.90	1,563.58		671.12			966,410	
6-Jun-24	50.80	0.31	-31.89	1,596.68		639.12			920,333	
7-Jun-24	52.10	0.24	-31.88	1,616.81		651.61			938,325	
8-Jun-24	52.00	0.20	-31.87	1,623.66		644.98			928,770	
9-Jun-24	---	0.23	-31.84	1,619.43		643.81			927,092	
10-Jun-24	52.20	0.29	-31.84	1,606.66		643.34			926,412	
11-Jun-24	---	0.26	-31.85	1,602.63		642.22			924,803	
12-Jun-24	51.80	0.31	-31.84	1,598.10		647.68			932,664	
13-Jun-24	52.45	0.30	-31.84	1,613.45		645.40			929,372	
14-Jun-24	52.60	0.31	-31.83	1,601.08		645.28			929,197	
15-Jun-24	52.60	0.31	-31.83	1,602.19		644.40			927,931	
16-Jun-24	---	0.32	-31.83	1,602.01		646.46			930,898	
17-Jun-24	51.45	0.28	-31.83	1,617.41		673.34			969,609	
18-Jun-24	50.75	0.27	-31.84	1,627.19		711.79			1,024,984	
19-Jun-24	50.40	0.24	-31.83	1,629.60		706.93			1,017,978	
20-Jun-24	50.10	0.24	-31.83	1,632.69		719.87			1,036,619	
21-Jun-24	---	0.31	-31.84	1,633.46		745.62			1,073,696	
22-Jun-24	50.00	0.34	-31.82	1,629.08		742.50			1,069,202	

Appendix A, continued

Date	Methane Daily Avg	Oxygen Daily Avg	Field Pressure ("H2O)	Flare 1 Temp Avg	Flare 2 Temp Avg	Groundflare Daily Flow	Candlestick Flare 2 Daily Flow	Gen Flow	TotalFlow	Comments
23-Jun-24	---	0.43	-31.83	1,624.25		745.51			1,073,529	
24-Jun-24	48.85	0.44	-31.81	1,623.87		746.42			1,074,847	
25-Jun-24	49.00	0.36	-31.83	1,632.75		777.26			1,119,250	
26-Jun-24	48.75	0.40	-31.83	1,635.75		815.31			1,174,052	
27-Jun-24	48.45	0.39	-31.84	1,631.73		809.45			1,165,601	
28-Jun-24	---	0.39	-31.82	1,631.77		804.39			1,158,318	
29-Jun-24	48.30	0.38	-31.81	1,632.82		801.37			1,153,969	
30-Jun-24									1,150,244	
1-Jul-24	---	0.41	-31.80	1,629.50		791.52			1,017,768	For July, due to the challenges with WAGA methane sensor, Methane data from the CRD staff GEM reading is used. The data is averaged per multiple readings for each day when available. The rest of the data is from WAGA.
2-Jul-24	47.80	0.39	-31.80	1,630.11		788.90			1,017,768	
3-Jul-24	47.20	0.34	-31.79	1,632.18		786.30			1,132,269	
4-Jul-24	49.10	0.33	-31.77	1,634.62		783.46			1,128,175	
5-Jul-24	---	0.30	-31.75	1,636.64		780.33			1,123,671	
6-Jul-24	50.20	0.32	-31.75	1,636.35		776.55			1,118,226	
7-Jul-24	---	0.29	-31.74	1,639.16		799.53			1,151,318	
8-Jul-24	49.50	0.29	-31.76	1,638.47		823.26			1,185,487	
9-Jul-24	48.25	0.36	-31.75	1,630.70		811.09			1,167,975	
10-Jul-24	48.05	0.42	-31.75	1,625.89		815.47			1,174,281	
11-Jul-24	47.80	0.37	-31.73	1,629.00		822.14			1,183,876	
12-Jul-24	48.60	0.35	-31.70	1,630.61		817.72			1,177,512	
13-Jul-24	48.80	0.38	-31.70	1,628.85		816.60			1,175,905	
14-Jul-24	---	0.43	-31.70	1,626.36		819.06			1,179,441	
15-Jul-24	48.50	0.35	-31.69	1,630.38		816.70			1,176,046	
16-Jul-24	48.30	0.36	-31.68	1,631.13		807.68			1,163,053	
17-Jul-24	48.15	0.43	-31.69	1,625.72		807.38			1,162,621	
18-Jul-24	48.20	0.47	-31.68	1,620.29		807.48			1,162,769	
19-Jul-24	---	0.39	-31.69	1,626.96		809.03			1,164,999	
20-Jul-24	---	0.40	-31.67	1,627.49		809.88			1,166,224	
21-Jul-24	---	0.45	-31.68	1,622.51		809.34			1,165,451	
22-Jul-24	47.95	0.47	-31.68	1,616.21		809.62			1,165,846	
23-Jul-24	48.80	0.41	-31.69	1,623.23		808.61			1,164,398	
24-Jul-24	48.15	0.77	-30.77	1,584.08		785.74			1,131,460	
25-Jul-24	48.65	0.42	-30.72	1,599.71		780.49			1,123,901	

Appendix A, continued

Date	Methane Daily Avg	Oxygen Daily Avg	Field Pressure ("H2O)	Flare 1 Temp Avg	Flare 2 Temp Avg	Groundflare Daily Flow	Candlestick Flare 2 Daily Flow	Gen Flow	TotalFlow	Comments
26-Jul-24	49.30	0.56	-30.40	1,590.02		771.07			1,110,335	
27-Jul-24	49.70	0.43	-31.69	1,636.90		798.19			1,149,391	
28-Jul-24	---	0.45	-31.70	1,635.47		799.53			1,151,321	
29-Jul-24	48.30	0.46	-31.73	1,632.04		799.44			1,151,194	
30-Jul-24	48.30	0.43	-31.70	1,629.92		772.79			1,112,822	
31-Jul-24									1,069,028	
1-Aug-24	47.20	0.33	-31.69	1,629.52		717.99			1,033,908	For June, due to the challenges with WAGA methane sensor, Methane data from the CRD staff GEM reading is used. The data is averaged per multiple readings for each day when available. The rest of the data is from WAGA.
2-Aug-24	---	0.21	-31.68	1,626.56		675.13			972,181	
3-Aug-24	51.30	0.20	-31.68	1,626.87		679.89			979,035	
4-Aug-24	---	0.21	-31.68	1,627.25		678.34			976,816	
5-Aug-24	---	0.24	-31.69	1,625.85		677.39			975,445	
6-Aug-24	47.45	0.33	-31.70	1,624.54		707.62			1,018,978	
7-Aug-24	47.40	0.42	-31.70	1,633.92		763.08			1,098,835	
8-Aug-24	48.70	0.33	-31.69	1,636.91		762.01			1,097,289	
9-Aug-24	48.70	0.34	-31.70	1,637.12		765.78			1,102,718	
10-Aug-24	48.80	0.39	-31.70	1,634.65		765.13			1,101,792	
11-Aug-24	---	0.43	-31.68	1,632.25		767.05			1,104,550	
12-Aug-24	47.45	0.49	-31.68	1,630.55		765.09			1,101,724	
13-Aug-24	47.80	0.51	-31.68	1,630.26		762.50			1,098,001	
14-Aug-24	47.55	0.51	-31.67	1,630.09		761.67			1,096,802	
15-Aug-24	46.40	0.45	-31.66	1,629.35		750.20			1,080,292	
16-Aug-24	49.00	0.41	-31.66	1,628.92		743.17			1,070,167	
17-Aug-24	48.40	0.35	-31.67	1,632.41		739.84			1,065,363	
18-Aug-24	---	0.48	-31.67	1,626.96		740.67			1,066,562	
19-Aug-24	---	0.50	-31.67	1,626.02		744.05			1,071,425	
20-Aug-24	---	0.48	-31.67	1,626.42		741.09			1,067,167	
21-Aug-24	47.80	0.46	-31.67	1,626.89		742.13			1,068,667	
22-Aug-24	48.80	0.42	-31.66	1,628.73		737.27			1,061,670	
23-Aug-24	48.40	0.43	-31.67	1,628.51		737.34			1,061,773	
24-Aug-24	46.20	0.60	-31.68	1,620.67		736.46			1,060,505	
25-Aug-24	---	0.61	-31.66	1,615.87		734.37			1,057,492	
26-Aug-24	48.35	0.48	-31.67	1,625.69		743.02			1,069,954	
27-Aug-24	47.00	0.54	-31.66	1,621.60		740.71			1,066,627	

Appendix A, continued

Date	Methane Daily Avg	Oxygen Daily Avg	Field Pressure ("H2O)	Flare 1 Temp Avg	Flare 2 Temp Avg	Groundflare Daily Flow	Candlestick Flare 2 Daily Flow	Gen Flow	TotalFlow	Comments
28-Aug-24	---	1.53	-29.23	1,513.02		689.00			992,163	
29-Aug-24	---	0.39	-31.67	1,629.93		745.66			1,073,750	
30-Aug-24	---	0.36	-31.67	1,630.31		735.17			1,058,642	
31-Aug-24	---	0.32	-31.67	1,631.34		732.03			1,054,117	
1-Sep-24	46.43	0.29	-31.66	889.36		729.09			1,049,890	For September, all data is from WAGA
2-Sep-24	46.26	0.38	-31.66	886.11		726.14			1,045,635	
3-Sep-24	46.47	0.46	-31.65	882.18		716.56			1,031,847	
4-Sep-24	39.35	3.84	-24.30	688.55		556.20			800,926	
5-Sep-24	47.11	0.23	-31.65	888.25		739.70			1,065,162	
6-Sep-24	46.28	0.17	-31.65	888.35		733.06			1,055,603	
7-Sep-24	46.54	0.20	-31.65	887.69		732.78			1,055,199	
8-Sep-24	46.12	0.24	-31.64	886.28		728.10			1,048,467	
9-Sep-24	45.77	0.32	-31.64	883.48		725.64			1,044,927	
10-Sep-24	44.97	1.21	-29.21	824.64		661.04			951,897	
11-Sep-24	48.83	0.31	-31.64	887.64		714.62			1,029,055	
12-Sep-24	46.59	0.35	-31.64	887.12		732.84			1,055,292	
13-Sep-24	46.51	0.33	-31.65	884.90		707.69			1,019,067	
14-Sep-24	46.81	0.29	-31.66	885.22		706.14			1,016,848	
15-Sep-24	46.23	0.34	-31.63	884.20		701.46			1,010,105	
16-Sep-24	45.75	0.31	-31.64	885.81		713.68			1,027,693	
17-Sep-24	47.70	0.42	-31.64	884.11		726.47			1,046,123	
18-Sep-24	46.71	0.75	-30.81	865.15		698.97			1,006,519	
19-Sep-24	48.28	0.45	-31.64	886.74		728.08			1,048,436	
20-Sep-24	47.72	0.53	-31.64	886.34		745.20			1,073,094	
21-Sep-24	48.34	0.50	-31.64	886.65		746.88			1,075,514	
22-Sep-24	48.76	0.46	-31.64	887.59		746.62			1,075,129	
23-Sep-24	48.48	0.49	-31.64	886.79		742.10			1,068,624	
24-Sep-24	49.06	0.36	-31.64	890.43		742.12			1,068,653	
25-Sep-24	47.79	0.61	-31.01	874.47		766.98			1,104,457	
26-Sep-24	41.96	2.67	-28.49	771.47		737.24			1,061,620	
27-Sep-24	47.53	0.62	-31.62	877.04		813.89			1,172,002	
28-Sep-24	48.81	0.49	-31.62	884.07		818.14			1,178,122	
29-Sep-24	46.01	0.70	-31.60	859.60		806.23			1,160,977	
30-Sep-24	46.46	0.63	-31.61	860.34		787.09			1,133,406	

Appendix A, continued

Date	Methane Daily Avg	Oxygen Daily Avg	Field Pressure ("H2O)	Flare 1 Temp Avg	Flare 2 Temp Avg	Groundflare Daily Flow	Candlestick Flare 2 Daily Flow	Gen Flow	TotalFlow	Comments
1-Oct-24	48.04	0.48	-31.60	1,614.93		771.78			1,111,367	For October, all data from WAGA except the last two days of the month where data was not available due to the change of the analyzer. For the two last days of the months, the average for the rest of the month is used.
2-Oct-24	46.36	1.02	-30.83	1,565.78		745.10			1,072,940	
3-Oct-24	48.78	0.51	-31.61	1,627.22		760.71			1,095,420	
4-Oct-24	47.41	0.73	-31.59	1,617.61		742.93			1,069,816	
5-Oct-24	46.44	0.84	-31.60	1,598.39		741.16			1,067,267	
6-Oct-24	47.26	0.71	-31.60	1,622.37		740.71			1,066,617	
7-Oct-24	47.24	0.66	-31.60	1,625.03		743.89			1,071,209	
8-Oct-24	47.07	0.74	-31.61	1,617.06		731.14			1,052,835	
9-Oct-24	46.29	0.79	-31.61	1,586.76		711.40			1,024,421	
10-Oct-24	43.12	2.61	-28.61	1,429.72		642.74			925,539	
11-Oct-24	47.71	0.71	-31.60	1,624.93		747.74			1,076,751	
12-Oct-24	46.48	0.71	-31.59	1,625.03		740.65			1,066,535	
13-Oct-24	46.42	0.67	-31.59	1,624.98		739.37			1,064,697	
14-Oct-24	46.87	0.67	-31.58	1,624.04		737.25			1,061,644	
15-Oct-24	46.98	0.67	-31.58	1,624.48		743.64			1,070,847	
16-Oct-24	48.68	0.75	-31.59	1,627.20		770.88			1,110,066	
17-Oct-24	48.20	0.86	-31.58	1,622.51		763.81			1,099,883	
18-Oct-24	47.72	0.76	-31.58	1,623.70		767.37			1,105,006	
19-Oct-24	47.68	0.45	-31.57	1,626.89		765.91			1,102,911	
20-Oct-24	48.27	0.47	-31.46	1,624.81		734.31			1,057,405	
21-Oct-24	47.43	0.69	-31.57	1,620.81		737.24			1,061,629	
22-Oct-24	46.12	0.78	-31.58	1,614.77		763.09			1,098,856	
23-Oct-24	46.14	0.82	-31.58	1,607.57		750.27			1,080,390	
24-Oct-24	46.49	0.85	-31.58	1,602.04		721.99			1,039,667	
25-Oct-24	47.20	0.72	-31.58	1,622.04		717.48			1,033,171	
26-Oct-24	45.78	0.76	-31.59	1,617.52		711.41			1,024,428	
27-Oct-24	45.89	0.76	-31.59	1,621.91		713.53			1,027,480	
28-Oct-24	45.84	0.76	-31.54	1,612.12		696.75			1,003,320	
29-Oct-24	42.80	0.86	-31.10	1,586.37		665.75			958,682	
30-Oct-24	46.78	0.79	-31.44	1,608.92		661.90			1,058,648	
31-Oct-24	46.78	0.79	-31.44	1,608.92		662.28			1,058,648	

Appendix A, continued

Date	Methane Daily Avg	Oxygen Daily Avg	Field Pressure ("H2O)	Flare 1 Temp Avg	Flare 2 Temp Avg	Groundflare Daily Flow	Candlestick Flare 2 Daily Flow	Gen Flow	TotalFlow	Comments
1-Nov-24	---	0.39	-31.54	1,621.91		661.77			952,953	For November, due to the challenges with WAGA methane sensor, Methane data from the CRD staff GEM reading is used. The data is averaged per multiple readings for each day when available. The rest of the data is from WAGA.
2-Nov-24	---	0.49	-31.55	1,604.57		660.54			951,175	
3-Nov-24	---	0.36	-31.55	1,615.80		668.83			963,121	
4-Nov-24	---	0.50	-31.58	1,606.64		679.93			979,094	
5-Nov-24	---	0.43	-31.57	1,607.16		683.68			984,503	
6-Nov-24	44.50	0.30	-31.56	1,617.85		686.02			987,866	
7-Nov-24	49.90	2.85	-27.79	1,443.28		689.99			993,583	
8-Nov-24	51.60	1.22	-30.49	1,582.66		775.79			1,117,137	
9-Nov-24	47.65	0.88	-31.54	1,630.05		790.22			1,137,924	
10-Nov-24	---	0.76	-31.56	1,633.38		788.32			1,135,175	
11-Nov-24	---	1.06	-31.58	1,627.38		777.87			1,120,137	
12-Nov-24	46.10	0.82	-31.55	1,630.65		777.46			1,119,537	
13-Nov-24	47.65	1.17	-31.59	1,625.78		763.13			1,098,902	
14-Nov-24	45.60	1.21	-31.55	1,615.43		760.51			1,095,133	
15-Nov-24	43.60	1.09	-31.57	1,620.76		763.72			1,099,761	
16-Nov-24	45.80	0.90	-31.56	1,627.70		763.40			1,099,300	
17-Nov-24	---	1.38	-30.76	1,590.18		734.77			1,058,065	
18-Nov-24	45.70	1.18	-29.62	1,570.66		730.42			1,051,803	
19-Nov-24	47.05	0.80	-31.56	1,629.66		759.62			1,093,848	
20-Nov-24	46.20	0.52	-31.57	1,632.36		826.53			1,190,199	
21-Nov-24	---	0.46	-31.57	1,635.41		859.59			1,237,802	
22-Nov-24	46.85	0.51	-31.57	1,630.89		862.62			1,242,174	
23-Nov-24	44.80	0.63	-31.57	1,623.87		870.14			1,253,009	
24-Nov-24	---	0.85	-31.31	1,612.69		894.10			1,287,507	
25-Nov-24	44.00	1.07	-27.76	1,446.26		787.63			1,134,182	
26-Nov-24	44.75	1.17	-27.31	1,418.58		770.53			1,109,569	
27-Nov-24	43.75	0.44	-31.55	1,620.12		879.68			1,266,738	
28-Nov-24	44.10	0.39	-31.59	1,622.12		891.96			1,284,426	
29-Nov-24	43.65	0.49	-31.58	1,619.03		878.29			1,264,740	
30-Nov-24	43.65	0.48	-31.58	1,618.60		871.58			1,255,080	
1-Dec-24	41.25	0.47	-31.59	1,619.89		870.50			1,253,515	For December, all data from WAGA
2-Dec-24	40.35	0.80	-31.57	1,614.53		866.43			1,247,660	
3-Dec-24	44.68	0.53	-31.57	1,616.86		829.74			1,194,826	

Appendix A, continued

Date	Methane Daily Avg	Oxygen Daily Avg	Field Pressure ("H2O)	Flare 1 Temp Avg	Flare 2 Temp Avg	Groundflare Daily Flow	Candlestick Flare 2 Daily Flow	Gen Flow	TotalFlow	Comments
4-Dec-24	45.12	0.50	-31.57	1,620.02		792.82			1,141,654	
5-Dec-24	44.30	0.63	-31.55	1,590.70		797.20			1,147,964	
6-Dec-24	44.81	0.59	-31.55	1,597.91		809.28			1,165,368	
7-Dec-24	44.67	0.57	-31.55	1,620.19		799.76			1,151,660	
8-Dec-24	43.31	0.82	-31.56	1,573.44		795.06			1,144,892	
9-Dec-24	43.05	0.96	-31.58	1,570.74		822.32			1,184,146	
10-Dec-24	43.44	1.04	-31.59	1,615.59		845.65			1,217,742	
11-Dec-24	45.01	0.85	-31.56	1,631.06		836.78			1,204,961	
12-Dec-24	44.97	0.83	-31.54	1,633.02		823.94			1,186,478	
13-Dec-24	45.00	0.79	-31.55	1,632.52		802.84			1,156,083	
14-Dec-24	43.82	1.04	-31.56	1,630.32		792.83			1,141,680	
15-Dec-24	42.38	1.28	-31.57	1,618.06		792.96			1,141,861	
16-Dec-24	43.77	1.01	-31.40	1,623.88		794.96			1,144,738	
17-Dec-24	44.58	0.79	-29.51	1,531.85		759.59			1,093,805	
18-Dec-24	45.12	0.90	-31.41	1,620.41		796.36			1,146,754	
19-Dec-24	46.61	0.64	-31.54	1,625.98		784.28			1,129,366	
20-Dec-24	46.80	0.54	-31.55	1,624.15		747.92			1,077,009	
21-Dec-24	47.22	0.51	-31.55	1,625.04		746.63			1,075,148	
22-Dec-24	47.16	0.51	-31.55	1,624.99		749.51			1,079,298	
23-Dec-24	46.35	0.61	-31.55	1,623.14		749.76			1,079,660	
24-Dec-24	45.81	0.62	-31.55	1,623.46		745.83			1,073,997	
25-Dec-24	46.77	0.47	-31.55	1,624.87		750.34			1,080,491	
26-Dec-24	46.50	0.52	-31.54	1,626.88		743.80			1,071,072	
27-Dec-24	45.94	0.54	-31.54	1,624.27		738.74			1,063,780	
28-Dec-24	45.36	0.65	-31.55	1,620.75		737.27			1,061,662	
29-Dec-24	45.28	0.66	-31.55	1,614.96		737.47			1,061,954	
30-Dec-24	44.65	0.80	-31.55	1,596.99		747.11			1,075,841	
31-Dec-24	46.22	0.63	-31.55	1,620.43		772.94			1,113,040	
Total	14,593.39					68,117,404	7,563,290	138,224.00	408,153,904	
Daily Average	47.9	0.6	-31.5			187,651	145,448	1,236	1,115,175	
scfm						130.31	101.01	0.86	774	
Normalize to 50% methane						38,034.3	29,480.25	250.6	67,765	

APPENDIX B

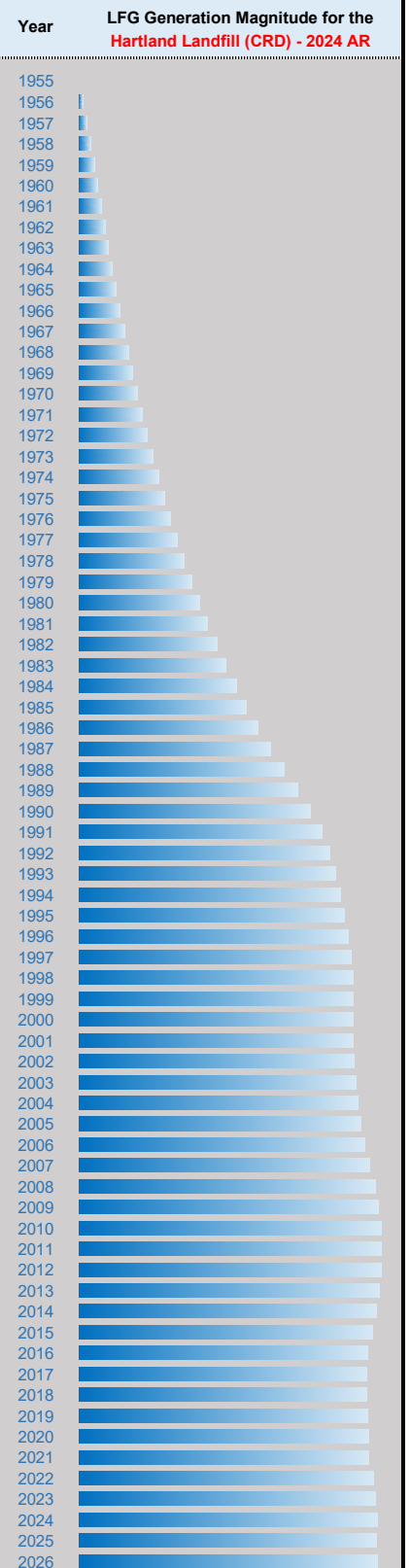
Methane Generation Estimates from the Hartland Landfill (2024)

Methane Generation Estimates from the Hartland Landfill (CRD) - 2024 AR

Actual CH₄ Yields

L ₀ (m ³ /tonne)	131	163	147	70	117	105	76.7
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Year	Methane generation estimates for the Hartland Landfill (CRD) - 2024 AR							Methane Generation Potential	Total LFG Flow Rate Estimated
	Food	Garden	Paper	Wood	Textile	Nappies	Total	(L ₀ , m ³ /tonne)	(scfm)
	(tonnes)	(tonnes)	(tonnes)	(tonnes)	(tonnes)	(tonnes)	(tonnes)		
1955	5	1	1	0	0	0	9	81.3	2
1956	65	12	18	5	5	3	109	81.3	22
1957	120	23	36	9	10	6	204	81.3	42
1958	172	35	53	13	15	10	297	81.3	61
1959	221	46	71	18	20	13	388	81.3	80
1960	267	57	89	23	26	16	478	81.3	98
1961	313	68	108	28	31	20	568	81.3	116
1962	357	79	128	33	37	23	657	81.3	135
1963	401	91	148	39	42	27	748	81.3	153
1964	445	103	169	45	48	31	840	81.3	172
1965	489	115	191	51	54	35	934	81.3	191
1966	534	128	213	57	61	39	1,031	81.3	211
1967	580	141	237	64	68	43	1,132	81.3	232
1968	628	154	261	71	75	47	1,236	81.3	253
1969	677	168	287	78	82	52	1,344	81.3	275
1970	728	183	314	86	90	57	1,457	81.3	299
1971	782	198	342	94	98	62	1,576	81.3	323
1972	838	214	372	103	106	67	1,701	81.3	349
1973	897	231	404	112	115	73	1,832	81.3	375
1974	959	248	437	122	125	79	1,970	81.3	404
1975	1,025	267	472	132	135	85	2,116	81.3	434
1976	1,095	286	509	143	145	92	2,270	81.3	465
1977	1,168	307	547	154	156	99	2,433	81.3	499
1978	1,246	329	589	167	168	107	2,605	81.3	534
1979	1,329	352	632	179	181	115	2,788	81.3	571
1980	1,417	377	678	193	194	123	2,982	81.3	611
1981	1,511	403	727	208	208	132	3,188	81.3	653
1982	1,610	430	779	223	223	141	3,407	81.3	698
1983	1,716	460	834	239	238	151	3,639	81.3	746
1984	1,828	491	893	257	255	162	3,885	81.3	796
1985	1,948	524	954	275	273	173	4,147	81.3	850
1986	2,076	559	1,021	295	292	185	4,427	81.3	907
1987	2,226	599	1,094	317	313	198	4,747	81.3	973
1988	2,380	641	1,172	340	335	212	5,080	81.3	1,041
1989	2,530	682	1,250	363	357	227	5,409	81.3	1,109
1990	2,669	723	1,328	386	380	241	5,726	81.3	1,173
1991	2,783	759	1,400	409	400	254	6,004	81.3	1,231
1992	2,850	787	1,460	428	417	265	6,207	81.3	1,272
1993	2,875	806	1,508	445	431	273	6,339	81.3	1,299
1994	2,889	822	1,551	461	443	281	6,448	81.3	1,322
1995	2,895	836	1,591	476	455	288	6,540	81.3	1,340
1996	2,908	851	1,631	490	466	295	6,641	81.3	1,361
1997	2,911	862	1,666	504	476	302	6,722	81.3	1,378
1998	2,892	869	1,694	516	484	307	6,763	81.3	1,386
1999	2,849	870	1,713	526	489	310	6,758	81.3	1,385
2000	2,813	872	1,731	536	495	314	6,760	81.3	1,385
2001	2,791	874	1,751	546	500	317	6,779	81.3	1,389
2002	2,765	876	1,768	555	505	320	6,788	81.3	1,391
2003	2,761	881	1,789	565	511	324	6,831	81.3	1,400
2004	2,764	886	1,811	575	518	328	6,882	81.3	1,410
2005	2,783	894	1,836	586	525	333	6,957	81.3	1,426
2006	2,821	906	1,867	598	533	338	7,064	81.3	1,448
2007	2,864	919	1,899	611	543	344	7,179	81.3	1,471
2008	2,918	934	1,934	624	553	350	7,313	81.3	1,499
2009	2,945	944	1,962	636	561	355	7,402	81.3	1,517
2010	2,952	950	1,984	646	567	359	7,459	81.3	1,529
2011	2,935	952	1,998	655	571	362	7,473	81.3	1,532
2012	2,900	949	2,006	661	573	363	7,454	81.3	1,528
2013	2,851	943	2,008	667	574	364	7,407	81.3	1,518
2014	2,794	933	2,006	671	574	365	7,342	78.6	1,505
2015	2,716	899	1,996	677	572	378	7,237	78.6	1,483
2016	2,639	863	1,982	682	570	396	7,133	75.9	1,462
2017	2,611	814	1,984	696	575	417	7,098	75.9	1,455
2018	2,604	770	1,990	711	580	440	7,097	75.9	1,454
2019	2,610	730	2,000	728	587	464	7,119	76.0	1,459
2020	2,618	694	2,010	743	594	490	7,149	76.3	1,465
2021	2,599	659	2,019	758	599	529	7,164	76.9	1,468
2022	2,621	633	2,042	779	610	588	7,272	69.8	1,490
2023	2,554	630	2,064	807	618	636	7,308	70.4	1,498
2024	2,500	628	2,086	834	626	690	7,363	70.5	1,509
2025	2,418	621	2,093	855	629	740	7,355	70.5	1,507
2026	2,352	615	2,101	876	633	787	7,363	70.4	1,509

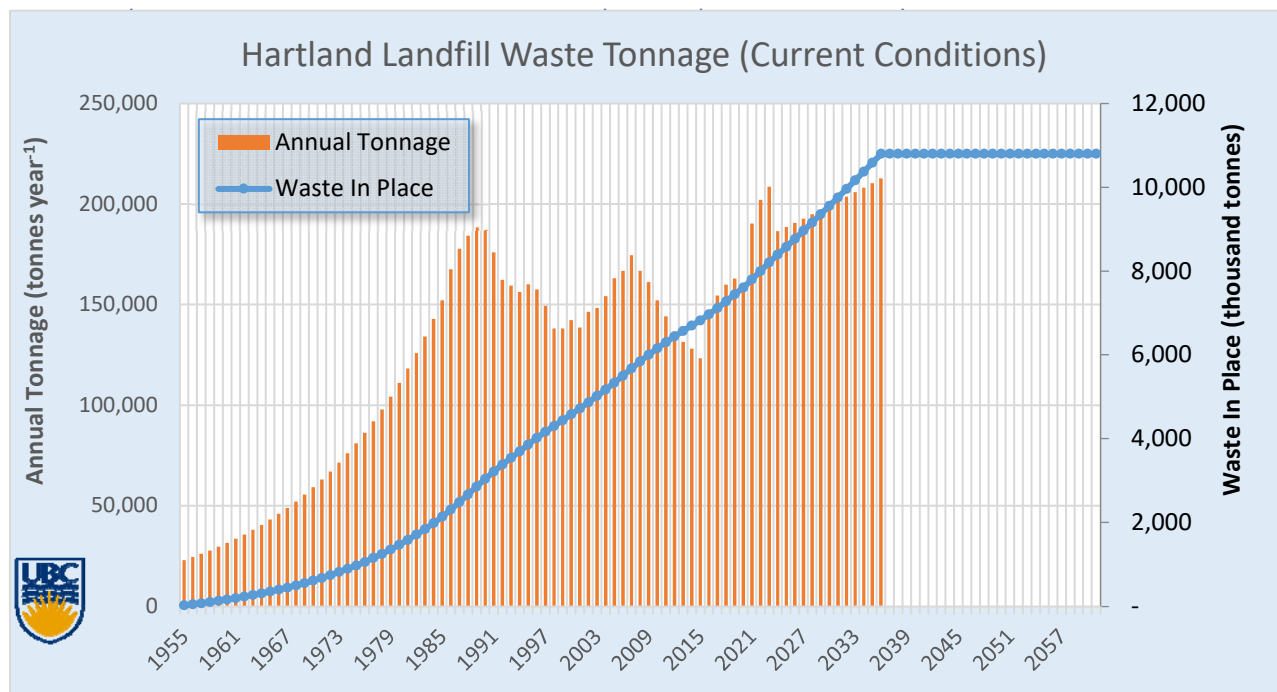
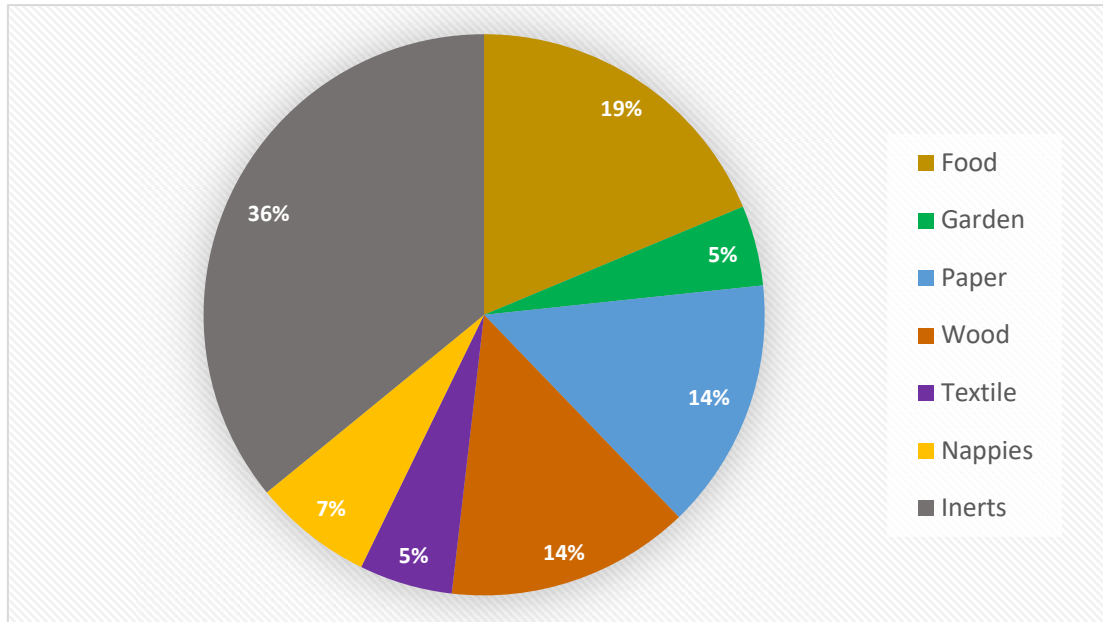


Methane generation estimates for the Hartland Landfill (CRD) - 2024 AR								Methane Generation Potential (L ₀ , m ³ /tonne)	Total LFG Flow Rate Estimated (scfm)	LFG Generation Magnitude for the Hartland Landfill (CRD) - 2024 AR	
Year	Food (tonnes)	Garden (tonnes)	Paper (tonnes)	Wood (tonnes)	Textile (tonnes)	Nappies (tonnes)	Total (tonnes)			Year	
2027	2,298	610	2,110	896	636	833	7,383	70.4	1,513	2027	
2028	2,255	605	2,120	917	641	877	7,415	70.4	1,520	2028	
2029	2,221	602	2,131	938	645	919	7,456	70.4	1,528	2029	
2030	2,196	600	2,143	959	649	959	7,505	70.4	1,538	2030	
2031	2,177	598	2,156	979	654	997	7,562	70.4	1,550	2031	
2032	2,165	597	2,170	1,000	659	1,034	7,625	70.3	1,563	2032	
2033	2,158	596	2,184	1,021	664	1,069	7,693	70.3	1,577	2033	
2034	2,156	597	2,199	1,042	670	1,103	7,766	70.3	1,592	2034	
2035	2,158	597	2,215	1,062	676	1,136	7,844	70.3	1,608	2035	
2036	2,163	599	2,232	1,083	682	1,166	7,925	70.1	1,624	2036	
2037	2,149	597	2,241	1,100	685	1,181	7,953		1,630	2037	
2038	1,849	551	2,132	1,068	651	1,123	7,375		1,511	2038	
2039	1,592	509	2,028	1,036	620	1,068	6,853		1,404	2039	
2040	1,370	470	1,929	1,006	589	1,016	6,380		1,308	2040	
2041	1,179	434	1,835	976	561	967	5,951		1,220	2041	
2042	1,015	400	1,746	947	533	919	5,561		1,140	2042	
2043	874	370	1,660	919	507	875	5,205		1,067	2043	
2044	752	341	1,579	892	483	832	4,879		1,000	2044	
2045	647	315	1,502	866	459	791	4,581		939	2045	
2046	557	291	1,429	840	437	753	4,306		883	2046	
2047	479	268	1,359	815	415	716	4,054		831	2047	
2048	413	248	1,293	791	395	681	3,821		783	2048	
2049	355	229	1,230	768	376	648	3,605		739	2049	
2050	306	211	1,170	745	358	616	3,406		698	2050	
2051	263	195	1,113	723	340	586	3,220		660	2051	
2052	226	180	1,059	702	324	558	3,048		625	2052	
2053	195	166	1,007	681	308	530	2,887		592	2053	
2054	168	153	958	661	293	505	2,737		561	2054	
2055	144	141	911	641	278	480	2,597		532	2055	
2056	124	131	867	622	265	457	2,465		505	2056	
2057	107	121	825	604	252	434	2,342		480	2057	
2058	92	111	784	586	240	413	2,227		456	2058	
2059	79	103	746	569	228	393	2,118		434	2059	
2060	68	95	710	552	217	374	2,015		413	2060	
2061	59	88	675	536	206	356	1,919		393	2061	
2062	51	81	642	520	196	338	1,828		375	2062	
2063	43	75	611	504	187	322	1,742		357	2063	
2064	37	69	581	490	178	306	1,660		340	2064	
2065	32	64	553	475	169	291	1,584		325	2065	
2066	28	59	526	461	161	277	1,511		310	2066	
2067	24	54	500	447	153	263	1,442		295	2067	
2068	21	50	476	434	145	251	1,376		282	2068	
2069	18	46	453	421	138	238	1,314		269	2069	
2070	15	43	430	409	132	227	1,255		257	2070	
2071	13	39	409	397	125	216	1,199		246	2071	
2072	11	36	389	385	119	205	1,146		235	2072	
2073	10	34	370	374	113	195	1,096		225	2073	
2074	8	31	352	363	108	186	1,048		215	2074	
2075	7	29	335	352	102	177	1,002		205	2075	
2076	6	26	319	342	97	168	958		196	2076	
2077	5	24	303	331	93	160	917		188	2077	
2078	5	22	289	322	88	152	877		180	2078	
2079	4	21	274	312	84	145	840		172	2079	
2080	3	19	261	303	80	138	804		165	2080	
2081	3	18	248	294	76	131	770		158	2081	
2082	3	16	236	285	72	124	737		151	2082	
2083	2	15	225	277	69	118	706		145	2083	
2084	2	14	214	269	65	113	676		139	2084	
2085	2	13	203	261	62	107	648		133	2085	
2086	1	12	193	253	59	102	621		127	2086	
2087	1	11	184	246	56	97	595		122	2087	
2088	1	10	175	238	53	92	570		117	2088	
2089	1	9	166	231	51	88	546		112	2089	
2090	1	9	158	224	48	83	524		107	2090	
2091	1	8	151	218	46	79	502		103	2091	
2092	1	7	143	211	44	75	482		99	2092	
2093	0	7	136	205	42	72	462		95	2093	
2094	0	6	130	199	40	68	443		91	2094	
2095	0	6	123	193	38	65	425		87	2095	
2096	0	5	117	187	36	62	408		84	2096	
2097	0	5	112	182	34	59	392		80	2097	
2098	0	5	106	177	32	56	376		77	2098	
2099	0	4	101	171	31	53	361		74	2099	
2100	0	4	96	166	29	51	346		71	2100	
2101	0	4	91	161	28	48	332		68	2101	
2102	0	3	87	157	27	46	319		65	2102	
2103	0	3	83	152	25	44	307		63	2103	
2104	0	3	79	147	24	41	294		60	2104	
2105	0	3	75	143	23	39	283		58	2105	

Hartland Landfill (CRD) - 2024 AR

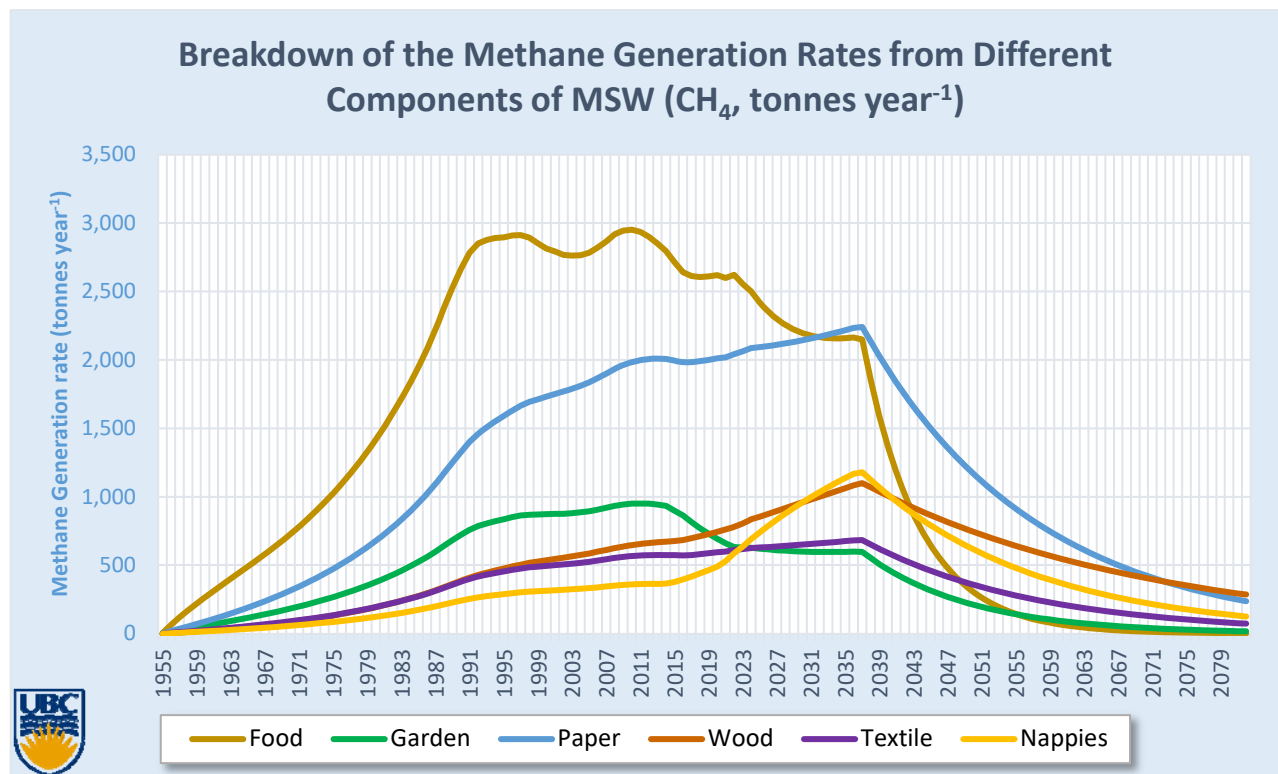
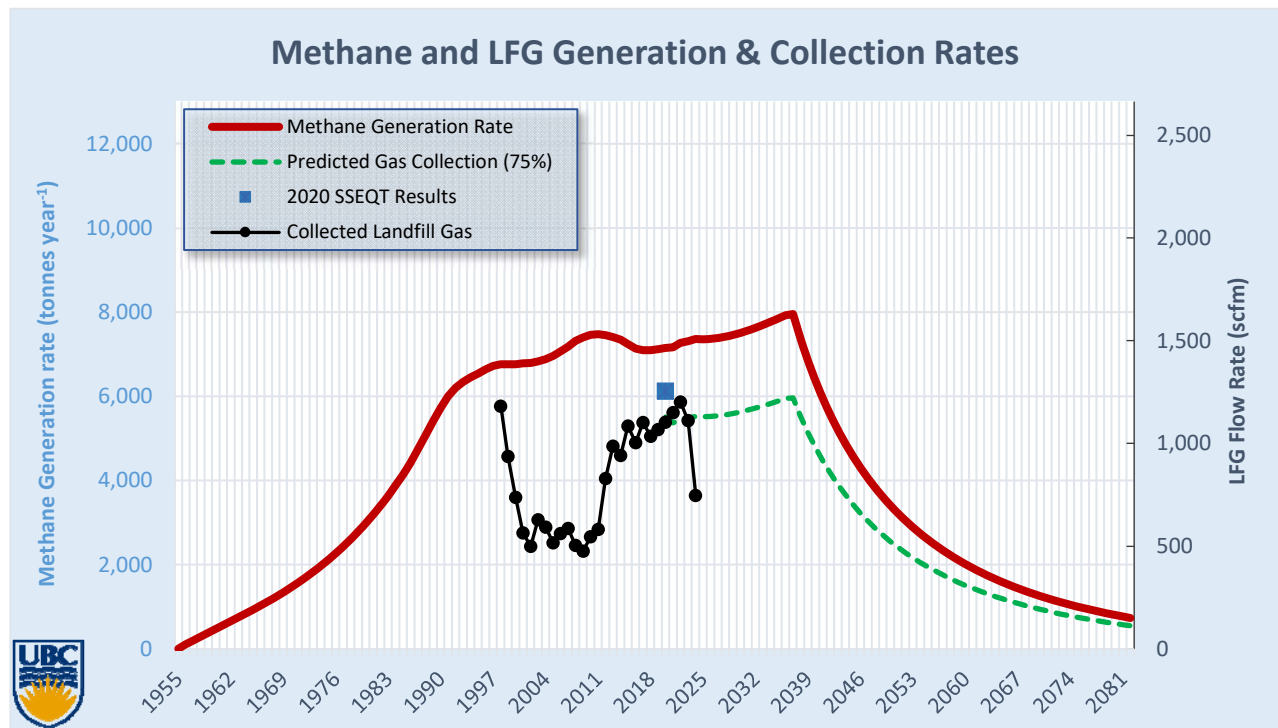
Landfill Gas Generation Analysis GRAPHICAL RESULTS

Average (Lifespan) Waste Composition



Hartland Landfill (CRD) - 2024 AR

Landfill Gas Generation Analysis GRAPHICAL RESULTS



APPENDIX C

Draft of Landfill Gas Design for Cell 4

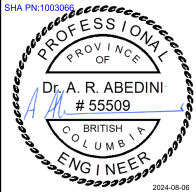
- C1 Draft of Landfill Gas Design Cell 3 New Header
- C2 Draft of Landfill Gas Design for Cell 4

Appendix C1 Draft of Landfill Gas Design Cell 3 New Header

Sheet No.	DWG No.	Rev. No.	Sheet Title
00	PRJ23001-00	0	COVER SHEET
01	PRJ23001-01	0	PLAN VIEW
02	PRJ23001-02	0	PROFILE VIEW
03	PRJ23001-03	0	DETAILS
04	PRJ23001-04	0	DETAILS
05	PRJ23001-05	0	DETAILS
06	PRJ23001-06	0	DETAILS
07	PRJ23001-07	0	DETAILS



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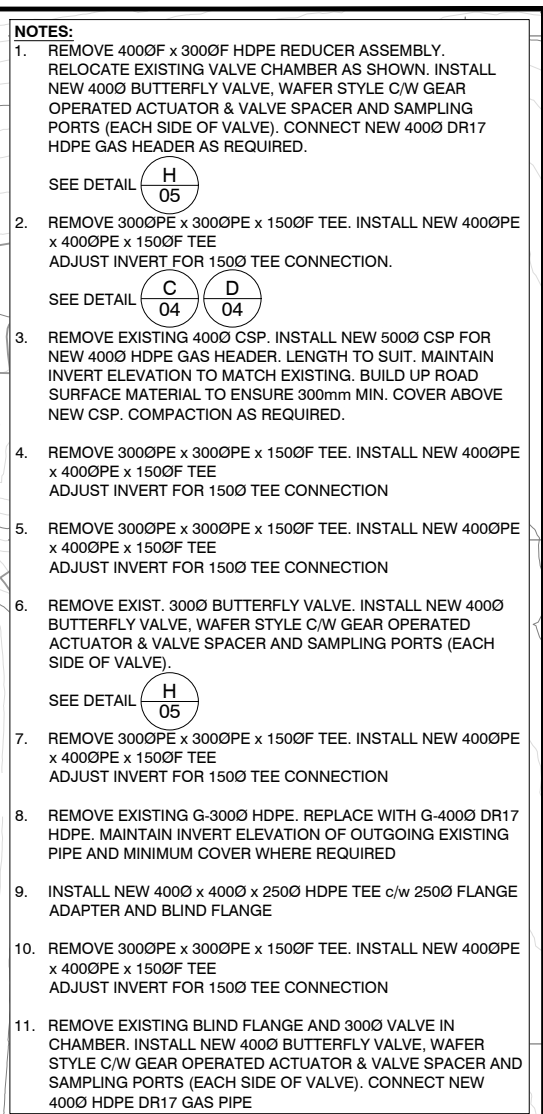
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No.	DATE y/m/day	REVISIONS	DRAWN	CHKD	APPD

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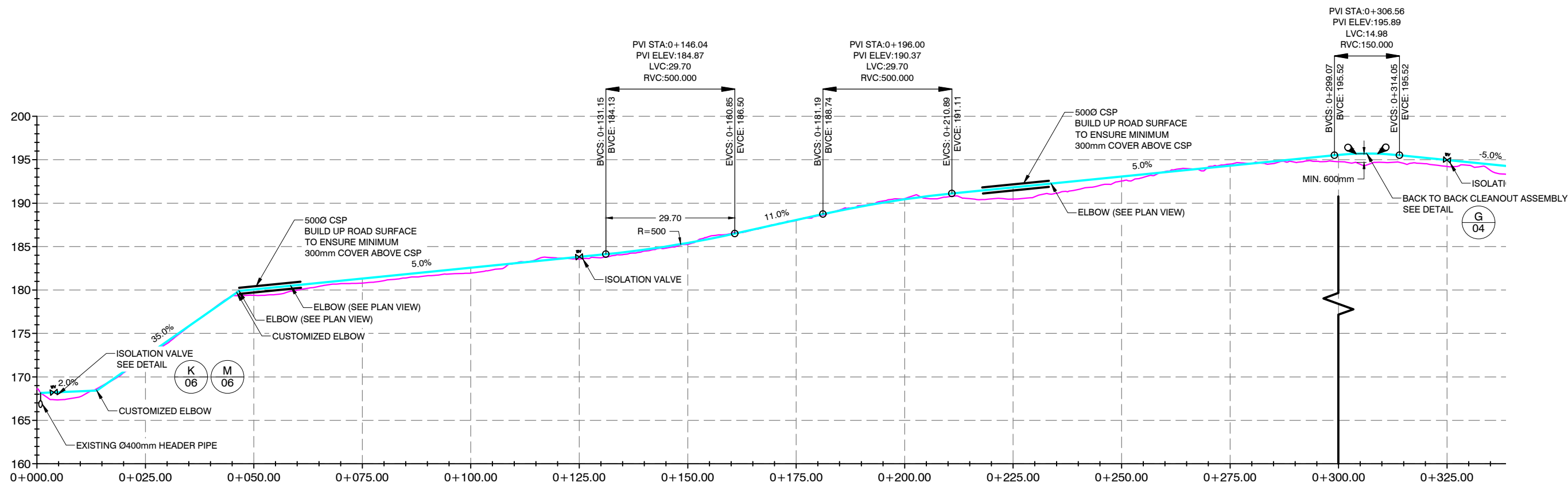
CRD
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DESIGN BY:	A.ABEDINI	SHA PROJECT #	PRJ 23001	CELL 3 LANDFILL GAS HEADER UPGRADE		
DRAWN BY:	L.BOBARIU	VERTICAL SCALE:	NTS	COVER SHEET		
CHECKED BY:	T.SPERLING	HORIZONTAL SCALE:	NTS			
APPROVED BY:	A.ABEDINI	C.R.D. CONTRACT# 30.22.06-03		DRAWING NO:	REV	SHEET
ADJUST SCALE 50% FOR 34"x22" SHEET				PRJ23001-00	0	00

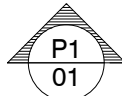
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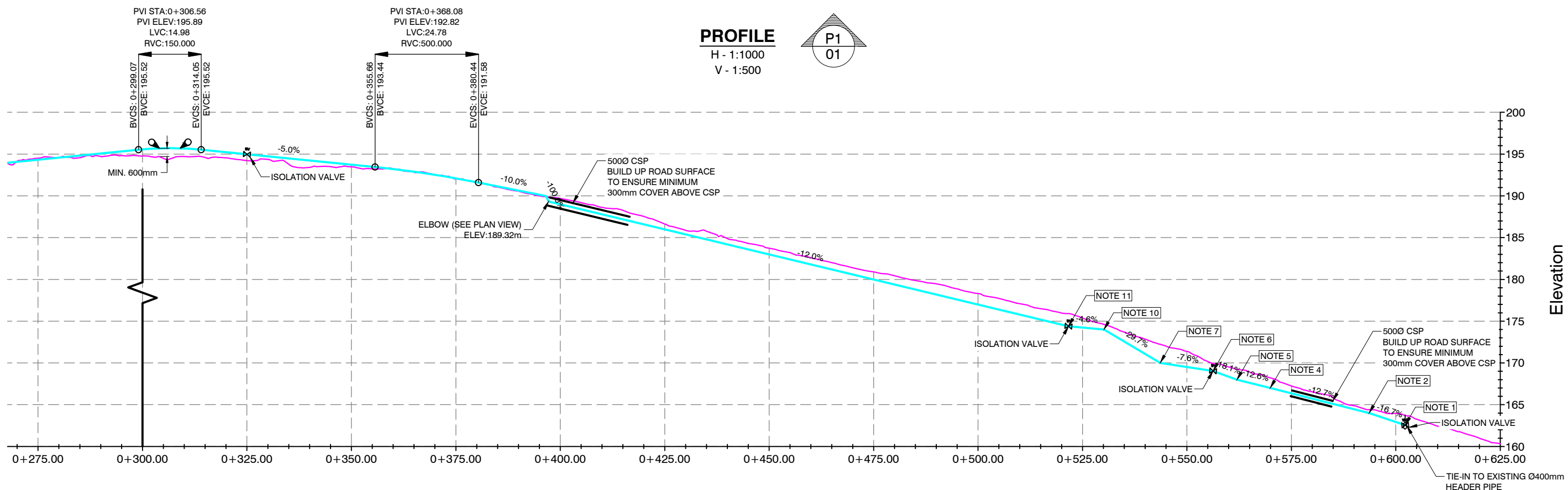
Elevation



PROFILE
H - 1:1000
V - 1:500

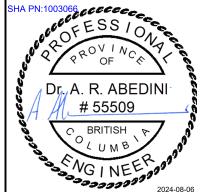


Elevation



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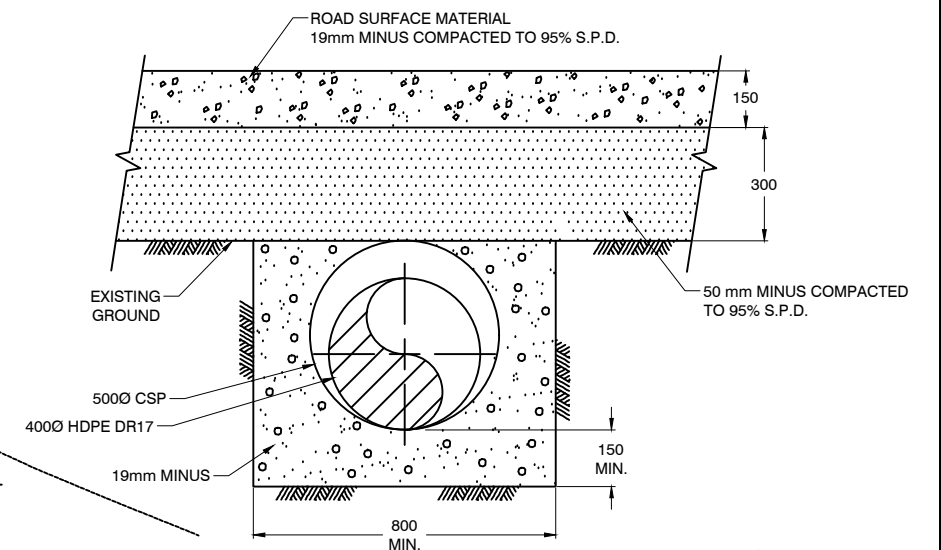
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DESIGN BY:	A.ABEDINI	SHA PROJECT #	PRJ 23001	CELL 3 LANDFILL GAS HEADER UPGRADE
DRAWN BY:	L.BOBARIU	HORIZONTAL SCALE:	1:500	PROFILE VIEW
CHECKED BY:	T.SPERLING	HORIZONTAL SCALE:	1:1000	
APPROVED BY:	A.ABEDINI	C.R.D. CONTRACT#	30.22.06-03	
ADJUST SCALE 50% FOR 34"x22" SHEET				

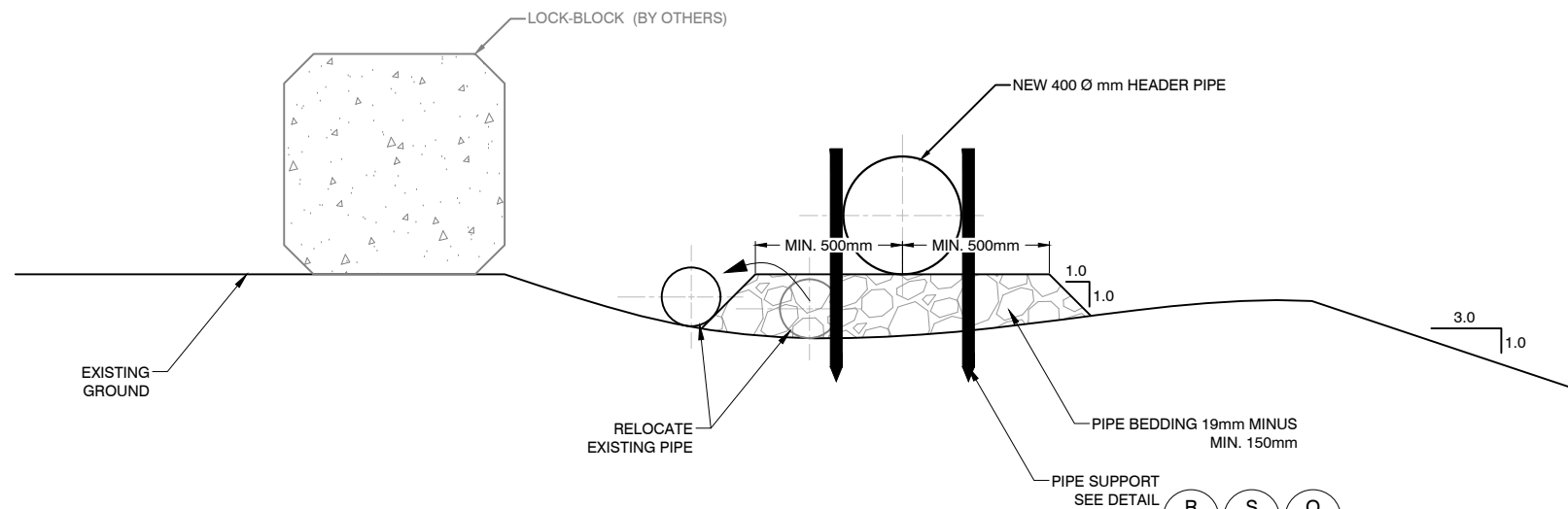
DRAWING NO.	REV	SHEET
PRJ23001-02	0	02

A
01



CULVERT CROSSING ROAD SECTION

SCALE 1:20

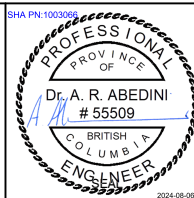


B
01

1. ALL PVC PIPE SHALL BE SCHEDULE 80 UNLESS NOTED OTHERWISE.
2. ALL HDPE PIPE SHALL BE SDR 17.0 UNLESS NOTED OTHERWISE.
3. HDPE PIPE JOINT SHALL BE THERMAL BUTT FUSION WELDED UNLESS NOTED OTHERWISE. ELECTRO-FUSION FITTINGS & FLANGES ARE NOT ALLOWED UNLESS NOTED OTHERWISE OR AUTHORIZED BY OWNER.
4. DEPTH OF PIPE VARIES. SEE PROFILE DRAWINGS. MINIMUM SOIL COVER OVER TOP OF PIPE 600 mm.
5. NEW HEADER PIPE TO BE SLOPED MINIMUM 5%, IF NEEDED, SOIL BERM TO BE ESTABLISHED FOR THE ABOVEGROUND SECTION OF THE HEADER.



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DRAWN BY:	NL			DETAILS		
CHECKED BY:	AA	HORIZONTAL SCALE: AS SHOWN				
APPROVED BY:	TS	C.R.D. CONTRACT# 30.22.06-03		DRAWING NO:	REV	SHEET
ADJUST SCALE 50% FOR 34"x22" SHEET				PRJ23001-03	0	03

1. ALL PVC PIPE SHALL BE SCHEDULE 80 UNLESS NOTED OTHERWISE.
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No.	DATE y/m/day	REVISIONS	DRAWN	CHK'D APP'D

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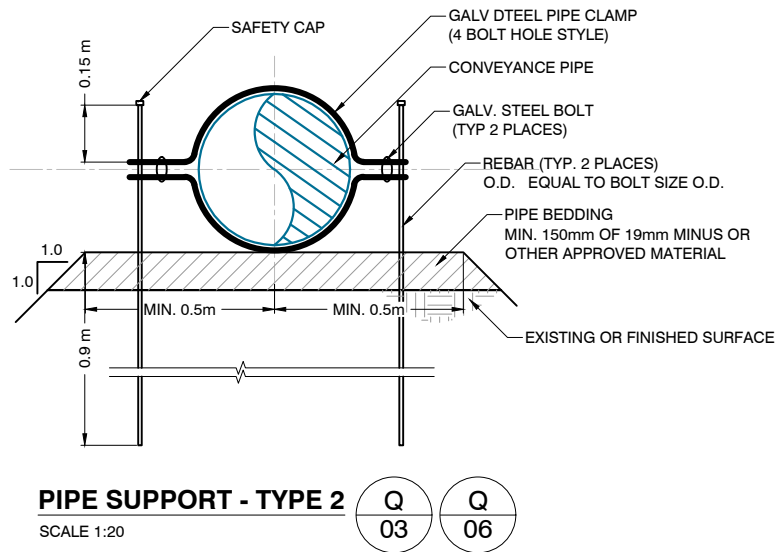
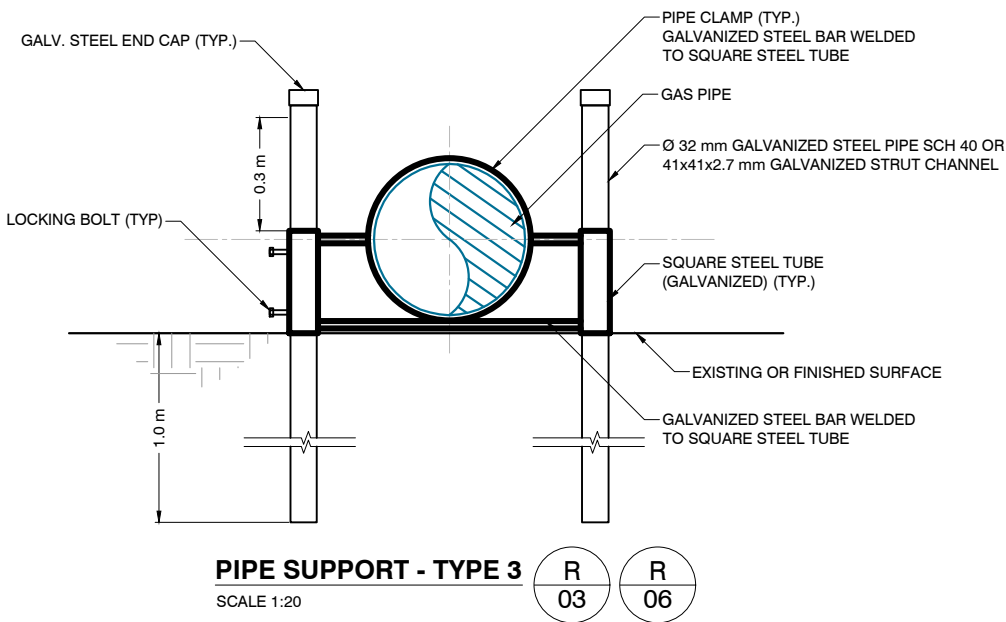
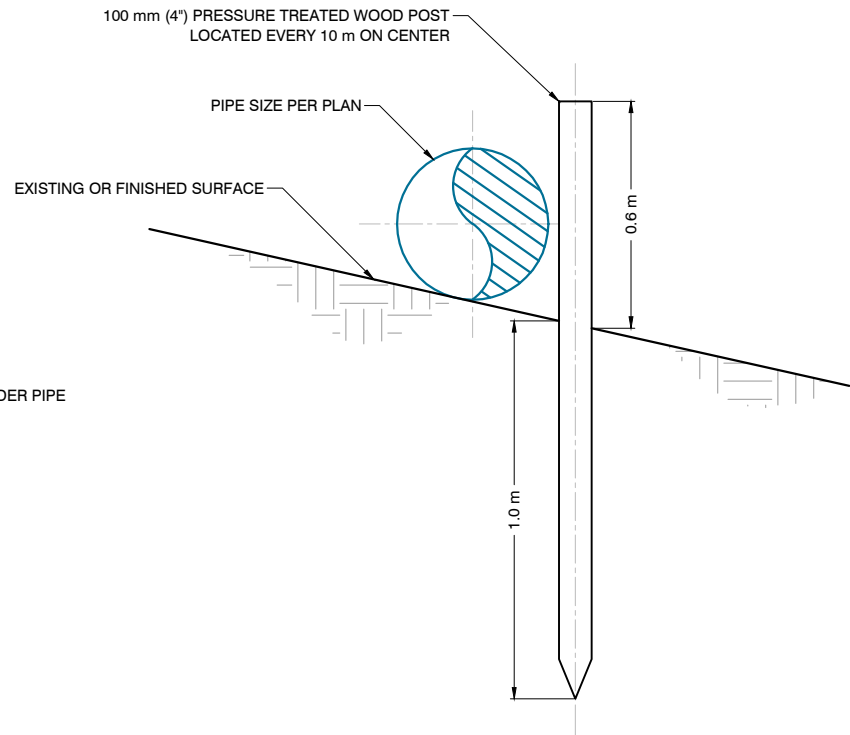
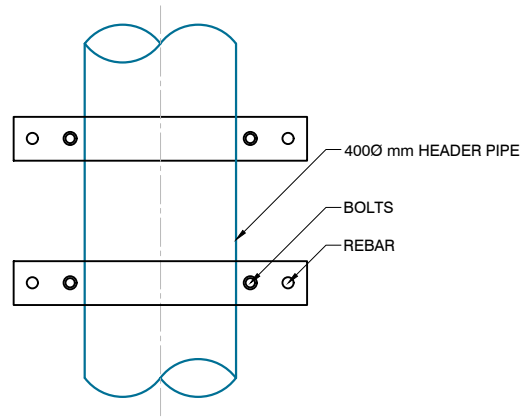
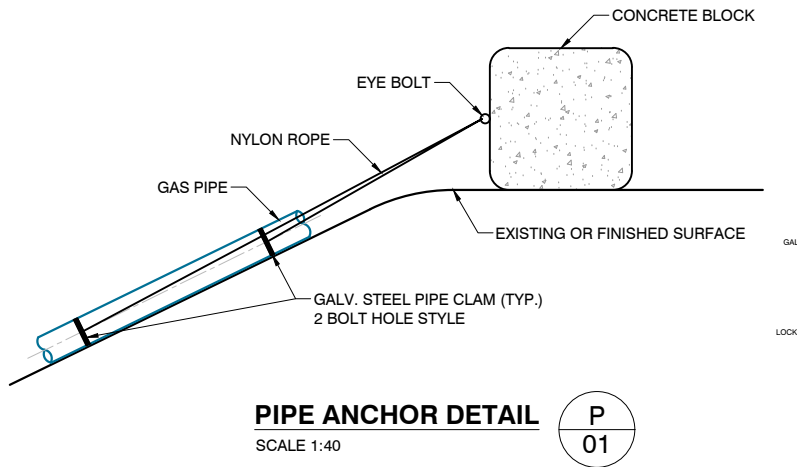
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DRAWN BY: L.BOBARIU		DETAILS		
CHECKED BY: T.SPERLING	HORIZONTAL SCALE: AS SHOWN			
APPROVED BY: A.ABEDINI	C.R.D. CONTRACT# 30.22.06-03	DRAWING NO:	REV	SHEET
ADJUST SCALE 50% FOR 34"x22" SHEET		PRJ23001-05	0	05

NOTES:

1. ALL PVC PIPE SHALL BE SCHEDULE 80 UNLESS NOTED OTHERWISE.
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3. HDPE PIPE JOINT SHALL BE THERMAL BUTT FUSION WELDED UNLESS NOTED OTHERWISE. ELECTRO-FUSION FITTINGS & FLANGES ARE NOT ALLOWED UNLESS NOTED OTHERWISE OR AUTHORIZED BY OWNER.
4. DEPTH OF PIPE VARIES, SEE PROFILE DRAWINGS. MINIMUM SOIL COVER OVER TOP OF PIPE 600 mm .
5. NEW HEADER PIPE TO BE SLOPED MINIMUM 5%, IF NEEDED, SOIL BERM TO BE ESTABLISHED FOR THE ABOVEGROUND SECTION OF THE HEADER.

[illegible]

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PIPE SUPPORT - TYPE 1
SCALE 1:20

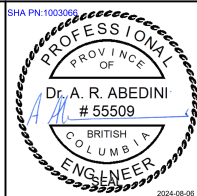
NOTES:

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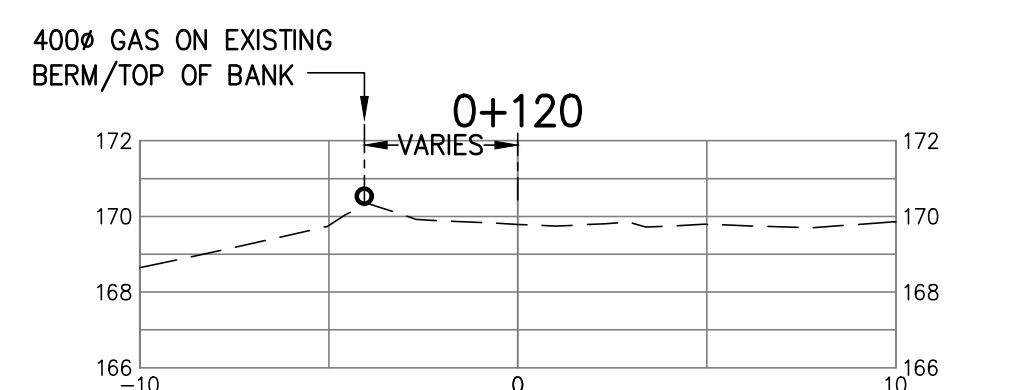
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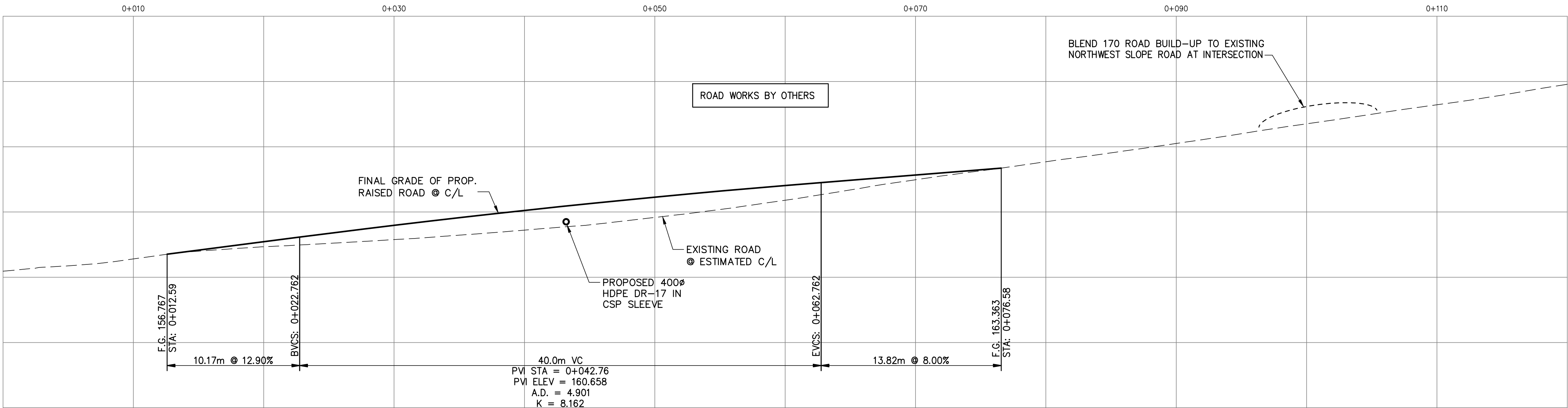
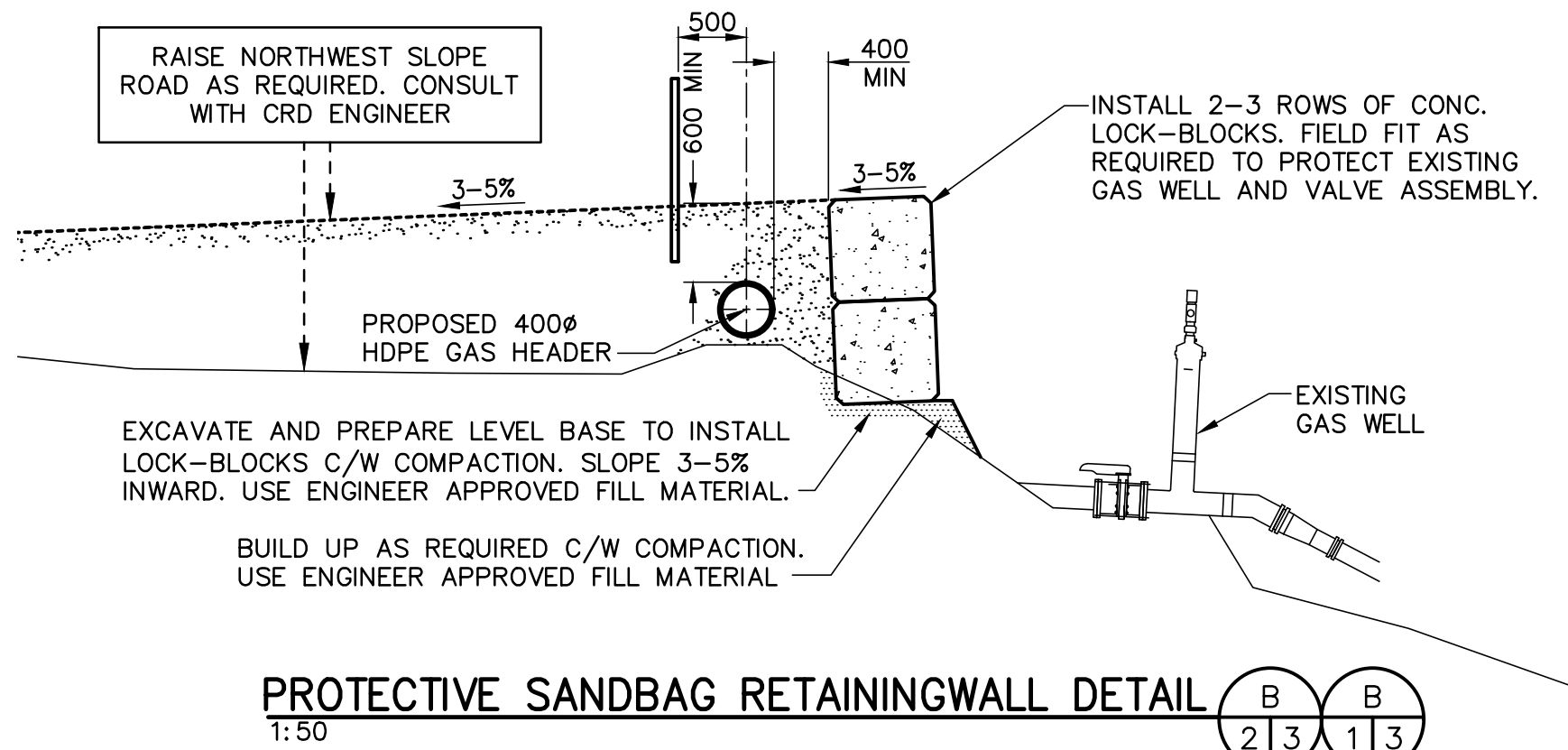
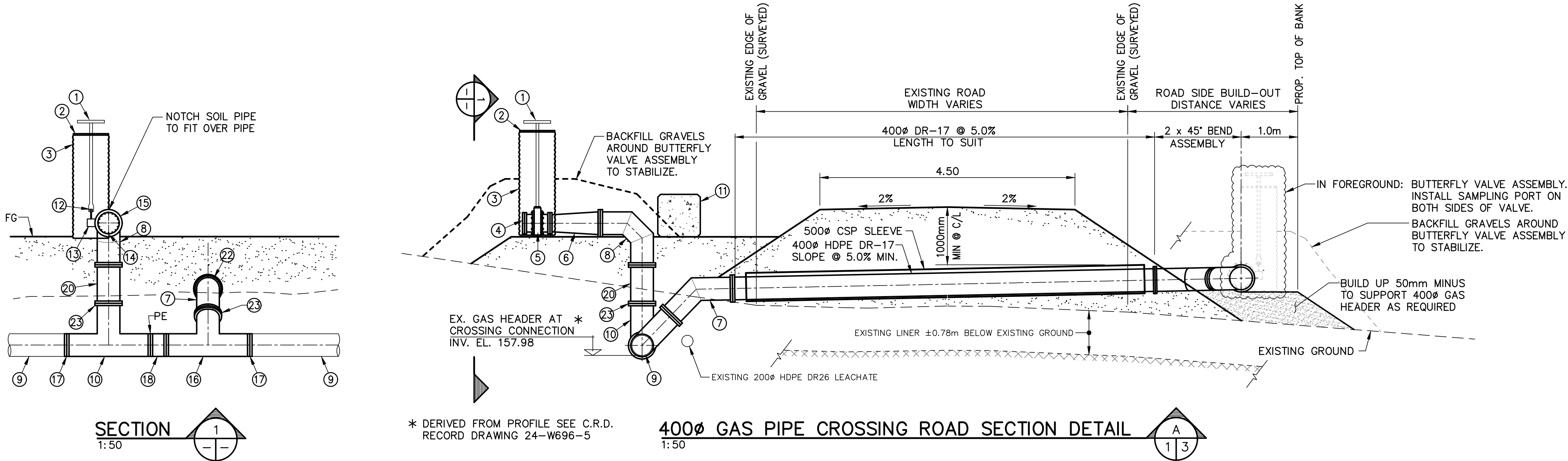
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DRAWN BY:	L.BOBARIU			
CHECKED BY:	T.SPERLING	HORIZONTAL SCALE:	AS SHOWN	
APPROVED BY:	A.ABEDINI	C.R.D. CONTRACT#	30.22.06-03	
ADJUST SCALE 50% FOR 34"x22" SHEET				
DRAWING NO:		REV	SHEET	
PRJ23001-07		0	07	



1:200 H&V NOTE: ROAD DESIGN AND CONSTRUCTION BY OTHERS



MATERIAL LIST	
ITEM	DESCRIPTION
1	VALVE OPERATING KEY (GALVANIZED OR EPOXY COATED)
2	LID
3	600#mm CORRUGATED HDPE SOIL PIPE
4	BLIND FLANGE
5	300# BUTTERFLY VALVE WITH BURIED SERVICE RATING (STEM IN HORIZONTAL POSITION)
6	400#F x 300#F HDPE DR17 REDUCER
7	400#F x 400#F HDPE DR17 45° ELBOW
8	400#F x 400#F 90° DR17 ELBOW
9	EXISTING 400# HDPE-DR26 GAS HEADER (CONTRACTOR TO VERIFY RATING)
10	400#PE x 400#PE x 400#PE HDPE DR26 TEE (FLANGE END ON VERTICAL SIDE)
11	PLACE LOCK BLOCK AS NEEDED TO PROTECT ABOVEGROUND PIPE
12	50mm SQUARE OPERATING NUT
13	GEAR OPERATOR (BURIED SERVICE RATING IP67)
14	PIPE INVERT
15	400# mm BUTTERFLY VALVE (STEM IN HORIZONTAL POSITION BURIED SERVICE RATING)
16	400#PE x 400#PE x 400#F HDPE DR26 TEE (BEFORE FUSING ROTATE TO ALIGN WITH 7)
17	DR26 EF COUPLING
18	400# DR26 SPOOL PIECE - FIELD FIT
19	DR17 400# SPOOL PIECE (LENGTH TO SUIT) c/w FLANGED ENDS
20	ROAD CROSSING C/W CULVERT SLEEVE
21	FLANGED END FOR DR26 TEE
22	
23	



PROFILE OF NORTHWEST SLOPE ROAD (LOWER) RAISING AT C/L OF PROPOSED ROAD
1:200



 SPERLING HANSEN ASSOCIATES Landfill Services Group • Landfill Bidding • Design & Operations Plans • Landfill Closure • Environmental Monitoring EGBC Permit No. 1003066	DESIGNED																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
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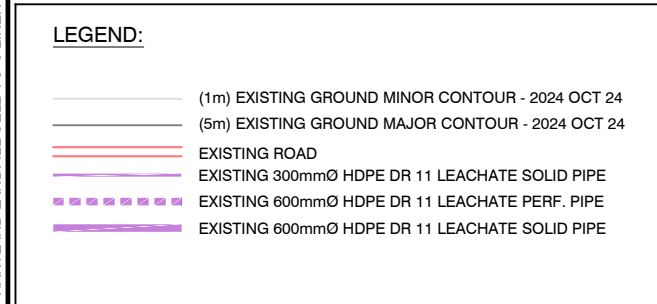


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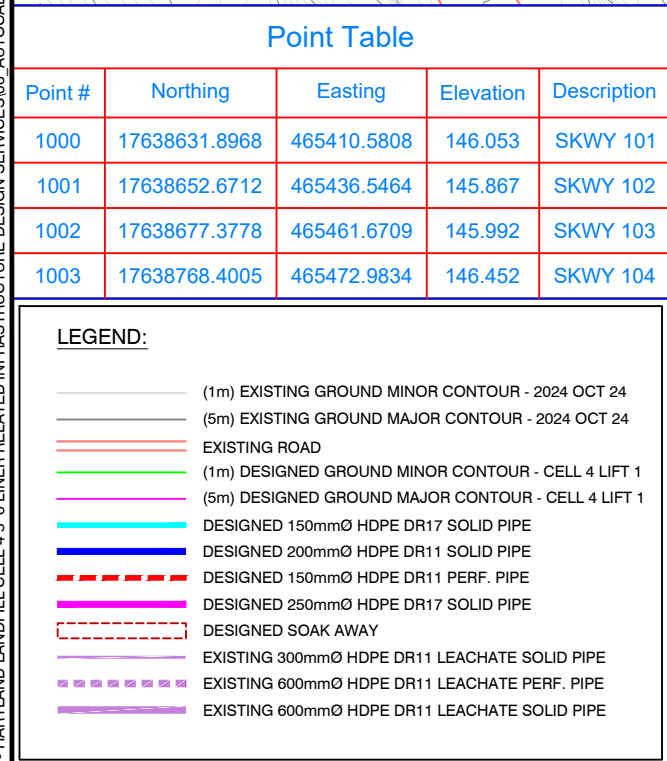
OTES

Appendix C2 Draft of Landfill Gas Design for Cell 4



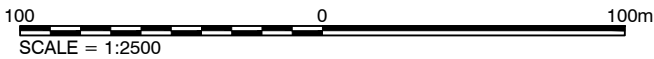
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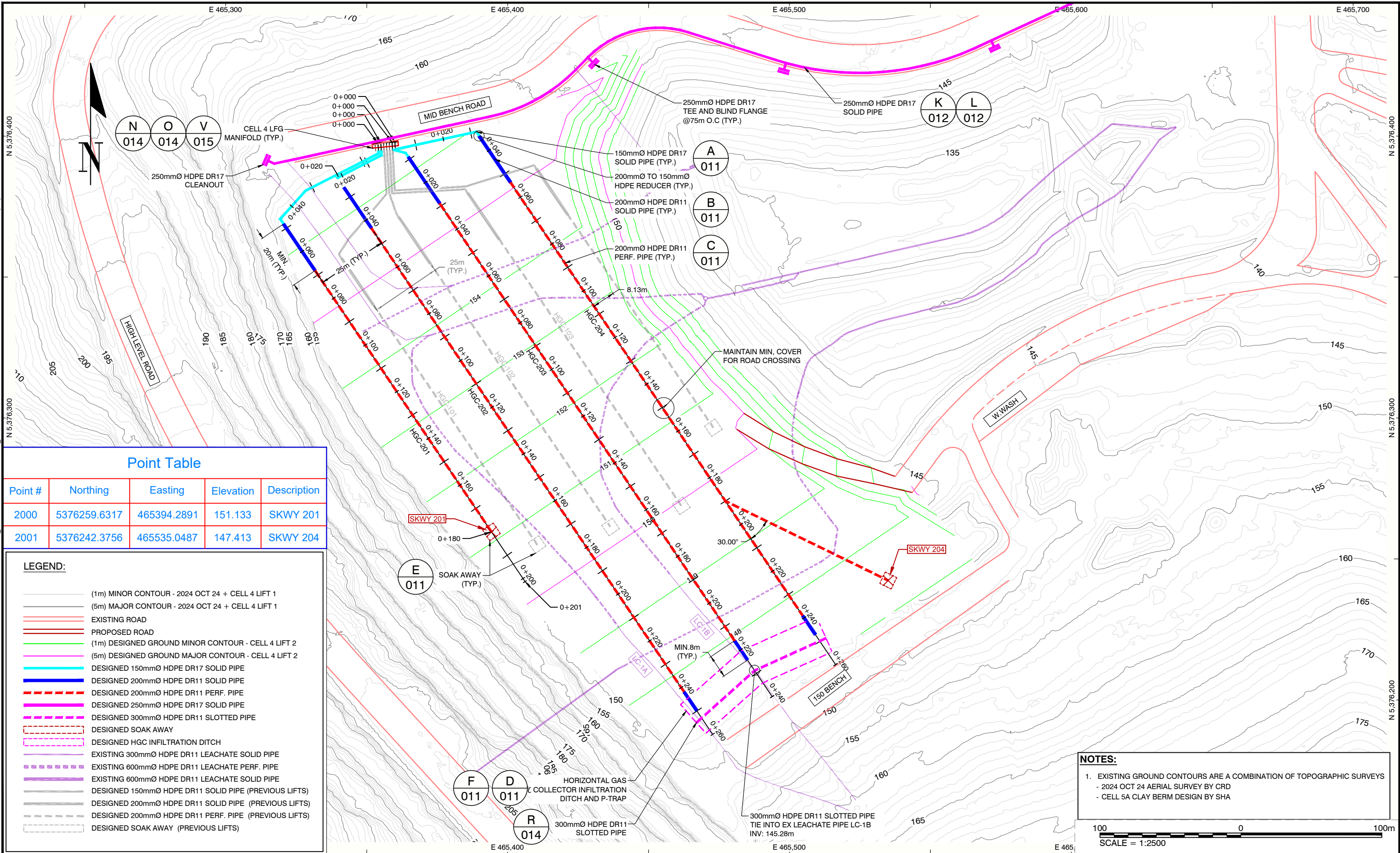


NOTES:

1. EXISTING GROUND CONTOURS ARE A COMBINATION OF TOPOGRAPHIC SURVEYS
 - 2024 OCT 24 AERIAL SURVEY BY CRD
 - CELL 5A CLAY BERM DESIGN BY SHA

[illegible]

PDF GENERATED by: Angus Tsang / 7/19/2025 11:24 AM X:\PRJ\PRJ23\PRJ23001 - HARTLAND LANDFILL CELL 4 5 6 LINER RELATED INFRASTRUCTURE DESIGN SERVICES\06 AUTOCAD DRAWINGS\01 DRAWINGS\PRODUCTION DRAWINGS\HARTLAND LF - CELL 4 LFG (AT)\003 - CELL 4 LIFT 2.DWG



Point Table

Point #	Northing	Easting	Elevation	Description
2000	5376259.6317	465394.2891	151.133	SKWY 201
2001	5376242.3756	465535.0487	147.413	SKWY 204

LEGEND:

- (1m) MINOR CONTOUR - 2024 OCT 24 + CELL 4 LIFT 1
- (5m) MAJOR CONTOUR - 2024 OCT 24 + CELL 4 LIFT 1
- EXISTING ROAD
- PROPOSED ROAD
- (1m) DESIGNED GROUND MINOR CONTOUR - CELL 4 LIFT 2
- (5m) DESIGNED GROUND MAJOR CONTOUR - CELL 4 LIFT 2
- DESIGNED 150mmØ HDPE DR17 SOLID PIPE
- DESIGNED 200mmØ HDPE DR11 SOLID PIPE
- DESIGNED 200mmØ HDPE DR11 PERF. PIPE
- DESIGNED 250mmØ HDPE DR17 SOLID PIPE
- DESIGNED 300mmØ HDPE DR11 SLOTTED PIPE
- DESIGNED SOAK AWAY
- DESIGNED HGC INFILTRATION DITCH
- EXISTING 300mmØ HDPE DR11 LEACHATE SOLID PIPE
- EXISTING 600mmØ HDPE DR11 LEACHATE PERF. PIPE
- EXISTING 600mmØ HDPE DR11 LEACHATE SOLID PIPE
- DESIGNED 150mmØ HDPE DR11 SOLID PIPE (PREVIOUS LIFTS)
- DESIGNED 200mmØ HDPE DR11 SOLID PIPE (PREVIOUS LIFTS)
- DESIGNED 200mmØ HDPE DR11 PERF. PIPE (PREVIOUS LIFTS)
- DESIGNED SOAK AWAY (PREVIOUS LIFTS)

NOTES:

- EXISTING GROUND CONTOURS ARE A COMBINATION OF TOPOGRAPHIC SURVEYS
- 2024 OCT 24 AERIAL SURVEY BY CRD
- CELL 5A CLAY BERM DESIGN BY SHA

100 0 100m
SCALE = 1:2500



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No.	DATE y/m/day	REVISIONS	DRAWN	CHK'D	APP'D
A	2025/07/16	ISSUED FOR 50% REVIEW	AT	TS	AA

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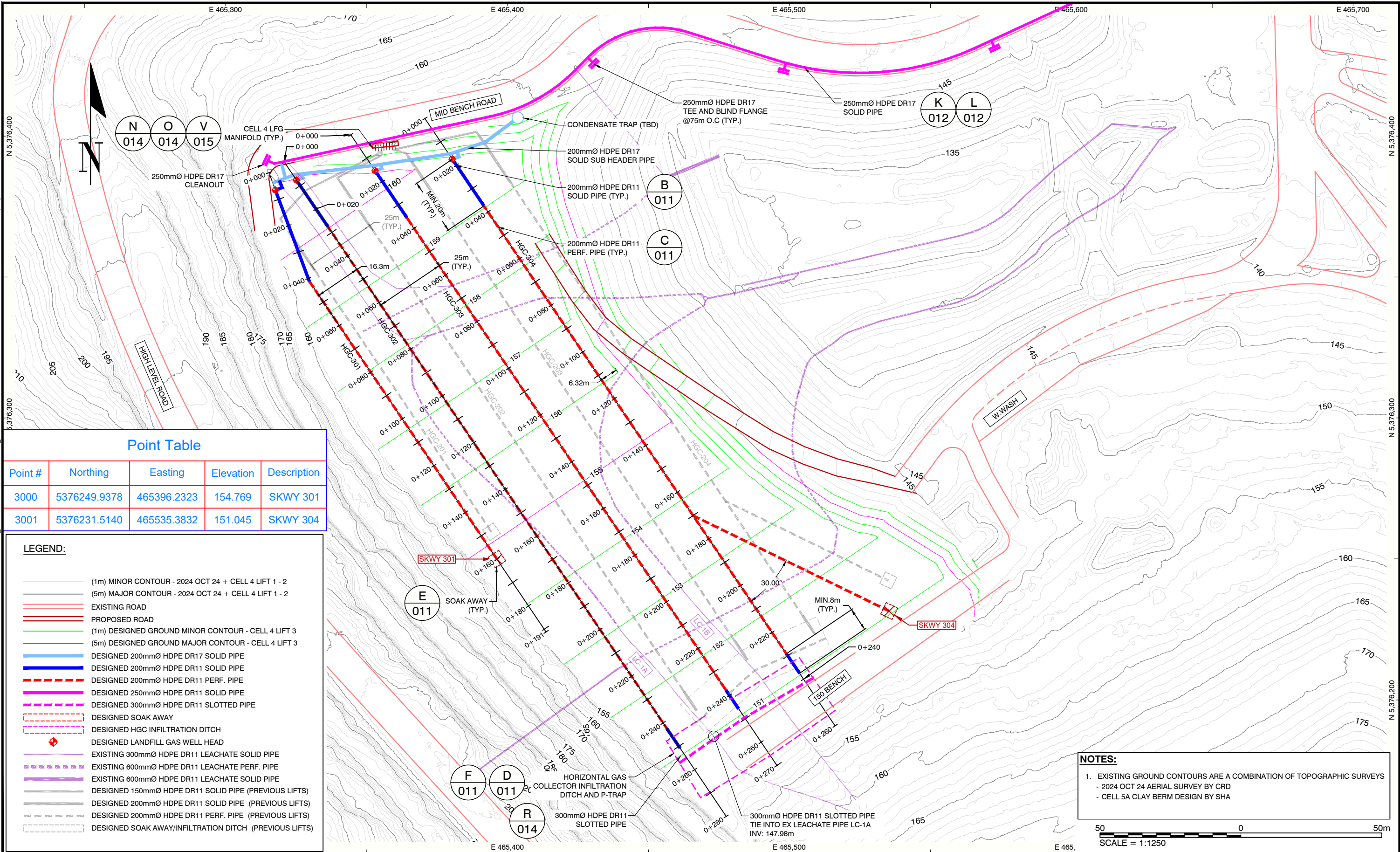
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CLIENT:

DESIGN BY: AA	SHA PROJECT # PRJ23001	HARTLAND LANDFILL - LFG CELL 4 DETAILED DESIGN		
DRAWN BY: AT	DATE CREATED: 2025/07/16	CELL 4 LIFT 2 LFG MANAGEMENT PLAN		
CHECKED BY: TS	HORIZONTAL SCALE: 1:1250			
APPROVED BY: AA	VERTICAL SCALE: 1:1250	DRAWING NO:	REV	SHEET
ADJUST SCALE 50% FOR 34"x22" SHEET		23001-003	A	003

PDF GENERATED by: Angus Tsang / 7/19/2025 12:21 PM X:\PRJ\PRJ23\PRJ23001 - HARTLAND LANDFILL CELL 4 5 6 LINER RELATED INFRASTRUCTURE DESIGN SERVICES\06 AUTOCAD DRAWINGS\01 DRAWINGS\PRODUCTION DRAWINGS\HARTLAND LF - CELL 4 LFG (AT)\004 - CELL 4 LIFT 3.DWG



Point Table

Point #	Northing	Easting	Elevation	Description
3000	5376249.9378	465396.2323	154.769	SKWY 301
3001	5376231.5140	465535.3832	151.045	SKWY 304

LEGEND:

- (1m) MINOR CONTOUR - 2024 OCT 24 + CELL 4 LIFT 1 - 2
- (5m) MAJOR CONTOUR - 2024 OCT 24 + CELL 4 LIFT 1 - 2
- EXISTING ROAD
- PROPOSED ROAD
- (1m) DESIGNED GROUND MINOR CONTOUR - CELL 4 LIFT 3
- (5m) DESIGNED GROUND MAJOR CONTOUR - CELL 4 LIFT 3
- DESIGNED 200mmØ HDPE DR17 SOLID PIPE
- DESIGNED 200mmØ HDPE DR11 SOLID PIPE
- DESIGNED 200mmØ HDPE DR11 PERF. PIPE
- DESIGNED 250mmØ HDPE DR11 SOLID PIPE
- DESIGNED 300mmØ HDPE DR11 SLOTTED PIPE
- DESIGNED SOAK AWAY
- DESIGNED HGC INFILTRATION DITCH
- DESIGNED LANDFILL GAS WELL HEAD
- EXISTING 300mmØ HDPE DR11 LEACHATE SOLID PIPE
- EXISTING 600mmØ HDPE DR11 LEACHATE PERF. PIPE
- EXISTING 600mmØ HDPE DR11 LEACHATE SOLID PIPE
- DESIGNED 150mmØ HDPE DR11 SOLID PIPE (PREVIOUS LIFTS)
- DESIGNED 200mmØ HDPE DR11 SOLID PIPE (PREVIOUS LIFTS)
- DESIGNED 200mmØ HDPE DR11 PERF. PIPE (PREVIOUS LIFTS)
- DESIGNED SOAK AWAY/INFILTRATION DITCH (PREVIOUS LIFTS)

NOTES:

- EXISTING GROUND CONTOURS ARE A COMBINATION OF TOPOGRAPHIC SURVEYS
 - 2024 OCT 24 AERIAL SURVEY BY CRD
 - CELL 5A CLAY BERM DESIGN BY SHA

50 0 50m
SCALE = 1:1250



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SEAL

No.	DATE y/m/day	REVISIONS	DRAWN	CHK'D	APP'D
A	2025/07/16	ISSUED FOR 50% REVIEW	AT	TS	AA

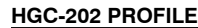
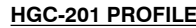
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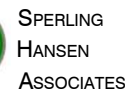
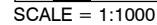
DESIGN BY: AA	SHA PROJECT # PRJ23001	HARTLAND LANDFILL - LFG CELL 4 DETAILED DESIGN
DRAWN BY: AT	DATE CREATED: 2025/07/16	CELL 4 LIFT 3 LFG MANAGEMENT PLAN
CHECKED BY: TS	HORIZONTAL SCALE: 1:1250	
APPROVED BY: AA	VERTICAL SCALE: 1:1250	
ADJUST SCALE 50% FOR 34"x22" SHEET		
23001-004		REV A SHEET 004



	EXISTING GROUND PROFILE - EG + CELL 4 LIFT 1
	DESIGNED FILL PROFILE - CELL 4 LIFT 2
	DESIGNED PIPE TRENCHING PROFILE
	DESIGNED 150mmØ HDPE DR17 SOLID PIPE
	DESIGNED 200mmØ HDPE DR11 SOLID PIPE
	DESIGNED 200mmØ HDPE DR11 PERF. PIPE
	DESIGNED SOAK AWAY
	DESIGNED HGC INFILTRATION DITCH
	EXISTING 300mmØ HDPE DR11 SOLID PIPE

1. EXISTING GROUND CONTOURS ARE A COMBINATION OF TOPOGRAPHIC SURVEYS

- 2024 OCT 24 AERIAL SURVEY BY CRD
- CELL 5A CLAY BERM DESIGN BY SHA



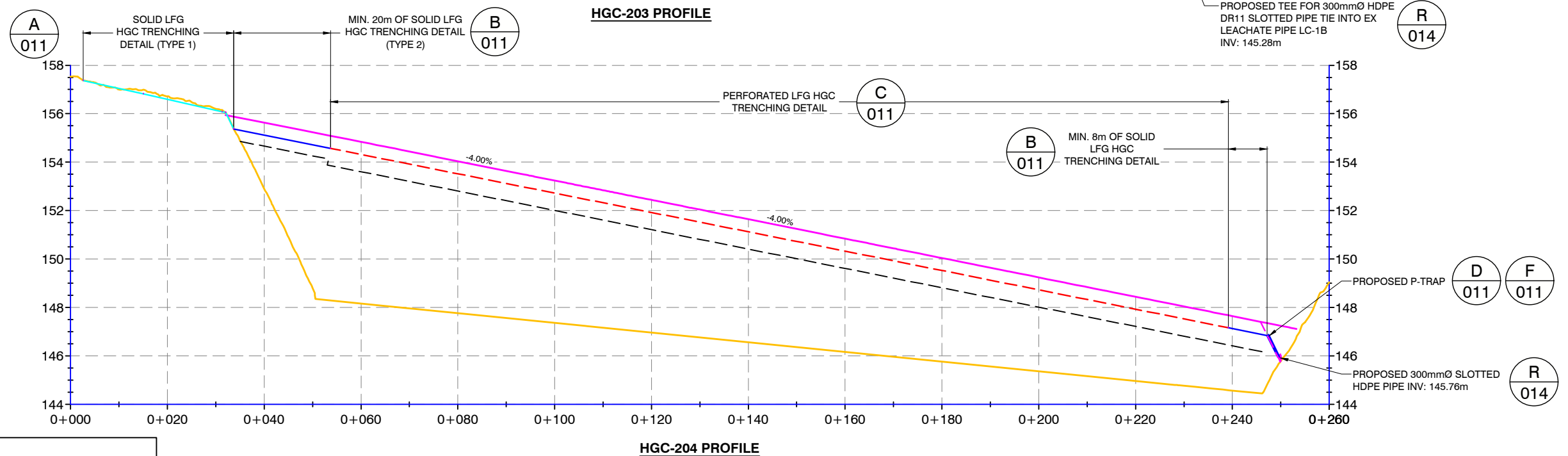
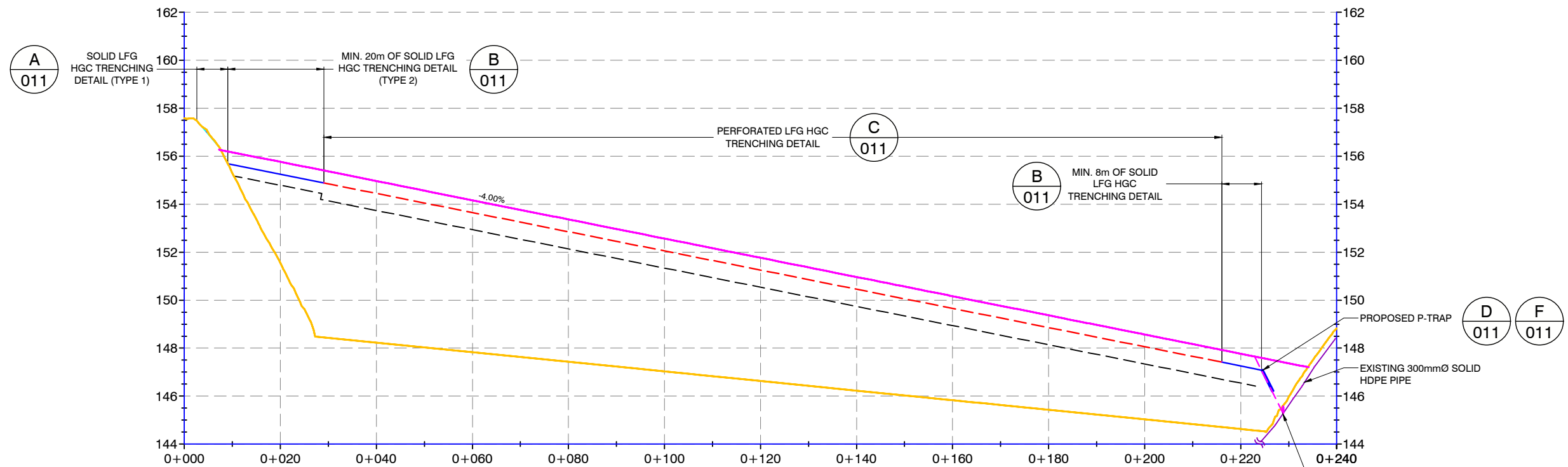
- #8 - 1225 Keith Road East
North Vancouver, B.C. V7J 1J3
Phone: (604) 986-7723

A	2025/07/16	ISSUED FOR 50% REVIEW	AT	TS	AA
No.	DATE yr/m/day	REVISIONS	DRAWN	CHKD	APP

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DRAWN BY: AT	DATE CREATED: 2025/07/16	PROFILE (HGC-201 & HGC-202)		
CHECKED BY: TS	HORIZONTAL SCALE: 1:1000			
APPROVED BY: AA	VERTICAL SCALE: 1:200	DRAWING NO:	REV	SHEET
ADJUST SCALE 50% FOR 34"x22" SHEET		23001-007	A	007

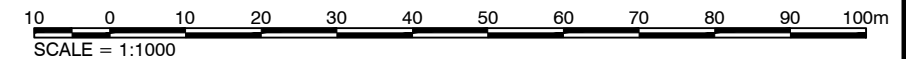


LEGEND:

- | | |
|---|--|
|  | EXISTING GROUND PROFILE - EG + CELL 4 LIFT 1 |
|  | DESIGNED FILL PROFILE - CELL 4 LIFT 2 |
|  | DESIGNED PIPE TRENCHING PROFILE |
|  | DESIGNED 150mmØ HDPE DR17 SOLID PIPE |
|  | DESIGNED 200mmØ HDPE DR11 SOLID PIPE |
|  | DESIGNED 200mmØ HDPE DR11 PERF. PIPE |
|  | DESIGNED SOAK AWAY |
|  | DESIGNED HGC INFILTRATION DITCH |
|  | EXISTING 300mmØ HDPE DR11 SOLID PIPE |

NOTES:

1. EXISTING GROUND CONTOURS ARE A COMBINATION OF TOPOGRAPHIC SURVEYS
- 2024 OCT 24 AERIAL SURVEY BY CRD
 - CELL 5A CLAY BERM DESIGN BY SHA



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No.	DATE yr/m/day	REVISIONS	DRAWN	CHKD	APP'D

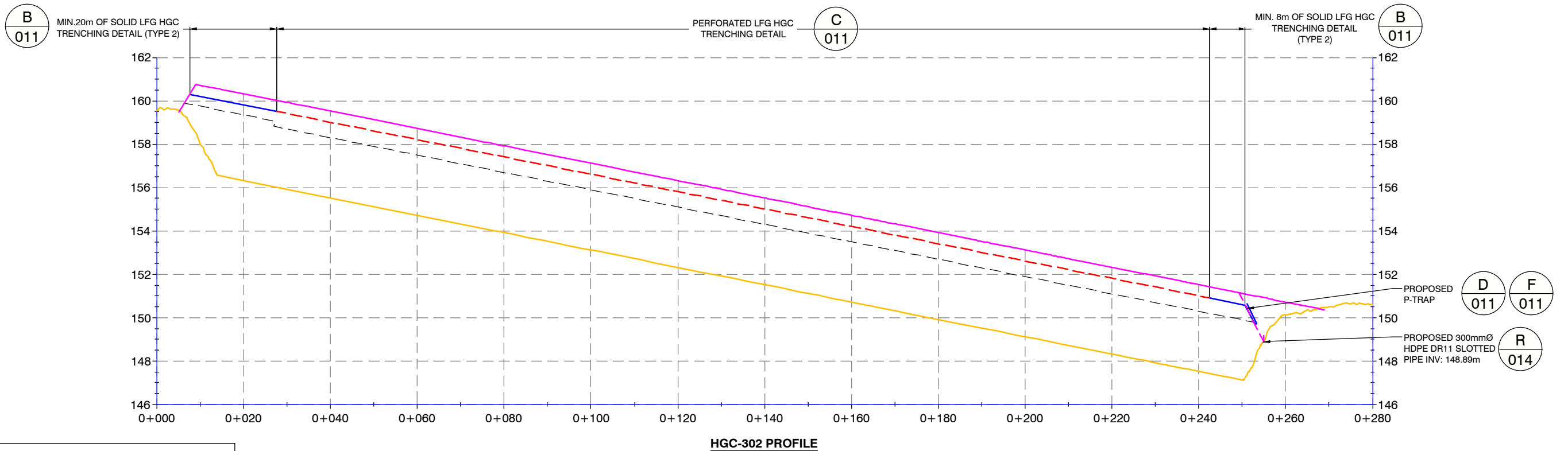
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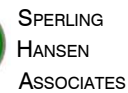
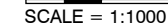
DESIGN BY: AA	SHA PROJECT # PRJ23001	HARTLAND LANDFILL - LFG CELL 4 DETAILED DESIGN		
DRAWN BY: AT	DATE CREATED: 2025/07/16	PROFILE (HGC-203 & HGC-204)		
CHECKED BY: TS	HORIZONTAL SCALE: 1:1000			
APPROVED BY: AA	VERTICAL SCALE: 1:200	DRAWING NO:	REV	SHEET
ADJUST SCALE 50% FOR 34"x22" SHEET		23001-008	A	008



	EXISTING GROUND PROFILE - EG + CELL 4 LIFT 1 - 2
	DESIGNED FILL PROFILE - CELL 4 LIFT 3
	DESIGNED PIPE TRENCHING PROFILE
	DESIGNED 200mmØ HDPE DR11 SOLID PIPE
	DESIGNED 200mmØ HDPE DR11 PERF. PIPE
	DESIGNED SOAK AWAY
	DESIGNED HGC INFILTRATION DITCH
	EXISTING 300mmØ HDPE DR11 SOLID PIPE

1. EXISTING GROUND CONTOURS ARE A COMBINATION OF TOPOGRAPHIC SURVEYS

- 2024 OCT 24 AERIAL SURVEY BY CRD
- CELL 5A CLAY BERM DESIGN BY SHA



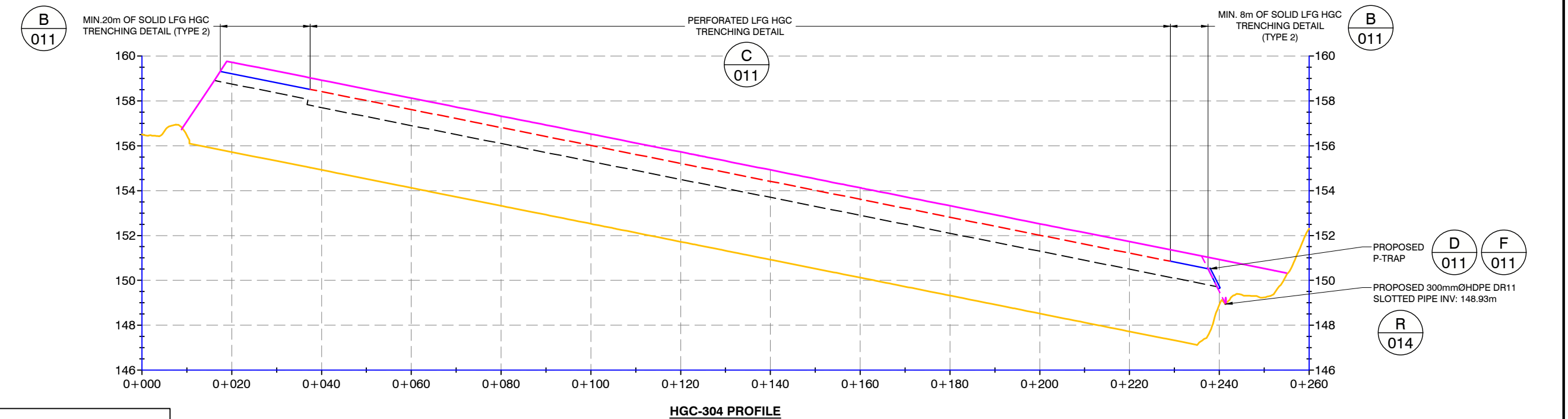
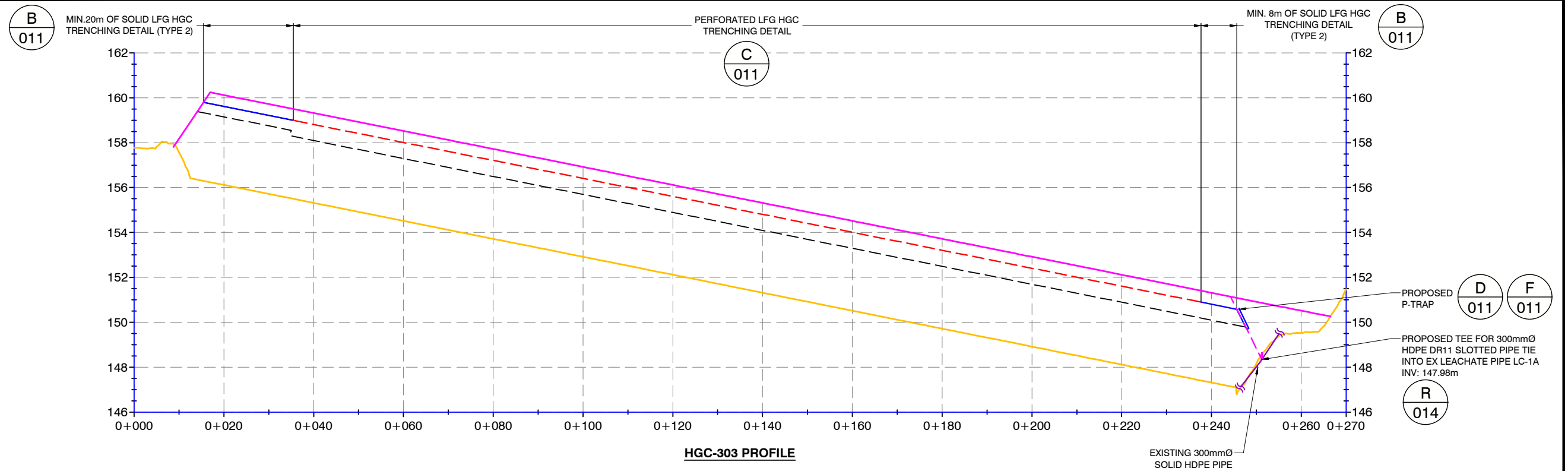
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Phone: (604) 986-7723

A	2025/07/16	ISSUED FOR 50% REVIEW	AT	TS	AA
No.	DATE yr/m/day	REVISIONS	DRAWN	CHKD	APP

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DRAWN BY: AT	DATE CREATED: 2025/07/16	PROFILE (HGC-301 & HGC-302)		
CHECKED BY: TS	HORIZONTAL SCALE: 1:1000			
APPROVED BY: AA	VERTICAL SCALE: 1:200	DRAWING NO:	REV	SHEET
ADJUST SCALE 50% FOR 34"x22" SHEET		23001-009	A	009

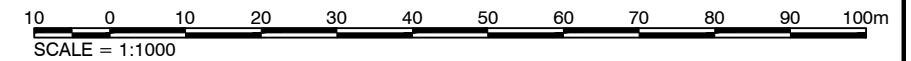


LEGEND:

-  EXISTING GROUND PROFILE - EG + CELL 4 LIFT 1 - 2
 DESIGNED FILL PROFILE - CELL 4 LIFT 3
 DESIGNED PIPE TRENCHING PROFILE
 DESIGNED 150mmØ HDPE DR11 SOLID PIPE
 DESIGNED 200mmØ HDPE DR11 SOLID PIPE
 DESIGNED 200mmØ HDPE DR11 PERF. PIPE
 DESIGNED SOAK AWAY
 DESIGNED HGC INFILTRATION DITCH
 EXISTING 300mmØ HDPE DR11 SOLID PIPE

NOTES:

1. EXISTING GROUND CONTOURS ARE A COMBINATION OF TOPOGRAPHIC SURVEYS
- 2024 OCT 24 AERIAL SURVEY BY CRD
 - CELL 5A CLAY BERM DESIGN BY SHA



SPERLING
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ASSOCIATES

- Landfill Siting
- Design & Operations Plans
- Landfill Closure
- Environmental Monitoring

#8 - 1225 Keith Road East
North Vancouver, B.C. V7J 1J3
Phone: (604) 986-7723

SEAL

A	2025/07/16	ISSUED FOR 50% REVIEW	AT	TS	AA
No.	DATE yr/m/day	REVISIONS	DRAWN	CHK'D	APP'D

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CLIENT:

DESIGN BY: AA	SHA PROJECT # PRJ23001	HARTLAND LANDFILL - LFG CELL 4 DETAILED DESIGN		
DRAWN BY: AT	DATE CREATED: 2025/07/16	PROFILE (HGC-303 & HGC-304)		
CHECKED BY: TS	HORIZONTAL SCALE: 1:1000			
APPROVED BY: AA	VERTICAL SCALE: 1:200	DRAWING NO:	REV	SHEET
ADJUST SCALE 50% FOR 34"x22" SHEET		23001-010	A	010

APPENDIX D

Subsurface Perimeter and Foundation Probe Monitoring

- D1 Subsurface Perimeter and Foundation Probe Monitoring Methodology
- D2 Probe Location and Completion Information
- D3 Hartland Landfill Gas Monitoring Program 2024 Gas Probe Data

Appendix D1 Subsurface Perimeter and Foundation Probe Monitoring Methodology

The following is the subsurface probe and foundation monitoring field methodology, as outlined in *Hartland Landfill Standard Operating Procedures* (2019). All monitoring is completed with a LANDTEC Gas Analyzer and Extraction Monitor (GEM) 2000+.

CALIBRATION

Prior to each monitoring event, the gas analyzer is calibrated using the calibration gases at Hartland. Prior to calibration, the gas monitor is set to Gas Analyzer (GA) mode for ambient measurements.

Methane and carbon dioxide gases are used to calibrate the methane and carbon dioxide sensors, and zero the oxygen sensor. Oxygen gas is used to calibrate the oxygen sensor and zero the methane sensor. All calibration values should be recorded on the field sheet.

MONITORING

Weather conditions, including barometric pressure, precipitation and temperature are recorded prior to commencing work.

The following monitoring procedure is followed for each gas probe:

1. Zero pressure.
2. Connect tubing to the gas sample port (ensure pump is off), open valve, wait until pressure reading stabilizes and record value.
3. Turn on pump and wait at least 200 seconds.
4. Watch for any methane or carbon dioxide spikes.
5. At the end of 200 seconds, record the gas concentrations and any spikes on the field sheet.
6. Quickly navigate to the pressure screen and record the static pressure reading (this helps determine whether the screen is plugged/open, or water is covering the screen).
7. Disconnect the tubing from the sampling port and close the gas monitoring valve.
8. Open the water level monitoring port (not all wells will have a water level monitoring port).
9. Follow the same procedure (steps 1-8) for gas probe B.
10. Once monitoring for probe B is completed measure the water level for probe A, followed by probe B.
11. Before moving to the next station, ensure that all valves are closed.

At the end of the day, check gas levels using the calibration gas and record on the field sheet.

Appendix D2 Probe Location and Completion Information

Probe	Probe Location	Well Information
East Property Boundary Perimeter Probes		
GP-1A	90 m north of main gate	Depth: 10.37 m, Screen height: 2.91 m
GP-1B	90 m north of main gate	Depth: 5.82 m, Screen height: 2.91 m
GP-2A	70 m north of GP-1	Depth: 10.61 m, Screen height: 2.91 m
GP-2B	70 m north of GP-1	Depth: 6.36 m, Screen height: 2.91 m
GP-3A	120 m north of GP-1	Depth: 10.63 m, Screen height: 2.91 m
GP-3B	120 m north of GP-1	Depth: 4.83 m, Screen height: unknown
GP-11A	20 m north of main gate in mountain biking parking lot	Depth: 10.72 m, Screen height: unknown
GP-11B	20 m north of main gate in mountain biking parking lot	Depth: 5.23 m, Screen height: unknown
GP-12A	50 m north of GP-3 along perimeter road	Depth: 9.00 m, Screen height: unknown
GP-12B	50 m north of GP-3 along perimeter road	Depth: 5.72 m, Screen height: unknown
Horizontal Subsurface Building Gas Probes		
GP-4A	Southeast corner of workshop	2.4 m from southeast corner of building in gravel road
GP-5A	Admin building parking lot, behind mountain bike washrooms	3 m along west side of mountain bike washroom building
GP-6A	Northeast corner of admin building	15 m west along north side of building
GP-6B	Northeast corner of admin building	15 m west along north side of building
GP-7A	Against north wall of Hartland admin office	10 m south toward southeast corner of building
GP-7B	Against wall in southwest corner of Hartland admin building	Follows 'H' pattern under building extension
GP-8A	East side of auto-scale building	Unknown
GP-9A	West side of auto-scale building	Unknown
GP-13A	2 m south of Hartland workshop entrance	Unknown
GP-17A	North corner of Hartland Interpretive Centre (monitoring initiated January 2011)	Follows building perimeter
GP-18A	Northwest corner of the contractor's workshop	Follows building perimeter

Appendix D3 Hartland Landfill Gas Monitoring Program 2024 Gas Probe Data

Probe #	Date	Time	Pressure/ Vacuum (before) (P")	Static water level (m)	Exposed screen above water (m)	Methane (CH ₄) % in air	Carbon Dioxide (CO ₂) % in air	Oxygen (O ₂) % in air	Pressure/ Vacuum (after) (P")	Comment
GP-01A	2024-04-09	10:05	0.04	4.14	1.23	0.0	0.1	21.20	-0.03	
GP-01B	2024-04-09	10:10	0.01	4.3	1.39	0.0	3.3	14.40	0.02	
GP-02A	2024-04-09	10:22	0.06	5.87	2.96	0.0	0.1	21.30	-0.02	Pump failed at 192 seconds
GP-02B	2024-04-09	10:24	-0.06	5.52	2.61	0.0	4.1	7.70	-0.01	
GP-03A	2024-04-09	10:32	0.02	10.61	7.7	0.0	1.1	16.60	0.02	
GP-03B	2024-04-09	10:36	-0.03	4.75	1.84	0.0	6.0	15.50	-0.03	
GP-04A	2024-04-09	9:52	0.03	---	---	0.0	1.6	20.00	0.03	
GP-05A	2024-04-09	8:53	-0.01	---	---	0.0	0.1	21.50	-0.01	
GP-06A	2024-04-09	8:42	-0.01	---	---	0.0	1.6	19.60	-0.01	
GP-06B	2024-04-09	8:47	-0.01	---	---	0.0	1.5	19.80	-0.01	
GP-07A	2024-04-09	9:24	-0.02	---	---	0.0	0.6	20.20	-0.02	
GP-07B	2024-04-09	9:14	-0.03	---	---	0.0	0.3	20.70	-0.03	
GP-08A	2024-04-09	9:03	0.02	---	---	0.0	0.2	21.30	0.02	
GP-09A	2024-04-09	9:09	0.02	---	---	0.0	0.2	20.10	0.02	
GP-11A	2024-04-09	9:31	-0.39	4.74	1.83	0.0	0.2	21.00	-15.66	Pressure after reading was taken after zeroing the instrument and re-connecting post sample collection
GP-11B	2024-04-09	9:38	0.02	4.78	1.87	0.0	2.4	18.80	0.02	
GP-12A	2024-04-09	10:46	0.03	8.19	5.28	0.0	0.1	21.50	0.03	
GP-12B	2024-04-09	10:49	0.02	6.53	3.62	0.0	4.8	8.00	0.02	Well blocked at 6.53 m
GP-13A	2024-04-09	9:57	-0.03	---	---	0.0	2.9	17.90	-0.03	
GP-17A	2024-04-09	10:02	0.01	---	---	0.0	0.1	21.20	0.01	
GP-18A	2024-04-09	10:58	-0.18	---	---	0.0	0.2	21.60	0.00	
GP-01A	2024-06-12	11:29	0.01	4.42	1.51	0.0	0.0	21.20	0.01	
GP-01B	2024-06-12	11:35	0.04	4.44	1.53	0.0	0.1	21.20	0.03	
GP-02A	2024-06-12	11:49	0.02	6.13	3.22	0.0	0.0	21.40	0.02	
GP-02B	2024-06-12	11:53	0.00	5.8	2.89	0.0	5.0	6.80	0.00	
GP-03A	2024-06-12	11:40	-0.02	dry	---	0.0	0.0	21.30	-0.02	
GP-03B	2024-06-12	11:44	0.00	4.73	1.82	0.0	8.5	13.60	0.00	
GP-04A	2024-06-12	11:10	0.03	---	---	0.0	1.7	19.70	0.03	

Appendix D3, continued

Probe #	Date	Time	Pressure/ Vacuum (before) (P")	Static water level (m)	Exposed screen above water (m)	Methane (CH ₄) % in air	Carbon Dioxide (CO ₂) % in air	Oxygen (O ₂) % in air	Pressure/ Vacuum (after) (P")	Comment
GP-05A	2024-06-12	10:10	-0.01	---	---	0.0	0.7	20.00	-0.01	
GP-06A	2024-06-12	10:02	-0.01	---	---	0.0	2.4	18.30	-0.02	
GP-06B	2024-06-12	10:05	-0.01	---	---	0.0	2.2	18.10	0.00	
GP-07A	2024-06-12	10:30	0.00	---	---	0.0	0.6	20.20	0.00	
GP-07B	2024-06-12	10:25	0.03	---	---	0.0	0.2	20.80	0.02	
GP-08A	2024-06-12	10:15	-0.01	---	---	0.0	0.4	20.30	-0.01	
GP-09A	2024-06-12	10:18	0.03	---	---	0.0	0.3	20.50	0.03	
GP-11A	2024-06-12	10:35	0.03	5.02	2.11	0.0	0.2	21.20	0.04	
GP-11B	2024-06-12	10:40	0.00	5	2.09	0.0	0.1	21.20	0.00	
GP-12A	2024-06-12	11:55	0.03	10.13	7.22	0.0	0.5	18.60	0.03	
GP-12B	2024-06-12	11:58	0.00	dry	---	0.0	0.1	21.40	0.00	Well blocked at 6.53 m?
GP-13A	2024-06-12	11:15	-0.02	---	---	0.0	5.4	16.80	-0.02	
GP-17A	2024-06-12	11:20	0.00	---	---	0.0	0.2	21.10	0.00	
GP-18A	2024-06-12	12:05	0.00	---	---	0.0	0.4	20.80	0.00	
GP-01A	2024-09-24	9:26	0.40	5.1	2.19	0.0	0.1	20.30	-23.84	P" after GEM disconnected = -4.91
GP-01B	2024-09-24	9:30	-0.03	4.91	2	0.0	3.6	16.80	-0.03	
GP-02A	2024-09-24	9:36	0.09	7.85	4.94	0.0	0.2	20.30	-54.35	P" after GEM disconnected = -0.01
GP-02B	2024-09-24	9:40	0.01	6.08	3.17	0.0	6.3	13.80	0.01	
GP-03A	2024-09-24	12:03	0.02	-10.66	-13.57	0.0	2.0	12.90	-0.88	Dry @ 10.66
GP-03B	2024-09-24	12:07	0.01	4.75	1.84	0.0	2.4	18.90	-0.03	Wet at bottom of well
GP-04A	2024-09-24	11:27	0.10	---	---	0.0	2.1	18.10	0.08	
GP-05A	2024-09-24	10:02	-0.01	---	---	0.0	1.2	19.90	0.00	
GP-06A	2024-09-24	9:53	-0.01	---	---	0.0	2.4	18.20	-0.02	
GP-06B	2024-09-24	9:57	0.02	---	---	0.0	2.0	18.50	-0.01	
GP-07A	2024-09-24	10:20	-0.04	---	---	0.0	0.5	20.10	-0.01	
GP-07B	2024-09-24	10:16	-0.01	---	---	0.0	0.2	20.40	-0.01	
GP-08A	2024-09-24	10:07	-0.47	---	---	0.0	0.3	20.70	-0.03	
GP-09A	2024-09-24	10:11	0.01	---	---	0.0	0.3	20.50	-0.03	
GP-11A	2024-09-24	10:30	0.29	6.55	3.64	0.0	0.2	20.80	-96.80	Vacuum stopped at approx. 160 seconds
GP-11B	2024-09-24	10:36	0.01	5.66	2.75	0.0	2.7	17.80	0.00	
GP-12A	2024-09-24	12:18	0.00	10.67	7.76	0.0	4.9	7.60	-0.08	O ₂ decreasing, CO ₂ increasing with time

Appendix D3, continued

Probe #	Date	Time	Pressure/ Vacuum (before) (P")	Static water level (m)	Exposed screen above water (m)	Methane (CH ₄) % in air	Carbon Dioxide (CO ₂) % in air	Oxygen (O ₂) % in air	Pressure/ Vacuum (after) (P")	Comment
GP-12B	2024-09-24	12:23	0.03	-6.52	-9.43	0.0	9.3	12.20	0.01	Dry @ 6.52
GP-13A	2024-09-24	11:50	0.04	---	---	0.0	4.6	15.90	0.01	
GP-17A	2024-09-24	11:38	0.00	---	---	0.0	0.2	20.90	-0.07	
GP-18A	2024-09-24	12:33	0.04	---	---	0.0	0.2	20.80	0.00	
GP-01A	2024-12-05	12:11	0.00	3.87	0.96	0.0	0.1	20.40	-2.22	
GP-01B	2024-12-05	12:14	0.01	4.14	1.23	0.0	4.6	11.30	0.00	
GP-02A	2024-12-05	10:43	0.03	5.61	2.7	0.0	0.1	21.30	0.02	
GP-02B	2024-12-05	10:37	0.02	5.36	2.45	0.0	5.4	10.20	0.00	
GP-03A	2024-12-05	10:26	0.01	9.51	6.6	0.0	0.3	20.30	-0.01	
GP-03B	2024-12-05	10:22	0.03	4.73	1.82	0.0	9.0	11.20	-0.01	
GP-04A	2024-12-05	11:02	0.05	---	---	0.0	4.3	14.90	-0.01	
GP-05A	2024-12-05	9:21	-0.01	---	---	0.0	0.9	20.10	-0.01	
GP-06A	2024-12-05	9:11	0.02	---	---	0.0	1.7	19.00	0.00	
GP-06B	2024-12-05	9:15	-0.02	---	---	0.0	2.2	18.60	0.00	
GP-07A	2024-12-05	9:41	0.02	---	---	0.0	0.6	20.70	0.00	
GP-07B	2024-12-05	9:38	0.06	---	---	0.0	0.3	20.90	0.01	
GP-08A	2024-12-05	9:30	-0.01	---	---	0.0	0.2	20.90	0.02	
GP-09A	2024-12-05	9:33	0.01	---	---	0.0	0.2	21.00	0.01	
GP-11A	2024-12-05	11:18	0.03	4.45	1.54	0.0	0.2	21.20	-9.57	
GP-11B	2024-12-05	11:16	0.02	4.61	1.7	0.0	3.0	17.60	-0.01	
GP-12A	2024-12-05	10:08	-0.01	7.25	4.34	0.0	10.8	3.00	0.00	O ₂ decreasing, as CO ₂ increasing. Stable at time of reading 200 seconds
GP-12B	2024-12-05	10:13	-0.01	6.06	3.15	0.0	0.7	20.40	-1.56	
GP-13A	2024-12-05	10:53	-0.09	---	---	0.0	3.5	17.70	0.03	
GP-17A	2024-12-05	11:08	-0.01	---	---	0.0	0.2	21.30	0.02	
GP-18A	2024-12-05	11:52	0.01	---	---	0.0	0.4	20.30	0.01	

APPENDIX E

Grid and Hot Spot Monitoring

- E1 Grid and Hot Spot Monitoring Methodology
- E2 2024 Grid and Z Point Monitoring Data

Appendix E1 Grid and Hot Spot Monitoring Methodology

The following is the grid sampling field methodology, as outlined in *Hartland Landfill Standard Operating Procedures* (2012).

Monitoring usually takes two full days, beginning at 0730 hours and ending between 1600 and 1630. Prior to each monitoring day, the gas analyzer must be calibrated using the calibration gases at Hartland. At the beginning of each field day, the fuel cell for the Flame Ionization Detector (FID) is filled with hydrogen gas and the unit is warmed up for at least 30 minutes before calibration. Calibration is conducted with two methane span gases (currently 500 ppm and 14,990 ppm methane), and a zero gas to generate a proper calibration slope. After successful calibration, as span check is completed and recorded on the calibration sheet. In addition, the Jerome sensor is regenerated at the beginning and end of each day to remove any residual hydrogen sulphide on the gold sensor.

The Jerome analyzer is factory calibrated and, therefore, does not require field calibration. After regeneration, the instrument is turned on for 30 minutes before zeroing. Once it is zeroed, the zero filter is attached to the unit and a sample is taken.

MONITORING

There is an established walking pattern over the grid points, and it denotes two distinct monitoring areas (Phase 1 and Phase 2/Active Face). These areas are monitored separately, due to the distinct differences in gas concentrations, level of landfilling activity, and placement of litter fences. This results in acquisition of data from a similar area under similar environmental conditions, as monitoring typically takes two days. In each area, the grid points are traversed alphabetically (e.g., B1, B2, B3, B4, etc.) where physically possible. In some cases, litter fences, controlled waste trenches or active filling areas limit or restrict access resulting in deviation from the standard protocol. These deviations should be recorded on the field sheet.

Weather conditions dictate when this monitoring can be completed. The FID cannot operate in rainy conditions and monitoring should be delayed until two consecutive days of dry weather are predicted. In addition, high to moderate winds blow gases away from their origin and dilute gas concentrations. These conditions are not representative of typical landfill conditions and monitoring does not take place on these days.

The following procedure is used to collect methane and H₂S readings at each grid point:

1. Place the hydrogen sulphide (H₂S) analyzer on the ground then press the “Sample” button.
2. The second staff person should place the FID intake controller 4 inches from the ground surface for 30 seconds.
3. Once the H₂S analyzer has reported a value (approximately 30 seconds), the methane value should be read from the FID and both values recorded on the field sheet.
4. The FID is programmed to alarm if methane levels exceed 100 ppm. If the alarm sounds while walking a traverse, staff must investigate the area for the source of elevated methane by means of a detailed 10-by-10 meter (m) grid. The 10-by-10 m grid should be traversed between all adjacent grid points. Obvious sources of methane include bird poles or a seam/edge of a temporary closure lining.
5. Once the source has been identified, record the source description, methane and H₂S values, as well as the location coordinates. This data represents a “hot spot” (>1,000 ppm of methane) or “Z-spot” (>12,500 ppm of methane), identified on figures 5 and 6 as a red, or purple, ‘X’, respectively.
6. If an obvious source cannot be identified, the location and data/observations from the highest localized reading should be recorded.
7. Continue with this method until all grid points, background stations, and pre-existing Z-spots have been monitored. Pre-existing Z-spots can be removed from the monitoring list if methane levels are below 1,000 ppm for three consecutive monitoring events.
8. At the end of each field day, a span check is completed on the FID and recorded on the field sheet.

Appendix E2 2024 Grid and Z Point Monitoring Data

Table 1. Hartland Landfill VOC & TRS Grid Data

July 2024		
Waypoint	Methane (ppm)	H2S
BACK-1	0	0.000
BACK-10	0	0.000
BACK-11	0	0.000
BACK-12	0	0.000
BACK-13	0	0.000
BACK-20	0	0.000
BACK-21	0	0.000
BACK-6	0	0.000
BACK-7	0	0.000
B1	0	0.000
B2	0	0.000
B3	0	0.000
B4	0	0.000
B5	0	0.000
B6	0	0.000
B7	0	0.000
B8	0	0.000
B9	0	0.000
B10	0	0.000
C1	0	0.000
C2	0	0.000
C3	0	0.000
C4	0	0.000
C5	0	0.000
C6	0	0.000
C7	0	0.000
C8	1	0.000
C9	0	0.000
C10	3	0.000
C11	3	0.000
D1	0	0.000
D2	0	0.000
D3	0	0.000
D4	0	0.000
D5	0	0.000
D6	0	0.000
D7	0	0.000
D8	0	0.000
D9	3	0.000
D10	3	0.000
D11	3	0.000
E1	0	0.000
E2	0	0.000
E3	0	0.000
E4	0	0.000
E5	0	0.000
E6	0	0.000
E7	1	0.000

Appendix E2
Table 1, continued

July 2024		
Waypoint	Methane (ppm)	H2S
E8	1	0.000
E9	2	0.000
E10	3	0.000
E11	0	0.000
F1	0	0.000
F2	0	0.000
F3	0	0.000
F4	0	0.000
F5	0	0.000
F6	0	0.000
F7	0	0.002
F8	0	0.005
F9	0	0.003
F10	2	0.095
F11	7	0.007
F12	5	0.000
G1	0	0.000
G2	0	0.000
G3	0	0.000
G4	0	0.000
G5	0	0.000
G6	0	0.000
G7	0	0.000
G8	0	0.000
G9	2	0.000
G10	1	0.000
G11	---	---
G12	11	0.000
G13	1	0.000
G14	0	0.000
G15	0	0.000
H1	0	0.000
H2	0	0.000
H3	0	0.000
H4	0	0.000
H5	0	0.000
H6	0	0.000
H7	0	0.000
H8	1	0.000
H9	9	0.000
H10	8	0.000
H11	2	0.000
H12	10	0.000
H13	3	0.000
I1	0	0.000
I2	0	0.000
I3	0	0.000
I4	0	0.000
I5	0	0.000
I6	0	0.000
I7	0	0.000

Appendix E2
Table 1, continued

July 2024		
Waypoint	Methane (ppm)	H2S
I8	0	0.000
I9	0	0.000
I10	4	0.000
I11	3	0.000
I12	1	17.330
I13	0	0.000
I14	0	0.000
I15	0	0.000
J1	0	0.000
J2	0	0.000
J3	0	0.000
J4	0	0.000
J5	0	0.000
J6	0	0.000
J7	0	0.000
J8	1	0.000
J9	3	0.000
K1	0	0.000
K2	0	0.000
K3	0	0.000
K4	0	0.000
K5	0	0.000
K6	0	0.000
K7	0	0.000
K8	0	0.000
K9	0	0.000
K10	1	0.000
K11	0	0.000
K12	0	0.000
K13	0	0.000
K14	3	0.000
K15	0	0.003
L1	0	0.000
L2	0	0.000
L3	0	0.000
L4	0	0.000
L5	0	0.000
L6	0	0.000
L7	0	0.000
L8	0	0.000
L9	0	0.000
L10	0	0.000
L11	0	0.000
L12	0	0.000
L13	0	0.000
L14	0	0.000
M1	0	0.000
M2	0	0.000
M3	0	0.000
M4	0	0.000
M5	0	0.000

Appendix E2
Table 1, continued

July 2024		
Waypoint	Methane (ppm)	H2S
M6	0	0.000
M7	0	0.000
M8	0	0.000
M9	0	0.000
M10	0	0.000
M11	0	0.000
M12	---	---
M13	---	---
M14	---	---
N1	0	0.000
N2	0	0.000
N3	0	0.000
N4	0	0.000
N5	0	0.000
N6	0	0.000
N7	0	0.000
N8	0	0.000
N9	0	0.000
N10	0	0.000
N11	---	---
N12	---	---
N13	---	---
P1	0	0.000
P2	0	0.000
P3	0	0.000
P4	0	0.000
Z88	---	---
Z94	---	---
Z100	20	0.000
Z106	---	---
Z118	---	---
Z122	500	0.00732
Z123	---	---
Z124	1000	0.00369
Z125	959	0.000
Z126	300	0
Z127	2.6	0.000
Z128	136	0.04443
Z129	---	---
Z130	---	---
Z131	---	---
Z132	---	---
Z133	0.3	0.000
Z134	0.2	0
Z135	---	---
Z136	---	---

Appendix E2, continued

Table 2. Hartland Landfill VOC from Walkabout

Waypoint	Methane (ppm)	Comments
Z100	20	Hole in tarp beside black pipe, approximately 20 feet downhill of gas well
Z119	0	4 holes along LFG pipe
Z124	1,000	Concrete box with metal hatch by road
Z125	959	Concrete box with metal hatch by road, adjacent to Z124, slightly south
Z126	300	Concrete box with metal hatch by road, uphill of Z125
Z127	3	Metal culvert parallel to road, flowing downhill into Toutle Valley
Z128	136	Inside casing of groundwater well 90-2-1 (90-1-1 reading: 1.3 ppm methane, 0.150 ppm H ₂ S in 2023)
Z133	0	Buried 2023
Z134	0	Flange on black pipe at top of slope