C&P Environmental Ltd

Giants Grave Landfill Site

Annual Environmental Monitoring Report 2022

Environmental Permit SP3298FT

Prepared for: Neath Port Talbot Waste Management Company Ltd

The Quays
Brunel Way
Baglan Energy Park
Neath
SA11 2GG

By: C & P Environmental Limited

31st March 2023

CP4259-SP3298FT-2022

C & P Environmental Limited
Directors: Andy Childs
2 Willmers Close, Bedford, Bedfordshire, MK41 8DX
Tel: 07774-423276
andy.childs@candpenvironmental.co.uk

Registered Office: 2 Willmers Close, Bedford, Bedfordshire, MK41 8DX. Registered in England & Wales No. 5361265.

EXECUTIVE SUMMARY

C&P Environmental Ltd has been commissioned by Neath Port Talbot County Borough Council (NPTCBC) to produce an Annual Environmental Monitoring Report for Giants Grave Landfill Site in accordance with the environmental permit EPR/SP3298FT and section 8 of the Landfill Aftercare Plan[1]. This Annual Environmental Monitoring Report summarises the monitoring data recorded at the Giants Grave Landfill Site between 1st January and 31st December 2022.

The following key points have been observed during 2022:

Leachate Monitoring

For leachate levels, the compliance limits that were changed from September 2020 have been used in this annual monitoring report. For 2022 the compliance leachate level was breached on four occasions: LW8 (February and December) and LW15 (September and October). These are the same wells for which exceedances were recorded in 2021.

For leachate quality, the overall mean concentration for parameters measured quarterly in 2022 (ammoniacal nitrogen, chloride and potassium) across all wells continued a falling trend year on year. No rising trends for ammoniacal nitrogen noted in any wells.

There were no breaches of the compliance levels for the Discharge Flap Valve in 2022 (following a single breach for copper in 2021). The concentrations of each of the other measured parameters within the effluent discharged via the Discharge Flap Valve are well within the compliance limits as stated within the Discharge Consent Number BP0236201.

The calculated flows of water over the Vee Notch Weir in 2022 are lower than those in 2021 and 2020 but within the range measured over the last four years. Although there was some unreliable data from March that has been removed for this overall flow rate calculation.

Groundwater Monitoring

Although the groundwater levels continue to fluctuate, the groundwater level data generally shows the highest levels in early 2022, with lowest levels in the summer and then an upward trend towards the end of 2022.

For groundwater quality, three of the eight boreholes exceeded either the trigger level or control level for ammoniacal nitrogen during 2022: BH9B, BH43B and BH45B. Of these BH9B recorded elevated ammoniacal nitrogen above the trigger level on one occasion and BH45B on six occasions.

Other than a gradual rising trend in BH8 year on year (when detections of ammoniacal nitrogen occur in the summer/autumn months), there were no adverse trends noted for ammoniacal nitrogen, chloride or potassium concentrations.

[1] Giants Grave Closed Landfill Site - Landfill Aftercare Plan (Version v3.1, September 2013) as accepted by NRW in November 2013

The biannual hazardous substances analysis recorded a rising trend in arsenic in BH9B and zinc in BH15, but lower mean concentrations for chromium across many locations.

Surface Water Monitoring

For the River Neath there were no exceedances of the trigger (compliance) level during 2022. The control levels were exceeded once upstream and once downstream in the same month. The ammoniacal nitrogen results in the River Neath suggest that the potential contamination is arising from upstream of the River North monitoring location.

There were no exceedances of the control of trigger levels for Canal North as the upstream monitoring location. However, for Canal South the trigger level was exceeded on one occasion (November 2022 at a significantly elevated 4mg/l), with the trigger level also exceeded in December 2022 at a value of 0.34mg/l. This is the first exceedance of either level since April 2021 at Canal South. In general, the data shows that the downstream sample tends to record slightly higher ammoniacal nitrogen concentrations, which may suggest some impact from the landfill.

Perimeter Gas Monitoring

There were no breaches of a permit compliance limit for methane in 2022 from the permitter gas monitoring locations. The data suggests no adverse methane trends in the perimeter gas locations.

There were several locations that recorded an exceedance of the carbon dioxide action level on one or more occasions in 2022. These were: BH4, BH5 and BH8 (western boundary); and BH40B (eastern boundary). No adverse trends in carbon dioxide appear to be present.

Elevated methane concentrations continue to be monitored along the canal tow path on the Eastern boundary (boreholes BH40B, BH43B and BH45B), although the data remains consistent with recent years.

Surface Emissions Monitoring

For the surface emissions survey in 2022 (undertaken early 2023) there were several surface areas recording elevated methane emissions plus three discrete leachate wells (LW1, LW2 and LW4).

Monitoring and Reporting Recommendations

A full description and list of recommendations is provided at the end of each section. The more significant recommendations for the different monitoring programmes are provided below.

Leachate

The monitoring point LW17 was unable to be monitored since 2017 due to damage within the leachate well. As the proposed leachate levels have been accepted during 2020 (and include LW17 as one of the six wells) then LW17 should undergo repair.

Groundwater

There are no specific recommendations for actions for the groundwater monitoring at Giants Grave.

Section 3.5.1 provides details of those boreholes where the control and trigger (C&T) levels for groundwater quality do not necessarily provide an appropriate early warning, although this report does not suggest any current action to amend these.

Surface water

There are no specific recommendations for actions for the surface water monitoring at Giants Grave.

Perimeter Gas

There are no specific recommendations for actions for the perimeter gas.

A recommendation retained from previous reports and to be considered during the next Landfill Aftercare Plan review:

> It is recommended that the revised action levels and compliance limits for borehole BH1B are more appropriate for ongoing monitoring and to determine any significant change in gas quality. Similarly, several locations seem to show a change in gas quality (specifically carbon dioxide) and the action levels should be considered for these to make sure they are fit for purpose. This would include the locations BH4, BH5 and BH8. The proposed methane action and compliance levels for BH3W would continue to be recommended for inclusion in the next revision to the Landfill Aftercare Plan.

Surface Emissions Monitoring

Due to the discrete surface emissions locations (and discrete aspects of the gas infrastructure) actions should be implemented to first understand the locations of these elevated surface emissions and determine whether any obvious fissures and cracks present. Remediation of these locations should then be implemented to try and minimise such methane emissions.

The three leachate wells should be remediated to try and prevent any significant methane emissions.

Further recommendations from the surface emissions survey:

- It is recommended that the surface emissions survey is completed in the summer to autumn months of the year.

It is to be noted that some locations of the survey were inaccessible due to areas of dense vegetation, particularly on the southern and western slopes. It is recommended to ensure access to as much of the site as possible prior to the next surface emissions survey.

Contents

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1 Introduction

C&P Environmental Ltd has been commissioned by Neath Port Talbot County Borough Council (NPTCBC) to develop an Annual Environmental Monitoring Report for Giants Grave landfill site in accordance with the requirement of the environmental permit EPR/SP3298FT and Section 8 of the Landfill Aftercare Plan.

In November 2013, NRW accepted the Closure Report (which included the Landfill Aftercare Plan) and confirmed that the site at Giants Grave is now definitively closed and is now in Aftercare. The Landfill Aftercare Plan now supersedes Section 7 of the Working Plan (the environmental monitoring requirements).

In addition, NRW issued an environmental permit (EPR/SP3298FT) in July 2015. This permit incorporates the environmental monitoring requirements.

The analysis and monitoring regime for the site was revised in June 2017 for the leachate, groundwater and surface water monitoring. In September 2020 the compliance limits for the leachate levels were revised following acceptance of the hydrogeological risk assessment and compliance limits for several groundwater parameters (chloride, arsenic, mercury and phenol) were removed.

This report makes reference to the environmental permit, the Landfill Aftercare Plan and the revised monitoring schedule for the monitoring requirements.

The routine monitoring was undertaken by Natural UK Ltd from April 2012 to March 2018. Since April 2018 the routine environmental monitoring has been undertaken by NPTCBC. The annual reporting has been undertaken by C&P Environmental since December 2012.

This Annual Environmental Monitoring Report covers the period of 1st January to 31st December 2022. This report includes the following information:

- Tabular and graphical summaries of key leachate, groundwater, surface water and perimeter gas monitoring results.
- A summary assessment of leachate, groundwater, surface water and perimeter gas monitoring results, including comparison to compliance limits where they exist and determination of any significant trends.
- Recommendations for changes and improvements to the monitoring programme going forward.
- Discussion of historical and previous monitoring data reviews to enable the site monitoring data to be put into perspective.

1.1 Site Location and Description

Giants Grave Landfill Site is located approximately 2.5km southwest of Neath, at NGR 733 957 (see Site Location Plan, Drawing B1404900/EP/APR2010/01). The site encompasses a total of sixty-five hectares and is bounded to the west by the River Neath, to the north by the main line railway embankment and to the east by the Neath Canal.

The Giants Grave Landfill Site was issued with a Waste Disposal Licence by Neath Borough Council on 1st April 1993, for the disposal of municipal waste to landfill. Subsequently, the Waste Disposal Licence was superseded by a Waste Management Licence (WML), Number EAWML 34060. It was considered that the in-situ permeability of the underlying ground was sufficiently low to act as a containment seal. As such, there are no records of more formal engineered lining or containment, and the landfill is considered a 'dilute and disperse landfill'. Giants Grave Landfill Site ceased accepting waste during July 2003 and subsequently the operational status of the landfill progressed from an operational landfill to a closed landfill. In September 2003, the site was progressively capped and restored with a landfill gas extraction system installed in April 2004.

In May 2005, a Pollution Prevention and Control Permit (HP3535PS) was issued by the Environment Agency (EA) for a new landfill sited directly adjacent to the existing closed landfill. No waste material was accepted under this permit and the permit was surrendered during 2018.

1.2 Site Development and Maintenance During 2022

C & P Environmental are not aware of, or been informed of, any significant site development or maintenance during 2022.

1.3 Report Structure

The remainder of this report is structured as follows:

Section 2: Leachate Monitoring:

Sets out details of the leachate monitoring infrastructure and locations; Permit requirements; compliance with the site discharge consent; and an assessment of leachate monitoring data obtained during 2022.

Section 3: Groundwater Monitoring:

Sets out details of the groundwater monitoring infrastructure and locations; Permit requirements; and an assessment of groundwater monitoring data obtained during 2022.

Section 4: Surface Water Monitoring:

Sets out details of the surface water monitoring infrastructure and locations; Permit requirements; and an assessment of surface water monitoring data obtained during 2022.

Section 5: Landfill Gas Monitoring:

Sets out details of the perimeter gas and in-waste monitoring infrastructure and locations; Permit requirements; and an assessment of gas monitoring data obtained during 2022.

2 Leachate Monitoring

This section provides a summary of the leachate level and quality monitoring at Giants Grave for 2021 in addition to the water quality at the Discharge Flap Valve as required by Schedule 3, Tables 3.2 and 3.3 of the environmental permit EPR/SP3298FT and Appendix A2 of the Landfill Aftercare Plan.

A new monitoring regime was agreed with NRW from June 2017 onwards. For leachate monitoring the primary changes is a reduction to the frequency of monitoring (although no reduction in the monthly monitoring requirement for the discharge flap valve).

From September 2020 the compliance limits for leachate levels were revised following acceptance by NRW of the 2016 hydrogeological risk assessment.

2.1 Leachate Monitoring Locations

Leachate monitoring points are situated throughout the existing waste mass at Giants Grave Landfill Site.

Previously (and until May 2017) a total of 6 leachate wells were required to be monitored although further leachate wells installed during the closure and aftercare period are also required to be monitored. Additional wells may also be monitored as substitutes when wells are dry. From June 2017 onwards, leachate level monitoring has been undertaken at all leachate monitoring and extraction wells.

The sampling and analysis monitoring regime for leachate was reduced from June 2017 onwards and this is reflected in Table 2B. Compliance levels for leachate levels are now in place for 6 dedicated leachate wells.

The locations of the leachate wells, Vee Notch Weir and Discharge Flap Valve monitoring points are shown on the sampling location plan in Appendix E.

2.2 Leachate Monitoring Requirements

Tables 2A and 2B identify the leachate wells that will be monitored, the type of monitoring and the frequency of the monitoring.

Table 2A - Leachate Level Monitoring Schedule (June 2017 onwards)

Monitoring Point	Parameter	Monitoring Frequency
All leachate monitoring and extraction wells This includes Leachate Wells (LW): 1, 3, 5, 8, 9, 15, 16, 17 & 18 *and A1301, A1302, A1303, A1304 and A1305CV*	Level / Dip	Monthly
	Base Level	Monthly

Leachate well LW17 currently damaged and unable to be monitored.

Table 2B – Leachate Quality Monitoring Schedule (June 2017 onwards)

Monitoring Point	Parameter	Monitoring Frequency
Leachate Wells (LW): 3, 5, 8, 9, 15, 16, 17 and *A1301, A1302, A1303, A1304 and A1305CV*	pH, Temperature, Electrical Conductivity, Ammoniacal Nitrogen, chloride, potassium	Quarterly
	Chemical Oxygen Demand, Biological Oxygen Demand, Nickel, Sulphate, Alkalinity, Total Organic Carbon, Sodium, Calcium, Magnesium, Iron, Manganese, Cadmium, Chromium, Copper, Lead, Zinc & Arsenic	Annually
	Hazardous substances	Every four years

The above schedule was followed (where samples were able to be obtained) including annual hazardous substances suite in October. The four yearly hazardous substances suite was completed on samples in October 2021 and so not due again until 2025.

Table 2C specifies the required flow monitoring at the Vee Notch Weir. This flow monitoring was previously undertaken through the recording of a single water depth at the Vee Notch Weir each month. Following discussions with NRW there was an option for using a calculated flow (on a 15-minute basis) from the automated telemetry set up at the site. Although there is some potentially unreliable flow data, this is considered to provide more reliable and relevant data overall.

Table 2C – Leachate Flow Monitoring Schedule

Monitoring Point	Parameter	Monitoring Frequency
Vee Notch Weir	Flow measurement	Monthly

Table 2D identifies the monitoring required at the Discharge Flap Valve and the compliance limits for each parameter.

Table 2D – Discharge Flap Valve Leachate Level Monitoring Schedule

Parameter	Compliance Level	Monitoring Frequency
Ammoniacal Nitrogen (mg/l)	190	Monthly
Nickel (µg/l)	90	
Copper (µg/l)	85	
Zinc (µg/l)	376	
Lead (µg/l)	40	
Chromium (µg/l)	40	
Cadmium (µg/l)	3	
Arsenic (µg/l)	130	
Iron (µg/l)	40,000	

2.3 Leachate Control and Trigger Levels

Control and trigger levels, along with observed trends from control and trigger charts, provide a warning to the site operator that a problem may be occurring. They can be used to spot adverse trends in the monitoring data, or changes because of natural variations in the background water quality. Control levels are intended to provide an early warning indicator for when the landfill is beginning to deviate from its design performance so that corrective or remedial measures can be implemented before a trigger level is exceeded.

For leachate levels a trigger level of 1m above cell basal liner is stated in the environmental permit (unless otherwise agreed in writing with Natural Resources Wales). Well specific levels were developed using statistical assessment of previous data and, from these, several well leachate compliance levels were proposed to NRW in April 2019[2]. The wells selected attempt to provide a geographical coverage of the site and are detailed in Table 2E. Following agreement by NRW these well specific revised leachate levels were applicable from September 2020.

Table 2E - Leachate Compliance Levels

Monitoring Point	From September 2020 - Leachate Level Above Base (m)
LW5	1.6
LW8	1.0
LW15	2.1
LW17 *	1.0
A1302	3.0
A1305CV	2.8
Any additional wells installed after April 2019	1.0

**Note - LW17 not able to be monitored currently due to damage within the well head.*

There are no control or trigger levels set for the quality of the leachate.

Compliance levels are set for several parameters at the Discharge Flap Valve as specified in Table 2D.

2.4 Leachate Monitoring Results and Data Assessment

2.4.1 Leachate Level Monitoring

Leachate level data is obtained by measuring the well base and the height of the leachate head within the well during each monitoring visit. The data is shown in depth above the well base and is not directly indicative of the overall leachate head in metres, as the actual depth to the bottom of the waste mass is unknown.

[2] Addendum to the Hydrogeological Risk Assessment Review 2016, Neath Port Talbot Waste Management Co Ltd, 30th April 2019.

A summary table of the leachate level data obtained during 2022 is given in Table 2F. All leachate monitoring data is provided in Appendix A.

Table 2F – Summary of Leachate Levels

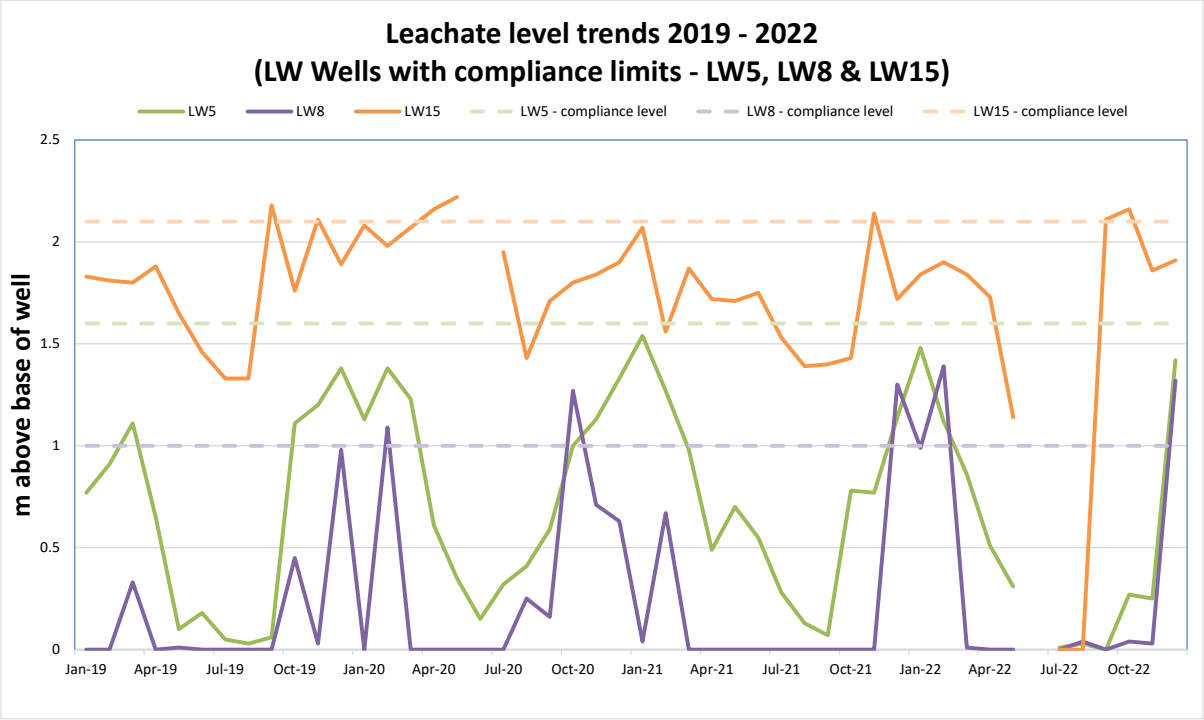
Monitoring Point	Minimum Leachate Level Above Base (m)	Maximum Leachate Level Above Base (m)	Comment
LW1	Dry	1.17	Low leachate levels January to May (no results in June) Leachate present July then dry August and September. Leachate present October & November with December showing 1.17m.
LW3	0.29	1.61	Peak leachate level in December with next highest in November. No results in June. Fluctuating for the remainder of the year.
LW5	Dry	1.48	Leachate >1m in January and February and again December with all levels between March and November <1.0m. Dry in September. No results in June.
LW8	Dry	1.39	Dry April to July & September (no results in June), with low leachate levels March, August, October & November. Highest recorded at 1.39m in February and 1.32m in December – both exceed the compliance level of 1.0m.
LW9	Dry	0.23	Dry throughout April to September. No results in June.
LW15	Dry	2.16	Leachate level typically between 1.1m and 1.9m, although two readings above 2m – September at 2.11m and October at 2.16m that marginally exceed the compliance level of 2.1m. Dry July & August and no results in June.
LW16	0.15	1.35	Highest readings in early and late 2022 with >1m across January to March and December. No results in June.
LW17	-	-	Damage within the leachate well – not able to be monitored during 2022
LW18	0.36	1.57	Highest readings >1m in February to April and December. No results in January & June.
A1301[2]	1.71	9.27	Leachate levels typically between 1.7m and 2.5m. July at 3.79m. The highest leachate in December at 9.27m, although this was questioned. No results in June.
A1302	1.66	2.44	Highest readings >2m in January to May and again in December.
A1303[1]	dry	2.17	Difficulty in reading well base levels in several months including December 2021. Well base continues to be read in 2022 as 5m shallower than previous years – see comment below). Dry in May and no results in June.
A1304	1.09	2.13	Highest leachate levels in January to March and December. No results in June. Lowest leachate levels in July to November.
A1305CV	1.23	2.67	Highest readings >2m in January to April and December. Lowest readings in July. No results in June.

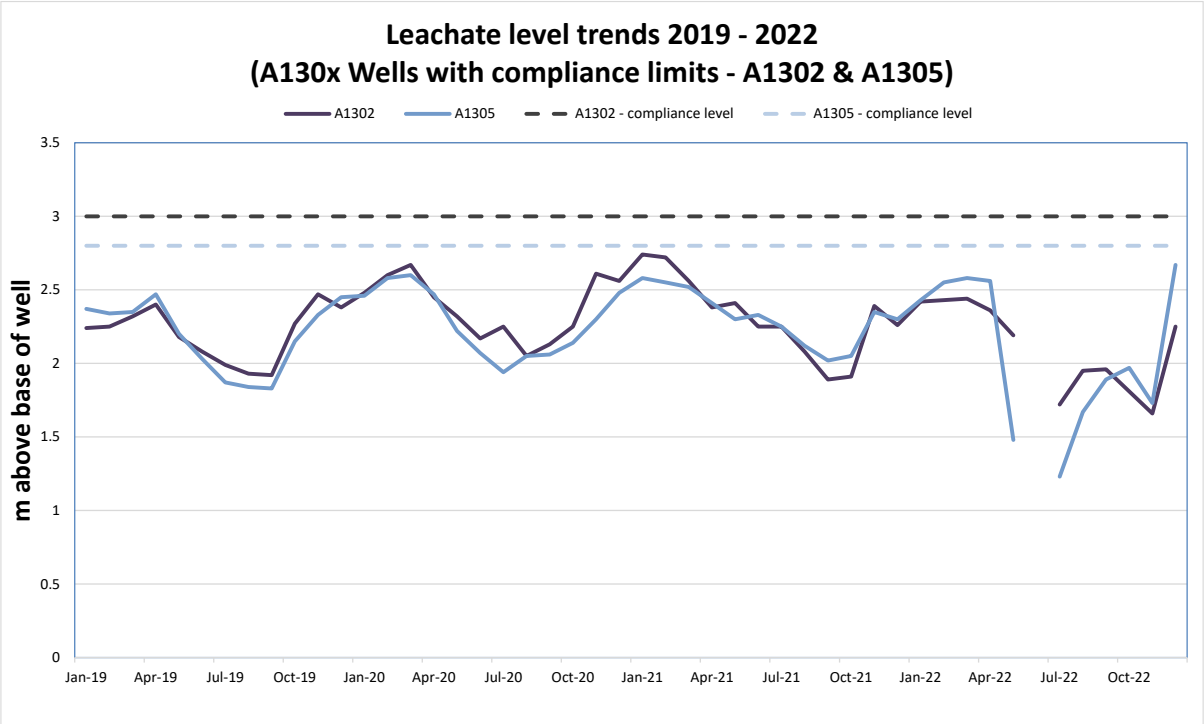
Note – the wells in bold are those with a leachate compliance level agreed from September 2020 onwards.

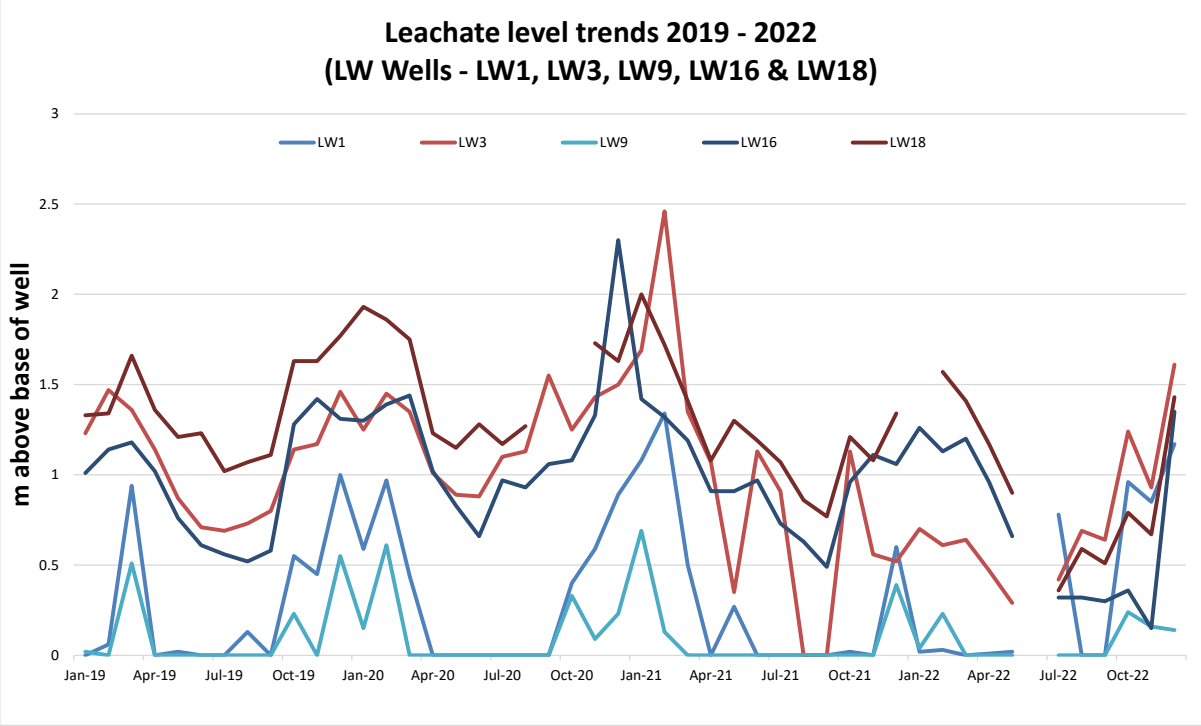
[1] A1303 results have been calculated using a well base figure of approximately 11.13mbTOC. This figure has been recorded since December 2021 and continued throughout 2022 – but compares with all other readings of approximately 16.84mbTOC prior to December 2021. All these readings have been included in the graphical representation below.

[2] A1301 result from December is significantly different to the rest of the year due to a leachate level depth of 10.42mbTOC. This compares to typical readings of approximately 17m and 18mbTOC over recent years. This data has been retained in the Table above but removed from graphical analysis below.

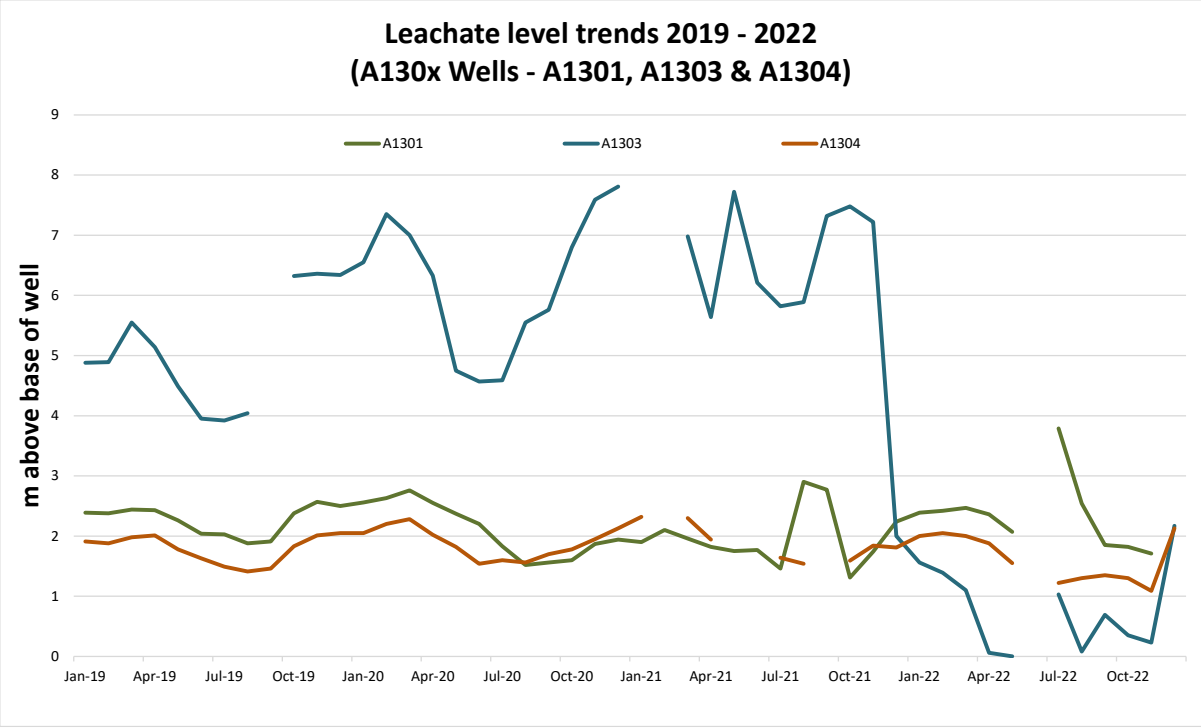
Graphs of the leachate levels are provided below (and reproduced again in Appendix A).







Two readings from LW18 in September and October 2020 (4.13m and 4.31m) have not been included in the graph above. Other gaps are due to not being able to take a reading (such as no access to location).



A leachate level of 9.27m in December 2022 for A1301 not included in the graph above. A leachate level of 4.7m in September 2021 for A1304 not included in the graph above. Other gaps are due to not being able to take a reading (such as no access to location).

Direct comparison of the leachate level above the base of each well against the revised compliance levels (from September 2020) for selected boreholes can be seen in Table 2G.

Table 2G - Summary of Leachate Trigger level exceedance

	Leachate Levels (m above base of well)												Leachate compliance level (from September 2020 onwards)
Leachate well	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	
LW1	0.02	0.03	0	0.01	0.02		0.78	dry	dry	0.96	0.85	1.17	
LW3	0.7	0.61	0.64	0.47	0.29		0.42	0.69	0.64	1.24	0.93	1.61	
LW5	1.48	1.12	0.86	0.51	0.31		0.01	0.03	dry	0.27	0.25	1.42	1.6
LW8	0.99	1.39	0.01	dry	dry		dry	0.04	dry	0.04	0.03	1.32	1
LW9	0.04	0.23	0	dry	dry		dry	dry	dry	0.24	0.16	0.14	
LW15	1.84	1.9	1.84	1.73	1.14		dry	dry	2.11	2.16	1.86	1.91	2.1
LW16	1.26	1.13	1.2	0.96	0.66		0.32	0.32	0.3	0.36	0.15	1.35	
LW18		1.57	1.41	1.17	0.9		0.36	0.59	0.51	0.79	0.67	1.43	
A1301	2.39	2.42	2.47	2.36	2.07		3.79	2.54	1.85	1.82	1.71	9.27	
A1302	2.42	2.43	2.44	2.36	2.19		1.72	1.95	1.96	1.81	1.66	2.25	3
A1303	1.56	1.39	1.1	0.06	dry		1.03	0.08	0.69	0.35	0.23	2.17	
A1304	2	2.05	2	1.88	1.55		1.22	1.3	1.35	1.3	1.09	2.13	
A1305	2.43	2.55	2.58	2.56	1.48		1.23	1.67	1.89	1.97	1.73	2.67	2.8

Empty cells signifies unable to be monitored

Yellow highlighted cells are leachate levels removed from previous graphs due to being potentially erroneous

Red text indicates exceedence of the (selected) well specific leachate level threshold (From September 2020)

Note - one of the proposed leachate levels was for LW17, although this was unable to be monitored in 2022 due to damage and so not included in the above table.

In summary:

- The exceedances of the revised compliance levels in 2022 was for the following:
    - LW8 in February at 1.39m and December at 1.32m compared with compliance level of 1.0m (above well base). This compares to a single exceedance in 2021 (December at 1.30m).
    - LW15 in September and October at 2.11m and 2.16m respectively compared with compliance level of 2.1m (above well base). This compares to a single exceedance in 2021 (November at 2.14m).

The following trends and comments can be noted from the leachate level monitoring:

- Most of the leachate wells show a standard pattern for leachate levels with the higher levels early and late in the year with lower levels during the summer months.
- The exceptions to the above were:
    - A1301 which recorded the highest leachate levels in July and August (not including the uncertain data from December).
    - LW3 which recorded much higher levels from October than early in the year.
    - LW1 which recorded low leachate levels until July and then higher levels from October (after dry months of August and September)
- Monitoring point LW17 was unable to be monitored since 2017 due to damage within the leachate well. As the revised leachate compliance limits have now been agreed (and included LW17) then LW17 should undergo repair.

2.4.2 Leachate Quality Monitoring

a) Leachate Wells

The frequency of testing on the leachate (including samples analysed at the laboratory) is quarterly. The on-site field monitoring for pH, conductivity and temperature was completed in January and April, although only temperature for July and October due to ongoing issues with the monitoring probes. It has been organised that samples from January 2023 onwards will include conductivity and pH as part of the laboratory analysis.

Quarterly monitoring data

The range of data for the key contaminants from quarterly monitoring of leachate wells is summarised in Table 2H.

Table 2H - Summary of Components from Quarterly Leachate Monitoring

Parameter	Unit	Minimum	Maximum	Mean 2022	Mean 2021	Mean 2020
pH	-	6.37	7.35	-	-	-
Temperature	°C	8.57	27.67	-	-	-
Conductivity	µS	732	5103	-	-	-
Ammoniacal Nitrogen (N)	mg/l	0.26	400	143	191	201
Chloride	mg/l	12	770	209	224	251
Potassium (diss.filt)	mg/l	9.4	300	124	136	137

Note - The calculated means were taken from the four quarterly monitoring results. In total there were 29 results for ammoniacal nitrogen, 30 results for chloride, and 30 results for potassium and across 11 separate wells.

Samples not able to be taken in the following locations due to dry wells; or insufficient sample able to be obtained; or unable to retrieve sample: LW5 (Jul); LW8 (Jan, Apr & Oct); LW9 (all); LW16 (Oct) A1301 (Jan & Oct); A1302 (Jan & Oct); A1303(Jan, Apr, Jul); A1304 (Jan); A1305CV (Jan)

No pH, conductivity or temperature for LW3 (Jul & Oct), LW8 (all), LW9 (all); LW15 (Jul & Oct); LW16 (Jul & Oct); A1302 (Jul); no pH or conductivity A1303 (Oct); A1304 (Jul & Oct); A1305CV (Jul & Oct)

From the quarterly leachate quality monitoring the following observations can be made:

- For 2022 the quarterly monitoring requirement for leachate sampling and analysis has been complied with (where samples were able to be taken), although the on-site monitoring in July and October did not include pH or conductivity.
- The mean for ammoniacal nitrogen across all samples for 2022 shows a continuing falling trend from the mean calculated in recent years. This falling trend has continued since 2018.
- The ammoniacal nitrogen concentrations between the samples taken from most wells was relatively consistent (within the same order of magnitude) other than for:
    - LW3 - range from 2.6mg/l to 33mg/l across the four samples taken.
    - LW5 - range from 0.26mg/l to 32mg/l across the four samples taken.

  - There were no wells indicating a rising trend throughout 2022 for ammoniacal nitrogen with most wells recording a fluctuating pattern, although some locations recorded a significantly higher mean concentration in 2022 compared with 2021 (see Table 2I):
    - LW3 (3 samples), LW8 (1), LW18 (4) and A1301 (2) – although across all wells the overall ammoniacal mean has fallen.

- The highest concentrations of ammoniacal nitrogen continue to be recorded in the A130x wells, with A1301 being the highest at up to 400mg/l. Typically A1303 also records elevated ammoniacal nitrogen compared with other wells, although no samples possible in 2022. The mean concentrations for each well are detailed in Table 2I.
- The mean chloride and potassium concentrations in 2022 also show a fall from the concentrations for 2020 and 2021.
- The results across the individual wells generally recorded a range in concentrations for chloride and potassium within an order of magnitude. However, the following locations show the most variance:
  - LW5 records a range of more than an order of magnitude difference for both chloride (range from 12mg/l to 220mg/l) and potassium (range from 9.4mg/l to 160mg/l).
- The pH across the wells is typically within the range pH 6.4 to 7.4, which remains similar to recent years.

Table 2I – Summary of Ammoniacal Nitrogen, Chloride and Potassium in Leachate

Monitoring Point	Number of Samples (for NH_3-N)	Ammoniacal Nitrogen mean (mg/l)		Chloride mean (mg/l)		Potassium mean (mg/l)	
		2022	2021	2022	2021	2022	2021
LW3	3	15.9	2.9	36.8	22.7	17.5	23.7
LW5	3	1.2	0.8	82	8.2	60.8	10.7
LW8	1	82	2.5	12	13	9.9	13
LW15	4	197.5	152.5	267.5	195	175	140
LW16	3	230	335	400	500	253.3	257.5
LW18	4	58.5	17.6	21.3	11.5	16.5	11.4
A1301	2	370	295	630	490	280	235
A1302	2	210	235	180	182.5	125	127.3
A1303	1	Insufficient sample	333.3	190	323.3	Insufficient sample	148
A1304	3	176.7	190	132	160	99.7	120
A1305CV	3	200	337.5	436.7	447.5	236.7	247.5

The mean ammoniacal nitrogen and chloride across the LWx wells is consistent with a leachate from an aged waste mass, although the results from the 2013 A130x installed leachate wells continue to record higher concentrations.

Annual monitoring data

The leachate samples taken in October 2022 were analysed for a range of hazardous substances in addition to the routine quarterly parameters. The four yearly hazardous substances suite was completed on samples in October 2021 and so not due again until 2025.

For information the parameters included in the annual monitoring are:

> Chemical Oxygen Demand, Biological Oxygen Demand, Nickel, Sulphate, Alkalinity, Total Organic Carbon, Sodium, Calcium, Magnesium, Iron, Manganese, Cadmium, Chromium, Copper, Lead, Zinc & Arsenic

Overall, six samples of leachate were analysed for the full annual suite (LW3, LW5, LW15, LW18, A1304 & A1305CV). One further sample (A1303) was analysed only for alkalinity, COD and BOD due to insufficient sample. This analysis was not completed in 2021 and so Table 2J provides a summary of the 2022 data only.

Table 2J – Summary of Components from annual leachate analysis suite

Parameter	Unit	Minimum	Maximum	Mean across samples 2022	Comments
Alkalinity expressed as CaCO3	mg/l	320	3000	1308.57	Maximum of 3000mg/l in A1305CV
As (Dissolved)	µg/l	1.12	6.54	3.39	LW18 & A1305CV both >5µg/l
Biochemical Oxygen Demand	mg/l	9.4	66	27.34	Max BOD of 66mg/l in LW15
Cd (Dissolved)	µg/l	<0.02	0.65	0.14	LW5 had max Cd of 0.65µg/l
Calcium	mg/l	170	400	248.33	Max of 400mg/l in LW5
Chemical Oxygen Demand	mg/l	120	4500	1378.57	COD of 4500mg/l in LW18. LW5 & A1303 >1000mg/l
Cr (Dissolved)	µg/l	1.2	3.7	2.13	Max of 3.7 µg/l in A1305CV
Cu (Dissolved)	µg/l	<0.5	12	3.56	Max of 12 µg/l in LW5
Iron	mg/l	0.036	0.26	0.14	A1304 & A1305CV had 0.25 mg/l & 0.26mg/l respectively
Pb (Dissolved)	µg/l	<0.2	2.1	0.75	Max of 2.1 µg/l in LW18
Magnesium	mg/l	24	150	66.17	A1305CV had max of 150mg/l
Mn (Dissolved)	µg/l	290	3300	1145	Maximum of 3300 µg/l in LW3
Ni (Dissolved)	µg/l	5.3	310	92.97	Max of 310 µg/l in LW5
Sodium	mg/l	18	550	166.17	A1305CV had 550mg/l
Sulphate	mg/l	16.8	613	209.78	Maximum 613mg/l in LW5
Total Organic Carbon	mg/l	9.73	93.8	32.61	Max TOC in A1305CV
Zn (Dissolved)	µg/l	3	1500	287.58	1500 µg/l in LW5, next highest was LW3 at 110 µg/l

NOTE [1] – When compiling summary statistics (e.g. mean values), where a parameter has not been detected at a concentration greater than the detection limit, the detection limit has been used in the calculations.

b) Discharge Flap Valve

A summary of the data collected from the consented discharge quality monitoring point at the Discharge Flap Valve during 2022 is given in Table 2K. Compliance levels for leachate quality are only specified for samples taken from the consented discharge monitoring point. Further detailed data for the Discharge Flap Valve are presented within Appendix A.

Table 2K - Summary of Leachate Quality Data from the Discharge Flap Valve

Parameter		Compliance Level	Minimum	Maximum	2022 Mean[1]	2021 Mean[1]
Ammoniacal Nitrogen as N	mg/l	190	<0.015	21	2.17	1.98
Arsenic	µg/l	130	1.13	75	11.78	17
Cadmium	µg/l	3	0.02	0.08	0.04	0.04
Chromium	µg/l	40	<0.2	6.1	1.51	5.3
Copper	µg/l	85	<0.7	7.7	4.43	35.5
Iron	mg/l	40	0.011	0.07	0.03	0.1
Lead	µg/l	40	<0.2	0.3	0.2	0.2
Nickel	µg/l	130	2.3	10	4.6	7.3
Zinc	µg/l	376	1.2	9.9	5.3	9.8

NOTE [1] - When compiling summary statistics (e.g. mean values), where a parameter has not been detected at a concentration greater than the detection limit, the detection limit has been used in the calculations.

No results for discharge flap in June 2022.

The concentrations in red indicate a breach of the compliance limit.

There were no breaches of the discharge consent for the discharge from the flap valve in 2022. This follows a single breach of the copper compliance level in August 2021 at 150µg/l compared with the 85µg/l limit.

The copper concentrations have recorded much lower concentrations throughout 2022 resulting in a mean concentration an order of magnitude lower than in 2021.

The analysis of samples collected throughout 2022 has shown that the concentrations of all of the measured parameters within the effluent discharged are well within the compliance limits as stated within the Discharge Consent Number BP0236201 (as reproduced in the Landfill Aftercare Plan).

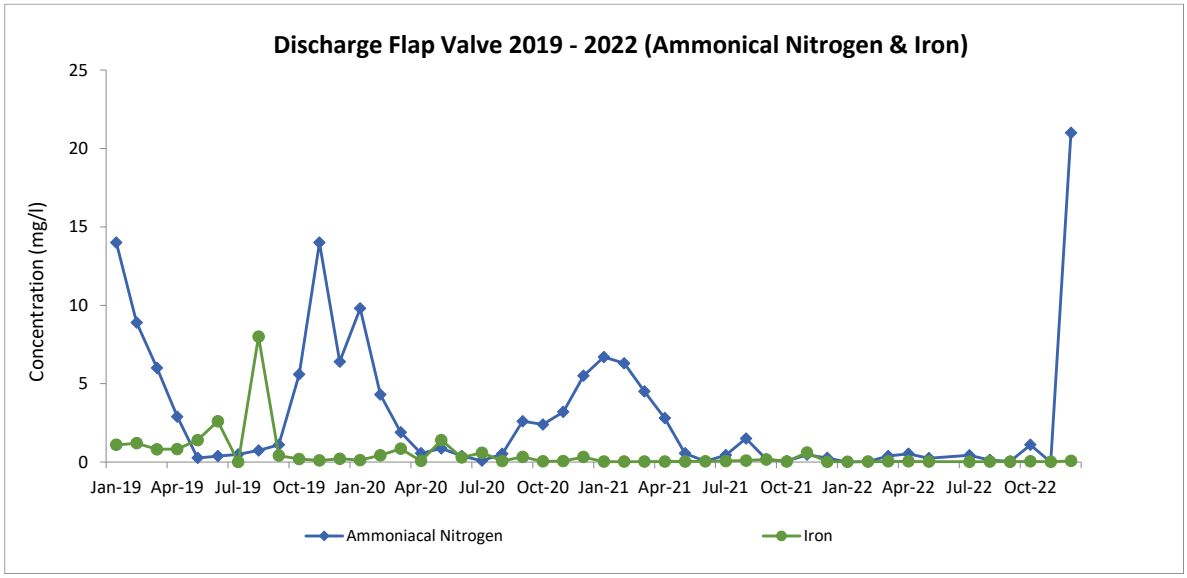
The majority of parameters also have recorded a similar or lower mean concentration in 2022 compared with the results from 2021. The parameters recording a more significant range in concentrations are:

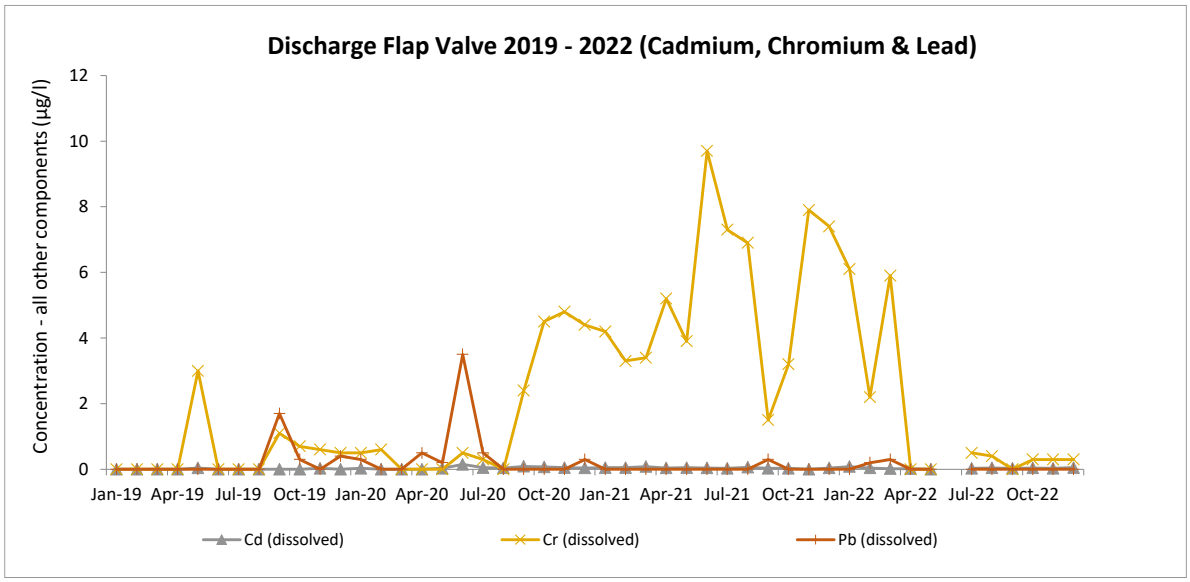
- Ammoniacal nitrogen – Low concentrations throughout 2022 but an elevated result in December at 21mg/l (compared to next highest of 1.1mg/l in October). Ammoniacal nitrogen has previously shown a seasonal trend previously with higher concentrations during the winter months.

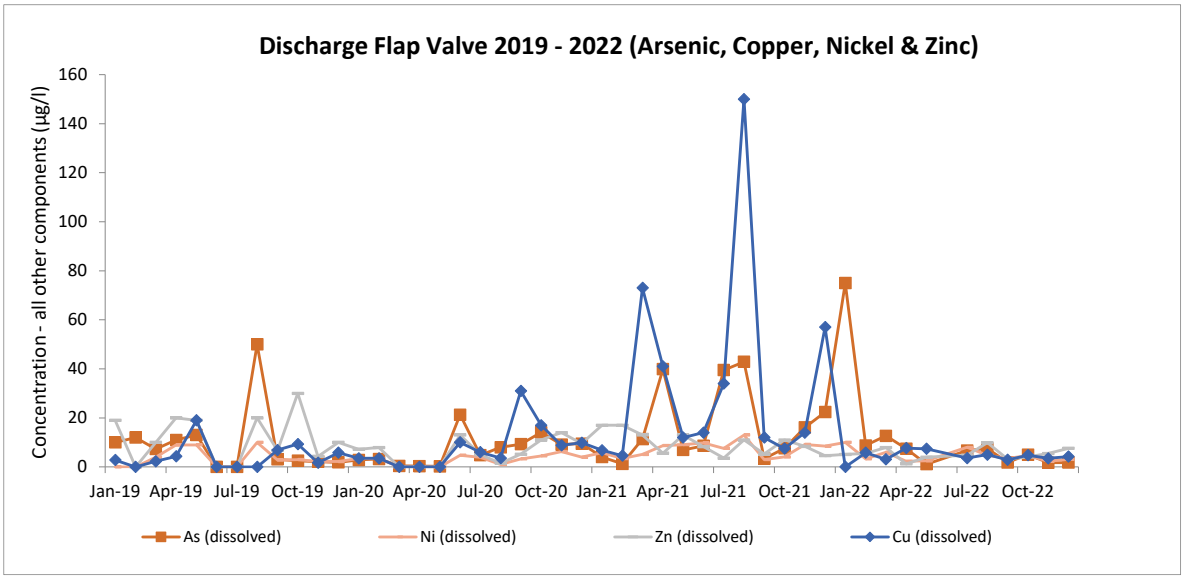
- Chromium – Detected levels between 2µg/l and 10µg/l since the end of 2020 until March 2022 but <1µg/l for the remainder of 2022.
- Arsenic – recorded a spike in January at 75µg/l but highest of 12.7µg/l for the remainder of 2022.

The mean concentration of all parameters is below 10% of their respective compliance limit in 2021 and no parameter closely approaches the compliance limit.

The graphs below provide visual trends since January 2019.







2.4.3 Leachate Flow Monitoring

Leachate flow data was obtained from the Vee Notch Weir during 2022 as summarised in Table 2L. The value recorded represents a calculated flow from the continuous level monitor connected to a data logger used by NRW to provide flow data for the site.

The data provided was on a 15-minute time period for each reading and provided in m^3/s. This data has been used to calculate averaged flow rate for the month (in m^3/day) for comparison to the data from previous years.

NRW provide the following important details regarding the use of the data:

> *The operational range of the thinplate weir located at this site is 0.0m to 0.26m stage (0.0 m^3/s to 0.046 m^3/s). Recorded level values outside this range will not generate reliable flows.*
>
> *The site is also significantly influenced by water level changes resulting from tidal cycles. Data recorded at the site suggests that moderately high tidal peaks can result in a variable backwater effect through the thinplate weir. Water level data recorded during periods of tidal influence should be treated as suspect, as should the calculated flow for such periods.*

The following table states the proportion (%) of readings in that month that are above the reliable range and the maximum flows recorded to provide an indication of the appropriateness of the data.

Table 2L – Summary of Flow Monitoring Data (Vee Notch Weir)

Month of Monitoring	Averaged Flow in 2022 (m^3/day)	Maximum flow rate reading (m^3/s)	Proportion (%) of readings greater than 0.046m^3/s (or no readings)	Averaged Flow in 2021 (m^3/day)	Averaged Flow in 2020 (m^3/day)
Jan-22	1282	0.38	4.1	4136	-
Feb-22	2623	0.93	14.8	1834	-
Mar-22*	29426 (947 if suspect data removed)	2.19 (0.19 if suspect data removed)	28.0 (total of 1.9% if suspect data removed)	769	3279
Apr-22	277	0.02	0.0	389	664
May-22	154	0.01	0.0	1580	227
Jun-22	89	0.01	0.0	193	177
Jul-22	45	0.00	0.0	263	345
Aug-22	89	0.01	0.0	246	1431
Sep-22	155	0.02	0.0	268	345
Oct-22	446	0.05	0.0	3298	2828
Nov-22	3280	0.55	18.4	800	1138
Dec-22	1965	0.52	8.5	1928	3642

*The instrumentation seemed to fail during March (between 9th and 23rd) with many readings extremely high compared to others. The data stated 'Suspect data. Erratic trace with periods of flatlining data caused by issue with instrumentation'. These readings have been included in the above summary but removed from the overall review of the flow data.

A daily flow rate (based on the 15-minute flow measurements) during 2022 was on average 932m^3/day. This compares to a mean of 1314 m^3/day in 2021, 1429 m^3/day in 2020, 953m^3/day in 2019 and 1486m^3/day in 2018.

The flow rate calculated for 2022 may underestimate the flow rate for March due to the removal of the unreliable data. However, the flow rate calculation for the year may be overestimated as all data (however far above the reliable range) has been included in this calculation. However, it is worth noting that there were no readings in the months of April through to October that exceeded the upper reliable flow calculation.

Overall, the reliability of the data-logged measurements would likely be significantly better than the single month readings that were used prior to 2018.

Specific rainfall data for the site has not been provided or reviewed for this annual report.

2.5 Summary and Recommendations for Leachate Monitoring Programme

The monitoring of the leachate wells has complied with the permit and Landfill Aftercare requirements other than the monitoring was not completed in June (leachate levels and Discharge Flap Valve). Note - the on-site monitoring in July and October did not include pH or conductivity (and this is now being organised as part of the laboratory analysis).

For leachate levels, there were two exceedances of the compliance limits for both LW8 (February and December) and LW15 (September and October).

For leachate quality the mean concentration for parameters measured quarterly in 2022 (ammoniacal nitrogen, chloride and potassium) were either similar or often lower than the 2021 data – other than for the wells LW3, LW8, LW18 and A1301 where higher mean concentrations were recorded in 2022. No specific rising trend noted across the wells and, overall, the mean ammoniacal nitrogen, chloride and potassium concentrations across all the wells continues to show a falling trend.

The mean ammoniacal nitrogen and chloride across the LWx wells continues to be lower than those from the 2013 installed A130x wells.

There were no breaches of the compliance levels for the Discharge Flap Valve in 2022 (following a single breach for copper in 2021). The concentrations of each of the other measured parameters within the effluent discharged via the Discharge Flap Valve are well within the compliance limits as stated within the Discharge Consent Number BP0236201.

The calculated flows of water over the Vee Notch Weir in 2022 are lower than those in 2021 and 2020 but within the range measured over the last four years. Although there is some unreliable data from March that has been removed for this overall flow rate calculation.

3 Groundwater Monitoring

This section provides a summary of the groundwater monitoring at Giants Grave for 2022 as required by Schedule 3, Tables 3.4 and 3.5 of the environmental permit EPR/SP3298FT and Appendix A3 of the Landfill Aftercare Plan.

A new monitoring regime was agreed with NRW from June 2017 onwards. For groundwater monitoring the primary changes was a reduction to the frequency of monitoring for groundwater quality.

Following a revision to the hydrogeological risk assessment the compliance limits for the parameters, arsenic, mercury and phenol have been removed from the permit (from September 2020).

3.1 Groundwater Monitoring Locations

Groundwater quality monitoring is undertaken from a total of eight boreholes from around the site including two from within each of the western and southern extension areas. The monitoring locations are as shown on the sampling location plan in Appendix E.

Groundwater level monitoring is also monitored from a further seven boreholes: BH3W, BH5B and BH7B (north); BH4, BH6, BH7 (west); and BH40B (east).

Groundwater quality was monitored from four boreholes to the north and east of the capped and restored area of the site. These boreholes are located as follows:

- Borehole BH9B is located on the northern boundary of the site, north of the Northern Leachate Drain; and
- Boreholes BH1B, BH45B and BH43B are situated along the eastern boundary adjacent to the canal from the north-eastern tip of the site (BH1B) proceeding south west along the eastern boundary (BH45B and BH43B).

The monitoring from within the Western Extension Area comprises boreholes BH5 and BH8 which run along the eastern boundary of the western extension. Both boreholes are located at the bottom of the west bund of the Cut (in which the reed bed system is located).

The monitoring from within the Southern Extension Area comprises boreholes BH12 and BH15. These boreholes are located as follows:

- Borehole BH12 is located towards the middle of the Southern Extension Area; and
- Borehole BH15 is located at the bottom of the river bund on the western edge of the Southern Extension Area.

3.2 Groundwater Monitoring Requirements

Tables 3A and 3B identify the groundwater wells that will be monitored, the type of monitoring and the frequency of the monitoring.

Table 3A - Groundwater Level Monitoring Schedule (June 2017 onwards)

Monitoring Point	Parameter	Monitoring Frequency
North: BH9B East: BH43B, BH1B, BH45B South: BH12, BH15 West: BH5, BH8 *Note – additional boreholes are also required to be monitored from June 2017: BH3W, BH5B and BH7B (north); BH4, BH6, BH7 (west); and BH40B (east)*	Water Level	Monthly

Table 3B - Groundwater Quality Monitoring Schedule (June 2017 onwards)

Monitoring Point	Parameter	Monitoring Frequency
North: BH9B East: BH43B, BH1B, BH45B South: BH12, BH15 West: BH5, BH8	pH, Temperature, Electrical Conductivity, Ammoniacal Nitrogen, Chloride, Potassium	Monthly
	Mercury, Chemical Oxygen Demand, Biological Oxygen Demand, Nickel, Chloride, Sulphate, Alkalinity, Total Organic Carbon, Sodium, Calcium, Magnesium, Iron, Manganese, Cadmium, Chromium, Copper, Lead, Zinc & Arsenic	6-monthly
	Hazardous substances	Every two years

The above quality monthly monitoring schedule was followed throughout 2022 (where monitoring was possible and where samples were able to be taken). Monitoring in April and October was completed for the 6-monthly monitoring (although no samples were able to be obtained from borehole BH43B in April). The full 2-yearly hazardous substances suite will be due in 2023.

3.3 Groundwater Control and Trigger Levels

Control and trigger levels, along with observed trends from control and trigger charts, provide a warning to the site operator that a problem may be occurring. They can be used to spot adverse trends in the monitoring data, or changes because of natural variations in the background water quality. Control levels are intended to provide an early warning indicator for when the landfill is beginning to deviate from its design performance so that corrective or remedial measures can be implemented before a trigger level is exceeded.

From September 2020, the only permit compliance levels are for ammoniacal nitrogen.

The current trigger and control levels for ammoniacal nitrogen date back to 2010 and so, as part of this annual review, the levels will be considered for revision to determine whether they remain fit for purpose (to provide the early warning). The potential for revision is discussed further in section 3.5.1.

Table 3C - Groundwater Control and Trigger Levels

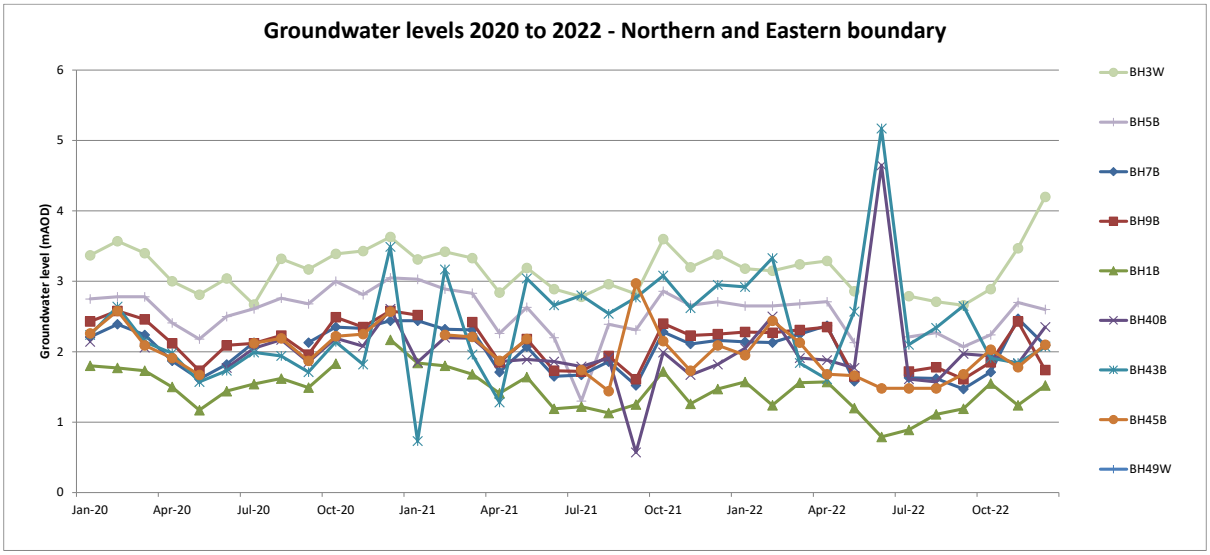
Parameter	Borehole	Permit compliance (Trigger) Level	Landfill Aftercare Plan Action (Control) Level
Ammoniacal Nitrogen (mg/l)	BH1B	3.1	2
	BH5	23.3	15.5
	BH8	88.6	59.1
	BH9B	1.6	1
	BH12	2.5	1.6
	BH15	2.3	1.5
	BH43B	108.9	72.6
	BH45B	59.5	39.7

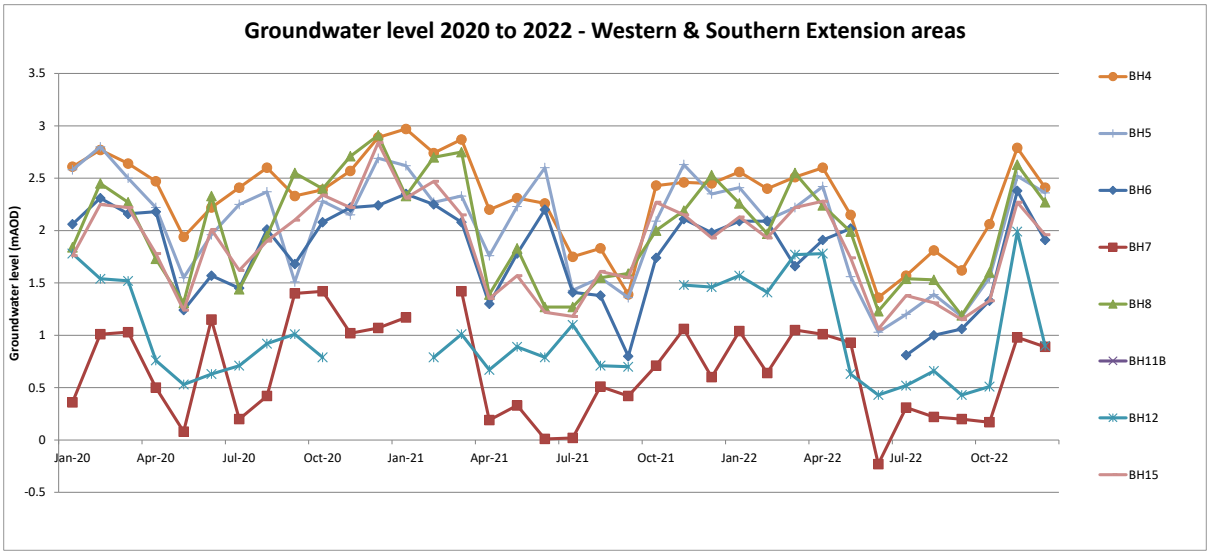
3.4 Groundwater Monitoring Results and Data Assessment

3.4.1 Groundwater Level Monitoring

Groundwater level monitoring has been carried out monthly during 2022 in accordance with the Landfill Aftercare Plan. The data obtained during 2022 is presented in Appendix B. A summary of the groundwater levels is set out in Table 3D.

Although groundwater level monitoring records typical an expected variations there remains some boreholes that seem to be difficult to measure accurately leading to highly variable groundwater levels – this includes BH40B and BH43B. To illustrate, graphs of the groundwater depth above AOD are provided below.





Note - for consistency the well depth and top of casing for 2017 have been used to calculate the levels for subsequent years including the 2022 levels. These mAOD depths have been used for many years to report the groundwater level data and were provided to C&P when compiling the first annual report in 2013.

The graphs above show some considerable changes to groundwater levels across 2022. Some water level or borehole depth level data has been questioned throughout the year to check for accuracy prior to the quarterly monitoring submissions although all the data has been included in the graphs and the table below.

Table 3D - Summary of Groundwater Level Monitoring

Borehole	Well Base (mAOD)	Top of casing (mAOD)	Minimum Groundwater Level (mAOD)	Maximum Groundwater Level (mAOD)	Difference in groundwater levels (max-min) (m)
Northern boundary					
BH3W	-1.40	6.51	2.66	4.2	1.54
BH5B	-3.91	7.36	2.07	2.71	0.64
BH7B	-4.39	6.87	1.47	2.47	1.00
BH9B	-3.06	7.42	1.61	2.43	0.82
Eastern boundary					
BH1B	-2.76	5.76	0.79	1.57	0.78
BH40B	-0.55	6.43	1.57	4.65	3.08
BH43B	-1.56	6.59	1.61	5.17	3.56
BH45B	-3.08	6.37	1.48	2.44	0.96
Western extension					
BH4	0.31	3.32	1.36	2.79	1.43
BH5	-0.51	3.27	1.03	2.52	1.49
BH6	-0.42	3.45	0.81	2.38	1.57
BH7	-1.58	3.06	-0.23	1.05	1.28
BH8	-0.82	2.47	1.19	2.63	1.44
Southern extension					
BH12	0.43	5.31	0.43	1.99	1.56
BH15	0.50	4.38	1.06	2.28	1.22

Note - all groundwater wells were monitored on every occasion in 2022 except: BH3W, BH5B, BH7B, BH9B and BH6 (all in June) due to overgrown conditions causing the borehole to be inaccessible.

The tidal nature of the River Neath Estuary, which is close to the Site, influences the groundwater beneath the site, and as such, there is relatively low (close to zero) hydraulic gradient beneath the site. The hydrogeological risk assessments have established the direction of groundwater flow beneath Giants Grave Landfill Site indicating that there is a slight hydraulic gradient within the superficial deposits towards the western side of the landfill and the River Neath, broadly consistent with local topography.

From Table 3D and the groundwater fluctuation graphs, the following observations can be made:

- The difference between the lowest and highest groundwater levels in each well is between 0.64m and 3.56m.
    - The most significant variation between minimum and maximum groundwater levels are in BH43B (3.56m) and BH40B (3.08m). As is obvious on the graphical representation above, these large differences are due to a single reading at each location in June where:
        - For BH40B the June reading of 4.65mAOD is more than 2m higher that the next highest reading of 2.5mAOD. If this reading was not included, then the difference between the minimum and maximum groundwater levels is 0.93m.
        - For BH43B the June reading of 5.17mAOD is more than 1.8m higher that the next highest reading of 3.33mAOD. If this reading was not included, then the difference between the minimum and maximum groundwater levels is 1.72m.
    - Other than BH40B and BH43B the highest difference is in borehole BH6 at 1.57m difference.
- For the western and southern locations, the 2022 groundwater level data generally shows the highest levels in early 2022, lower groundwater levels between May and September and upward trend to November. The highest water levels typically recorded in November.
- For the eastern and northern locations (and not including the June results for BH40B and BH43B), the difference between the minimum and maximum groundwater levels is less than the southern and western locations. Higher groundwater levels are recorded in early 2022 with slightly lower levels across the summer and levels increasing into winter. The most pronounced trend is the rising trend in BH3W from September through to December.

3.4.2 Groundwater Quality Monitoring – Key Parameters

A review of the groundwater quality monitoring data has been undertaken. Table 3E provides a summary of the concentrations for ammoniacal nitrogen which has trigger levels stated within the environmental permit (Schedule 3 Table 3.5) and control levels in accordance with the Landfill Aftercare Plan as detailed in Table 3C.

For Table 3E, when compiling summary statistics (e.g. mean values), where a parameter has not been detected at concentrations greater than the detection limit, the detection limit has been used in the calculations.

Table 3E - Groundwater Quality Indicator - Ammoniacal Nitrogen

Parameter	Borehole	Minimum	Maximum 2022	Mean	Minimum	Maximum 2021	Mean
Ammoniacal Nitrogen (mg/l)	BH1B	<0.015	1.5	0.3	0.035	1.8	0.7
	BH5	<0.015	0.31	0.5	<0.015	0.52	0.1
	BH8	<0.015	38	12.3	<0.015	22	0.6
	BH9B	0.13	1.8	0.8	0.36	4.7	1.3
	BH12	<0.015	1.5	0.29	0.044	2.8	0.7
	BH15	<0.015	0.71	0.17	0.016	0.61	0.2
	BH43B	29	95	57.1	1.7	91	62
	BH45B	14	96	58.8	52	110	80

For ammoniacal nitrogen the maximum values in red exceed the trigger level and those in orange exceed the control level.

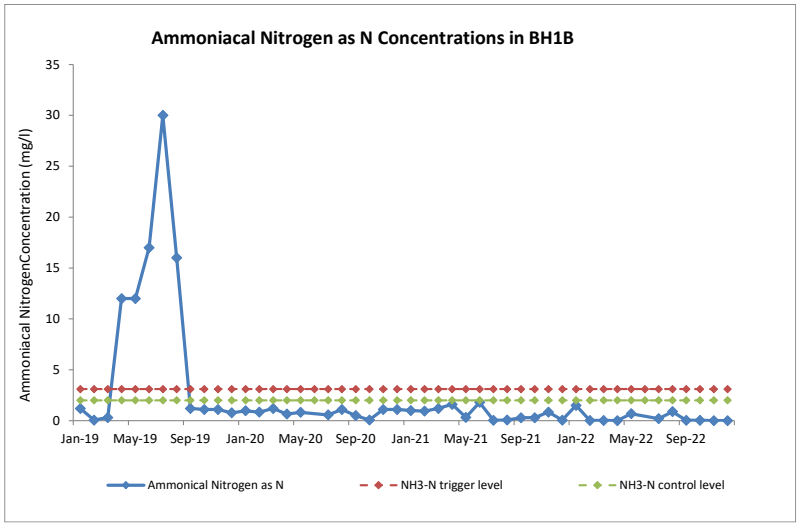
When comparing the 2022 groundwater data in Table 3E with the control and trigger levels specified in Table 3C, the following general comments can be provided:

- **Ammoniacal Nitrogen** – three of the eight boreholes exceeded either the trigger level or control level during 2022 (compares to four boreholes in 2021):
    - BH9B - Exceeded the trigger level of 1.6mg/l on one occasion (September) with the highest concentration being 1.8mg/l. This compares to the highest concentration of 4.7mg/l in 2021. BH9B also exceeded the control level of 1.0mg/l on one occasion (October). The mean concentration was 0.8mg/l which shows a fall from the 1.3mg/l recorded in 2021.
    - BH43B - exceeded the control level of 72.6mg/l on five occasions (March, May, July, August and December) with the highest concentration being 95mg/l. This compares to the highest concentration in 2021 of 91mg/l and in 2020 of 110mg/l. No sample in April or June 2022.
    - BH45B – The trigger level of 59.5mg/l was exceeded six occasions (January to May and December) The concentration recorded was up to a maximum concentration of 96mg/l in February. The control level of 39.7mg/l was exceeded in July and November. No analysis from June 2022.

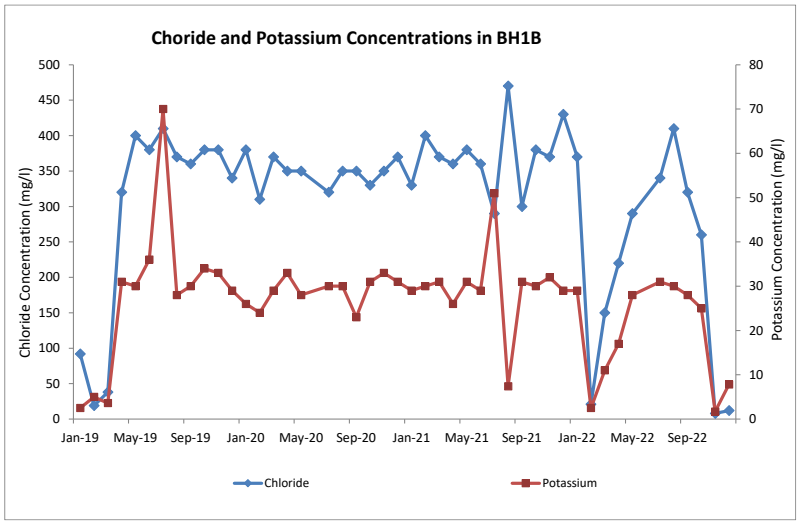
Note – graphical illustration of the ammoniacal nitrogen, chloride and potassium concentrations are provided for all boreholes below.

Borehole BH1B

There was a spike in ammoniacal nitrogen in September 2018 at 25mg/l and a period of elevated ammoniacal nitrogen between April and August 2019 (up to 30mg/l). Following the elevated concentrations during 2019, there has not been any ammoniacal nitrogen concentrations at or above the control level of 2mg/l throughout 2021 & 2022. The current ammoniacal nitrogen control and trigger levels for this location appear to remain relevant as they have indicated the dramatic change in groundwater quality on the occasions in 2018 and 2019, but subsequent results have returned to more historically typical concentrations.



The 2020 and 2021 chloride and potassium concentrations remained relatively consistent up until significant fluctuations in mid-2021 for both parameters. The 2022 results recorded a low result in February but a rising trend until the summer, followed by a falling trend to the end of the year. Overall, the concentrations of chloride and potassium have not exceeded those recorded in recent years and the mean concentration across 2022 is lower.

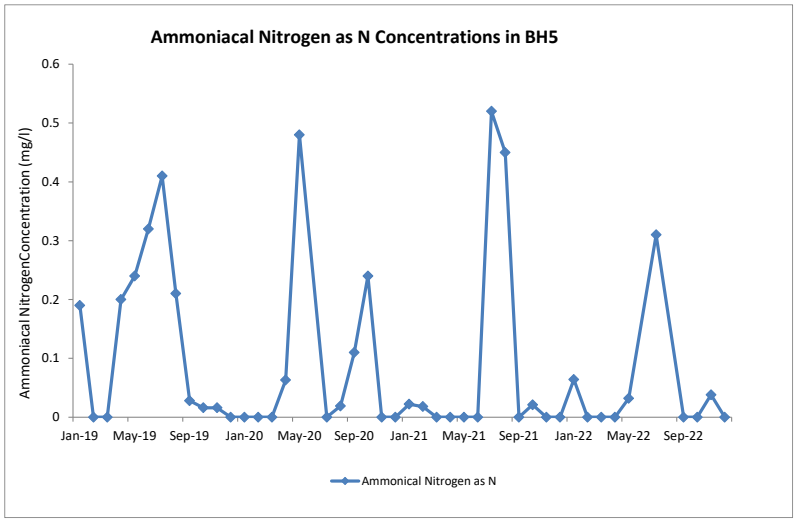


Note – there are no control or trigger levels set for the chloride or potassium concentrations in the groundwater at Giants Grave landfill.

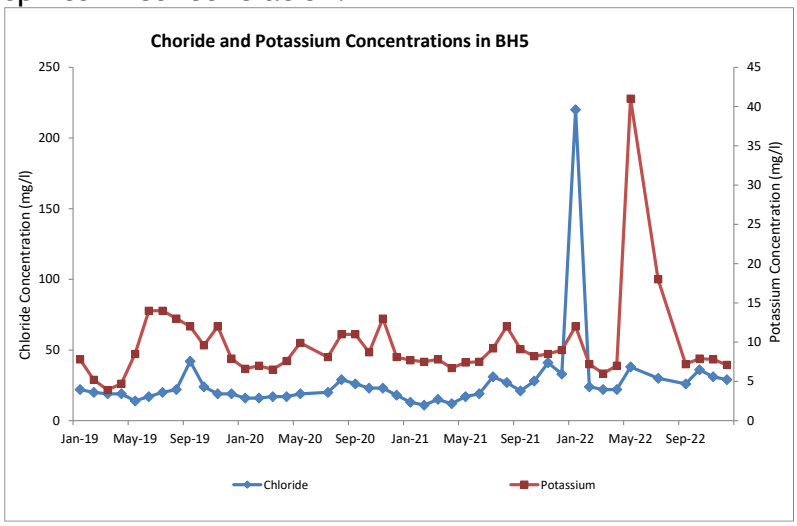
Borehole BH5

All concentrations since March 2018 have been <1mg/l. The control and trigger levels are not shown on the graph as they are set at concentrations of 15mg/l and 23mg/l respectively. There remains an argument that these are not fit for purpose as they are more than an order of magnitude above the typical concentrations recorded. This report does not consider a recalculation of the control and trigger levels – which would be considered as part of a separate project aligned with any permit variation application if considered applicable.

The highest concentrations recorded in 2022 were in July at 0.3mg/l. This seems to follow a similar seasonal pattern with higher concentrations during the summer months.



The graph below illustrates some significant fluctuations for the chloride and potassium in this groundwater with a single elevated spike for each parameter during 2022. For chloride, the spike is in January at 220mg/l is an order of magnitude higher than the typical results. For potassium the elevated spike at 41mg/l occurs in May. Following both single spikes the concentrations return to similar levels to before. The overall mean concentrations in 2022 are higher than 2021, mainly due to these spikes in concentration.

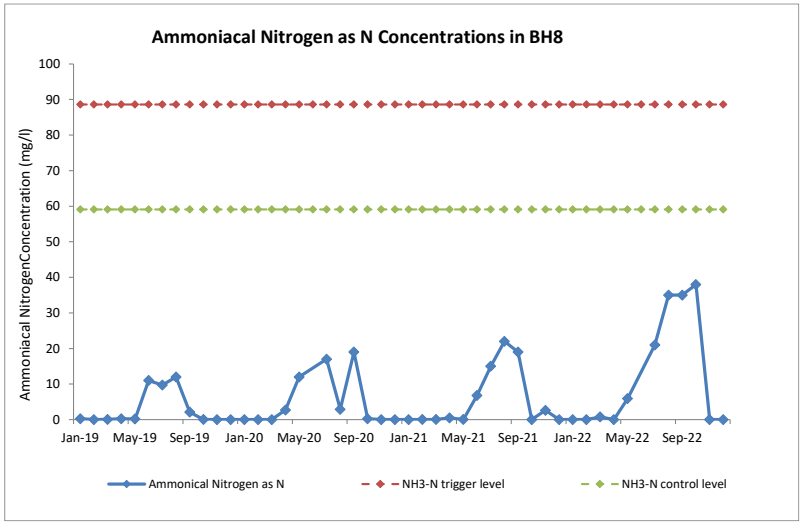


Note – there are no control or trigger levels set for the chloride or potassium concentrations in the groundwater at Giants Grave landfill.

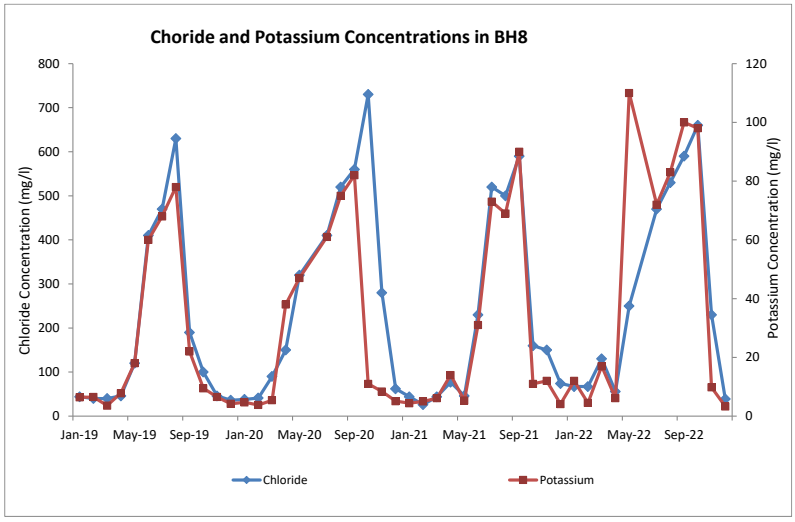
Borehole BH8

The ammoniacal nitrogen concentrations since early 2018 have remained below the control and trigger levels. The ammoniacal nitrogen concentrations recorded in 2022 show higher concentrations between July and October. The graph suggests that there may be a seasonal nature to the ammoniacal nitrogen detection with the highest concentrations recorded across the summer to autumn months each year. There appears to be a rising trend in mean concentrations for each year since 2019, when considering these detections.

Based on this most recent data and if the data continues to record similar trends, then the control level for ammoniacal nitrogen at 59mg/l (and higher trigger level of 88mg/l) would appear to be relevant.



The chloride and potassium in borehole BH8 generally show a close correlation throughout the recent years and including 2022. The highest concentrations for both potassium and chloride occur during the summer months. Although the seasonal spikes are noted there are no apparent adverse trends.

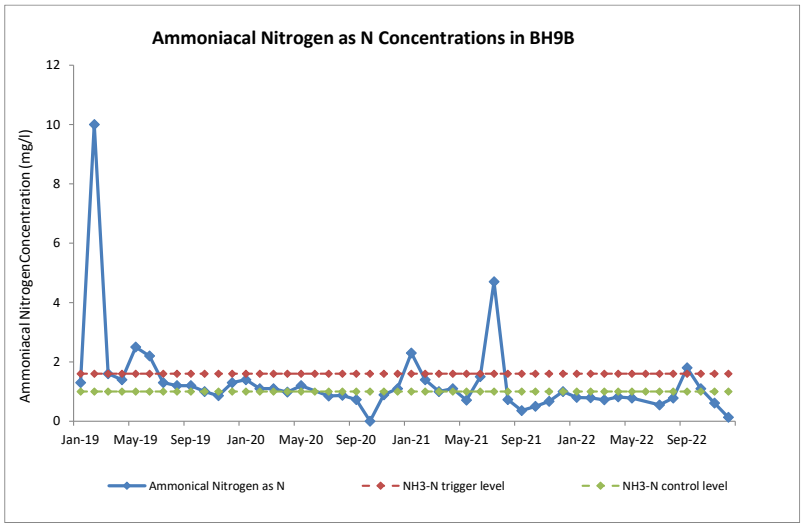


Note - there are no control or trigger levels set for the chloride or potassium concentrations in the groundwater at Giants Grave

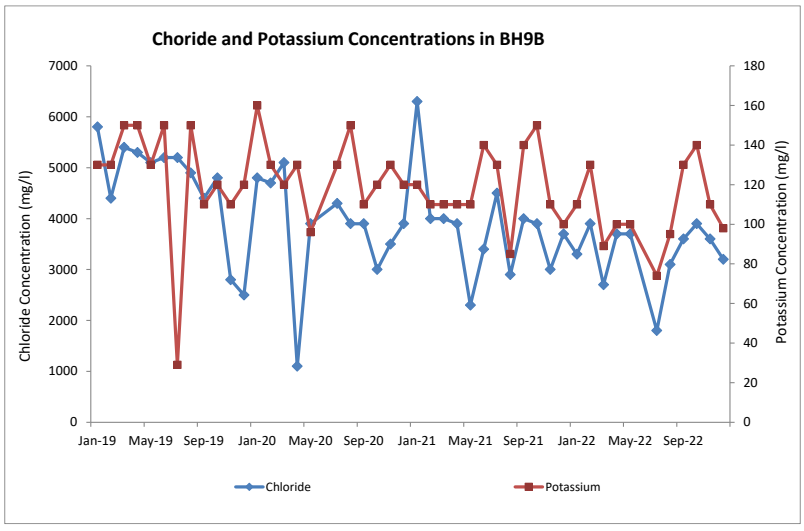
Borehole BH9B

This borehole has recorded some significant spikes in ammoniacal nitrogen over recent years – with a spike in October 2018 at 73mg/l. There have been further spikes in concentration in February 2019 at 10mg/l. The period since July 2019 shows the ammoniacal nitrogen concentrations were all below the trigger level of 1.6mg/l until two separate spikes were recorded in 2021 at above the trigger levels (January and July). For the 2022 data then only one result was above the trigger level (1.8mg/l in September) with one further result above the control level (1.1mg/l in October).

Based on this most recent data and if the data continues to record similar trends, then the control level for ammoniacal nitrogen at 1.0mg/l (and higher trigger level of 1.6mg/l) would appear to be relevant.



Borehole BH9B continues to record the highest chloride concentrations of all the groundwater. The concentration of chloride and potassium correlate well in 2022 but continue to fluctuate. No adverse trends noted.

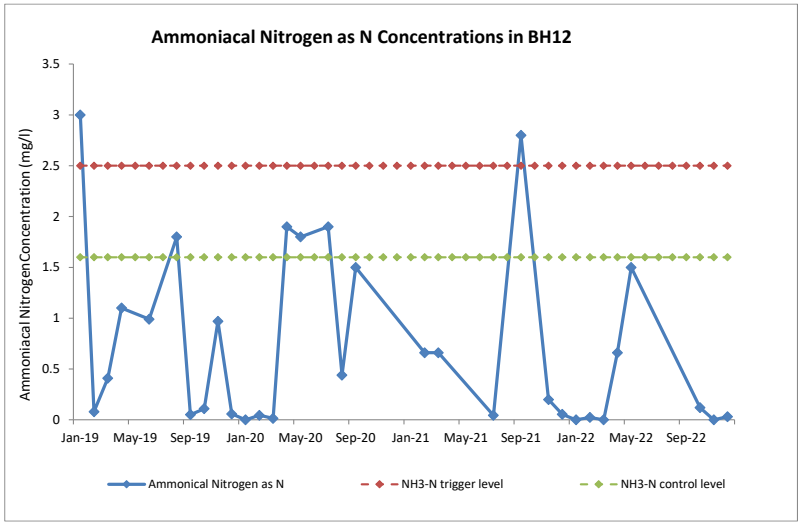


Note – there are no control or trigger levels set for the chloride or potassium concentrations in the groundwater at Giants Grave landfill.

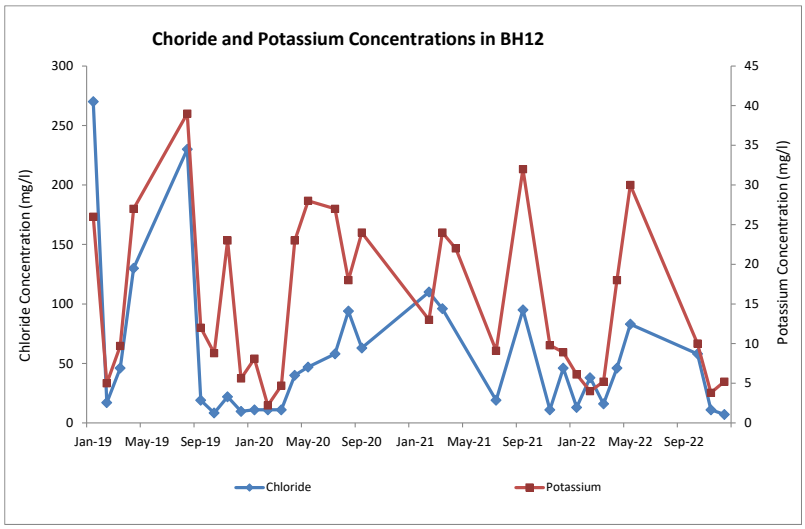
Borehole BH12

Due to insufficient groundwater being present, samples were not able to be obtained between June and September.

No exceedance of the control or trigger levels was recorded at this location in 2022, with the highest result marginally below the control level of 1.6mg/l. A repeat of the significant spike recorded in October 2018 has not been repeated since.



The 2021 concentrations continue to record low chloride (highest concentration of 83mg/l) and highly fluctuating potassium (but no adverse trend).

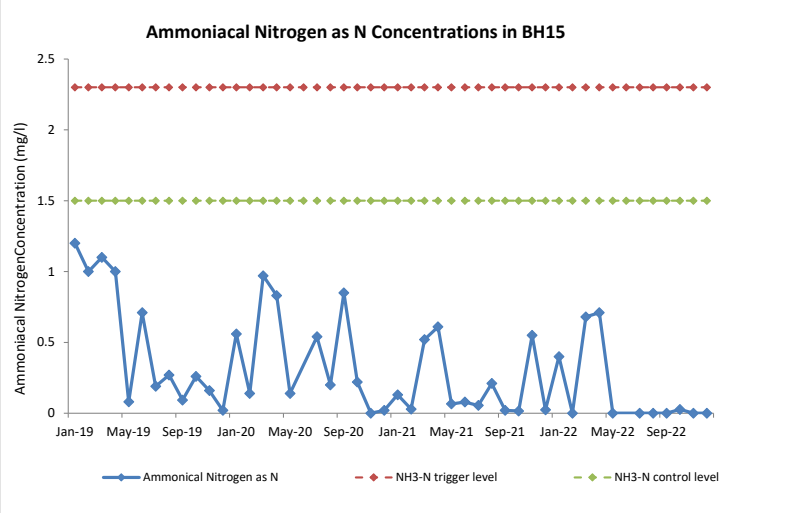


Note – there are no control or trigger levels set for the chloride or potassium concentrations in the groundwater at Giants Grave landfill.

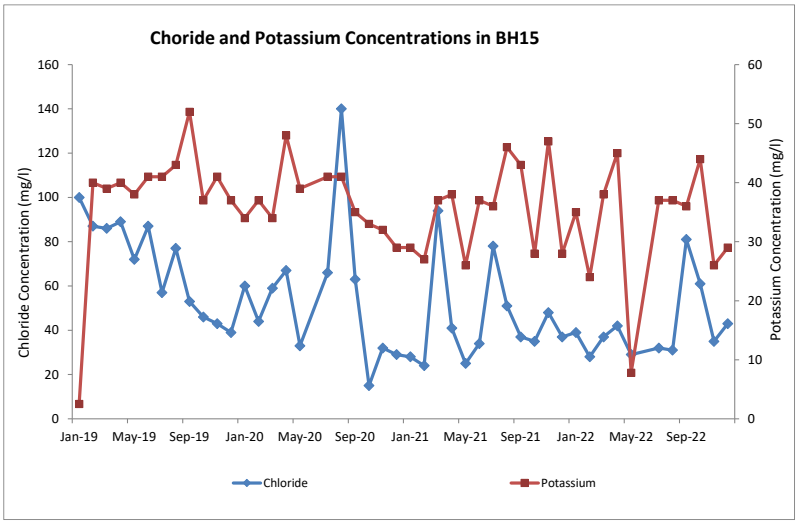
Borehole BH15

Similar to BH12, there was an elevated spike of ammoniacal nitrogen recorded in October 2018 at significantly above the trigger level, with all subsequent readings returning to typically lower concentrations. In 2022 all concentrations of ammoniacal nitrogen have been below the control level of 1.5mg/l.

The graph shows that the control and trigger levels are relevant to the data observed over the last few years.



Fluctuating results observed for chloride concentrations with the highest at 81mg/l with the overall mean in 2022 being slightly lower than 2021. The potassium concentrations have continued to fluctuate but typically within a consistent range (other than a lower result in June at <10mg/l compared to a mean of approximately 35mg/l for the remainder of 2022). Overall, no adverse trend noted for these two parameters.

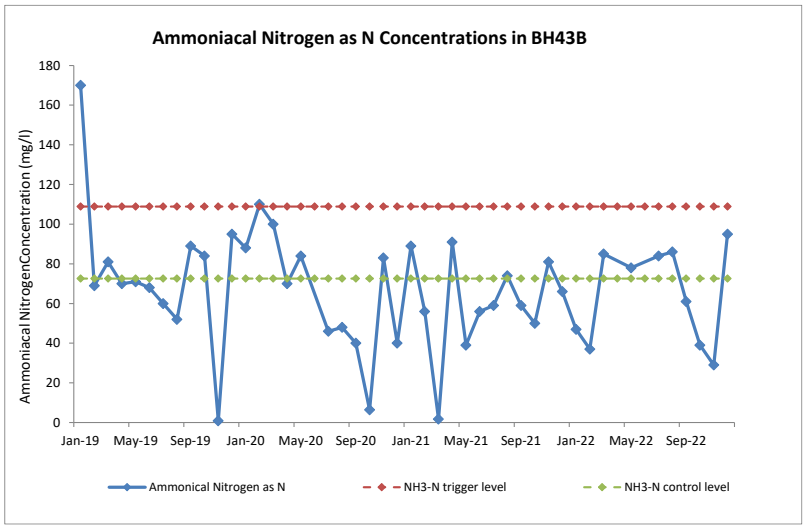


Note – there are no control or trigger levels set for the chloride or potassium concentrations in the groundwater at Giants Grave landfill.

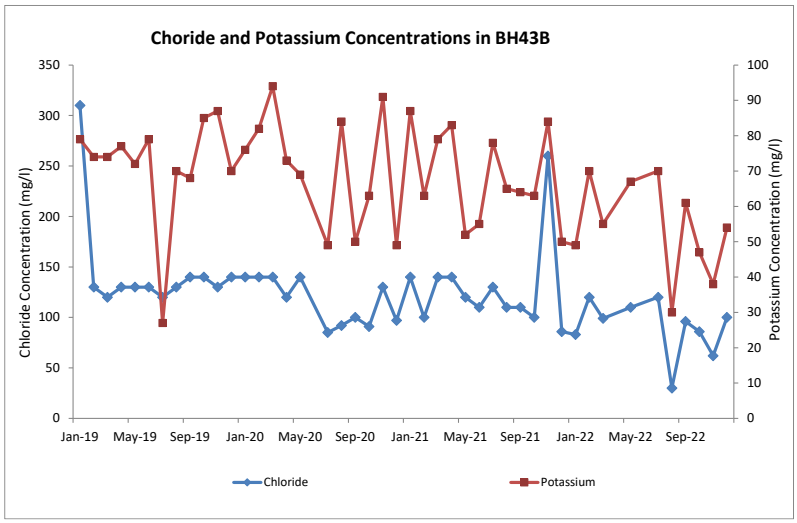
Borehole BH43B

The ammoniacal nitrogen in 2022 continues a fluctuating pattern around the control level of 72.6mg/l. Five results are above the control level, but all continue to be below the trigger level of 108.9mg/l. Although fluctuating there is no adverse trend apparent.

From the graph it suggests that the current trigger level for ammoniacal nitrogen remain relevant.



Consistent chloride concentrations were recorded since early 2019 until a spike at 260mg/l in November 2021. Since then, the chloride results are showing a slight falling trend. Although more fluctuating the potassium concentrations correlate well with the chloride and also records a slight falling trend in 2022.



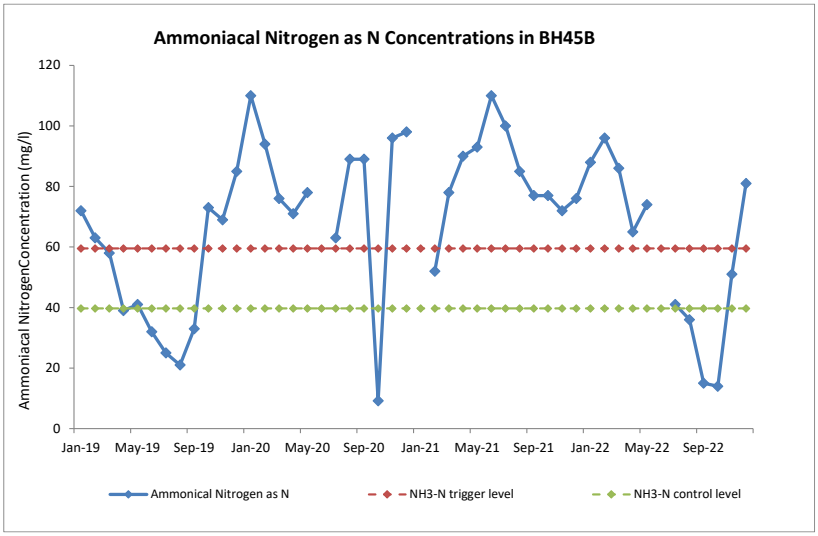
Note – there are no control or trigger levels set for the chloride or potassium concentrations in the groundwater at Giants Grave landfill.

Borehole BH45B

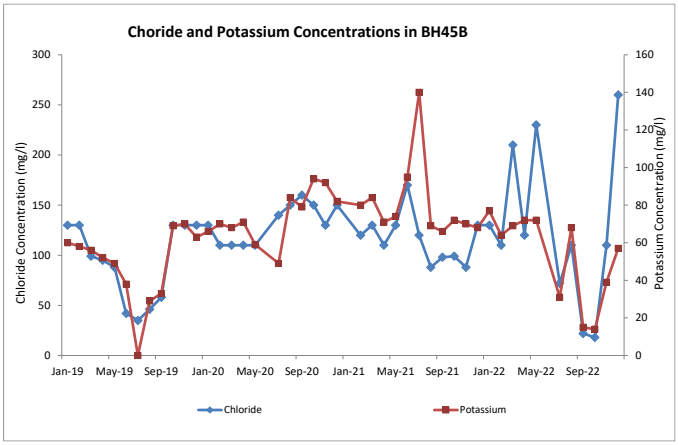
Eight of eleven concentrations in 2022 have exceeded the control level of 39.7mg/l – with 6 also exceeding the trigger level of 59.5mg/l. Overall, the mean concentration in 2022 of 58.8mg/l is lower than the 2021 mean of 82.7mg/l.

It is recognised that this location also records elevated methane and the likely presence of landfill gas as it is believed that this borehole (along with BH43B and BH40B) are buried in waste outside the landfill boundary and therefore outside the influence of the any onsite leachate and gas control infrastructure.

The continued elevated ammoniacal nitrogen concentrations suggest that the current control and trigger levels for ammoniacal nitrogen may not be relevant as an appropriate early warning of changes in the groundwater quality.



The chloride concentrations in 2022 have shown considerable fluctuation compared to results since 2019, although the mean in 2022 (126mg/l) is only slightly higher than in 2021 (116mg/l). The potassium concentrations have shown a falling trend in the second half of 2022 following consistent results at approximately 70mg/l in early 2022. No repeat of the spike of potassium in July 2021 has been recorded since.



Note – there are no control or trigger levels set for the chloride or potassium concentrations in the groundwater at Giants Grave landfill.

3.4.3 Groundwater Quality Monitoring – Other Parameters

a) Six-monthly

The six-monthly monitoring of groundwater for a range of metals and other parameters (such as COD, BOD etc) was undertaken in April and October in 2022 – although no sample available for BH43B in April.

For the components monitored then the most significant observations are:

BH5

- The sodium levels recorded an increase in 2021 (concentration up to 180mg/l) compared with results from 2020 (highest of 43mg/l), although the 2022 data has decreased with highest being at 67mg/l.
- No detection of mercury in 2022 (following a detection at 0.0066µg/l in 2021).
- The mean concentration for chromium increased in 2021 (compared to 2020) but has decreased by an order of magnitude in 2022.

BH8

- The October sample from BH8 has recorded elevated concentrations of many components when compared with 2021 and April 2022. This includes the highest concentrations recorded for alkalinity; arsenic; BOD; cadmium; COD; iron; magnesium; manganese; nickel; and sodium.
- The most significant increases are for:
    - COD at 3100mg/l (compared to next highest in 2021 and 2022 of 240mg/l). This continues a trend of higher concentrations each year with the highest in 2020 of 63mg/l.
    - BOD at 49mg/l compared to next highest at 1.4mg/l.
    - Total organic carbon at 36.6mg/l compared to next highest of 5.6mg/l.
    - Sodium at 970mg/l compared to next highest of 190mg/l.
    - Arsenic at 18µg/l compared to 5µg/l.
    - Manganese at 360µg/l compared to next highest of 16µg/l.

BH12

- The most significant differences between 2022 and 2021 are:
    - Elevated BOD at 18mg/l in October compared to <5mg/l in the previous 2 samples.
    - A falling manganese concentration from 940µg/l in April 2021 to 140µg/l in April 2022 and 55µg/l in October 2022.
    - Detection of mercury in April 2022 (0.0088µg/l).
    - Falling nickel and zinc concentrations from April 2021 to October 2022.

BH15

- The most significant differences between 2022 and 2021 are:
    - A falling arsenic concentration from 6.3µg/l down to 1.8µg/l between April 2021 and October 2022.
    - Undetected chromium in 2022 following a significant increase in the two samples from 2021.
    - Detection of mercury in April 2022 (0.0052µg/l), although this follows a detection in April 2021 (0.008µg/l).
    - A rising trend in concentration for zinc from 3.7µg/l in April 2021 up to 16µg/l in October 2022.

BH9B

- The increasing trend in arsenic concentration across 2020 and into 2021 with the highest concentration of 55µg/l in October 2021 has been reversed with both 2022 concentrations <1µg/l.
- Undetected chromium in 2022 (<0.2µg/l) compared to 2021 which recorded an increase in the mean concentration from the previous year. Mean in 2021 was 7.4µg/l.
- A falling copper concentration from 27µg/l down to 0.9µg/l between April 2021 and October 2022.
- Detection of mercury in April 2022 (0.0065µg/l).

BH1B

- A falling copper concentration from 18µg/l down to 1.3µg/l between April 2021 and October 2022.
- The highest concentrations of lead continue to be recorded at this location.
- Detection of mercury in April 2022 (0.0065µg/l) but not in October (following detections in both samples of 2021).

BH43B

Only one sample in 2022 (October)

- Order of magnitude lower chromium and copper concentration in 2022 compared to those recorded in 2021.

BH45B

- Order of magnitude lower chromium and copper concentration in 2022 compared to those recorded in 2021.

Although there are some order of magnitude increases the most significant trends observed are a rising trend in arsenic in BH9B (since 2020) and zinc in BH15; elevated concentrations for many components in BH8 in October 2022; but lower mean concentrations for chromium across many locations.

b) 2 yearly monitoring

The 2-yearly monitoring for other hazardous substances was undertaken in October 2021 and is not due again until 2023.

3.5 Summary and Recommendations for the Groundwater Monitoring Programme

Other than for the locations BH40B and BH43B (where unusual groundwater level data recorded), the groundwater levels follow a similar pattern throughout the year and are of a similar mean level to recent years.

For groundwater quality, the main concerns arising in 2022 are:

- The continued elevated ammoniacal nitrogen in borehole BH45B when compared to the trigger level.
- Occasional spikes in ammoniacal nitrogen above the control level in BH43B, although no results above the trigger level in 2022.
- A rising trend in ammoniacal nitrogen concentrations in BH8 (when the seasonal positive detections are recorded during the summer/autumn).

The biannual hazardous substances analysis recorded a rising trend in arsenic in BH9B and zinc in BH15, but lower mean concentrations for chromium across many locations.

3.5.1 Review of Control and Trigger Levels

The Landfill Aftercare Plan suggests that the control and trigger levels are considered as part of the Annual Environmental Performance Report. From a review of the data for each borehole monitored and a consideration of the concentrations recorded during 2022 most of the current control and trigger levels would appear to be relevant (fit for purpose) to provide a warning to adverse conditions in the groundwater.

A general review of the adequacy of the control and trigger levels was provided in section 3.4.2 above.

The locations that appear not to have relevant control and trigger levels are in:

- BH5 – the ammoniacal nitrogen C & T levels are set at concentrations two orders of magnitude *higher* than the results observed.
- BH45B – the continued elevated ammoniacal nitrogen concentrations suggest that the current control and trigger levels for ammoniacal nitrogen may not be relevant as an appropriate early warning of changes in the groundwater quality.

Although the control and trigger levels for groundwater quality in the above-mentioned boreholes do not necessarily provide an appropriate early warning, this report does not suggest any current action to amend these.

4 Surface Water Monitoring

This section provides a summary of the surface water monitoring at Giants Grave for 2022 in accordance with Schedule 3, Table 3.9 of the environmental permit EPR/SP3298FT and Appendix A4 of the Landfill Aftercare Plan.

A new monitoring regime was agreed with NRW from June 2017 onwards. For surface water monitoring the only change was to remove the requirement to analyse for chloride and to remove the visual inspection for any evidence of contamination.

A revised hydrogeological risk assessment was approved by NRW and ratified by the NPTWM Board during 2020, as described in the leachate section above. This does not directly impact surface water monitoring with no changes to the surface water compliance limits in the Landfill Aftercare Plan (there are no compliance limits stated in the environmental permit), although in the Addendum to the HRA[3] the following is stated:

> "Once the proposal to revise compliance limits, as set out in this Addendum, have been determined by NRW, NPTWM will submit a revision to the Aftercare Plan in respect of control and trigger levels for surface water:
>
> - To remove Chloride limits from River North and River South (in accordance with Section 8.2 of HRA2016); and
> - To revise Ammoniacal Nitrogen limits at River North and River South (in accordance with the 2018 Annual Report)."

Although the changes to chloride were implemented from June 2017, the changes to compliance limits for ammoniacal nitrogen have not been implemented within 2020 and awaiting a revision to the Landfill Aftercare Plan.

4.1 Surface Water Monitoring Locations

Surface water monitoring is undertaken at four monitoring locations near the site:

- The Neath Canal forms the eastern boundary of Giants Grave Landfill Site. The Canal has only minimal flow from north to south. The monitoring points, Canal North and Canal South, are located on the Canal, adjacent to the Northern and Southern extents of the site respectively.
- The River Neath forms the south western boundary to the western extension and also forms part of the western boundary to the southern extension. The River flows from north to south and is considered tidal at this point. Monitoring points – River North and River South - are located on the River Neath, adjacent to the Northern and Southern extents of the site respectively.

The locations of the surface water monitoring points are shown on the sampling location plan in Appendix E.

[3] Giants Grave Landfill Site (in Aftercare) – EPR/SP3298FT – Addendum to the Hydrogeological Risk Assessment Review 2016 (NPTWM, April 2016)

4.2 Surface Water Monitoring Requirements

Table 4A summarises the surface water monitoring requirements of the environmental permit and Landfill Aftercare Plan.

Table 4A - Surface Water Monitoring Schedule

Monitoring Point	Parameter	Monitoring Frequency
Canal North; Canal South; River North; River South NB River North and River South sampled at high tide to help minimise the safety risk to monitoring personnel at these locations	pH, Temperature, Electrical Conductivity, Ammoniacal Nitrogen, Suspended Solids, Chemical Oxygen Demand, Biological Oxygen Demand, Dissolved Oxygen, Nickel, Nitrate, Phenol	Monthly

The above monitoring schedule was completed for the surface water monitoring points, other than no samples taken in June.

4.3 Surface Water Control and Trigger Levels

Control and trigger levels, along with observed trends from control and trigger charts, provide a warning to the site operator that a problem may be occurring. They can be used to spot adverse trends in the monitoring data, or changes because of natural variations in the background water quality. Control levels are intended to provide an early warning indicator for when the landfill is beginning to deviate from its design performance so that corrective or remedial measures can be implemented before a trigger level is exceeded.

Surface water control and trigger charts for ammoniacal nitrogen (considered the key parameter) have been prepared for the surface water monitoring locations specified in Table 4B. These limits are not stated in the environmental permit but were set within the Landfill Aftercare Plan. This annual environmental report reviews and recommends whether these control and trigger levels are relevant.

Table 4B - Surface Water Control and Trigger Levels

Parameter	Surface Water Monitoring Location	2010 Trigger Level	2010 Control Level
Ammoniacal Nitrogen (mg/l)	Canal North	1.0	0.7
	Canal South	0.5	0.3
	River North	0.4	0.3
	River South	0.5	0.3

4.4 Surface Water Monitoring Results and Data Assessment

4.4.1 Surface Water Quality Monitoring

Table 4C provides a summary of the key surface water indicator parameters analysed monthly.

Table 4C – Surface Water Quality Indicator Parameters

Parameter	Monitoring Location	Minimum	Maximum	Mean	Comments
Parameters with Control and Trigger Levels					
Ammoniacal Nitrogen (mg/l)	Canal North	0.018	0.53	0.13	No exceedances of control or trigger levels
	Canal South	<0.015	4	0.45	One exceedance of trigger level (4mg/l in October)
	River North	<0.015	0.34	0.06	One exceedance of control level (July).
	River South	<0.015	0.38	0.06	One exceedance of control level (July)

Parameter	Monitoring Location	Minimum	Maximum	Mean	Comments
Nickel (µg/l)	Canal North	0.8	6.5	2.5	All samples recorded positive detections. The mean concentrations are like those recorded in recent years (although 10% higher than in 2021)
	Canal South	0.7	8.8	2.57	
	River North	1.1	47	8.96	All samples recorded positive detections. The higher mean concentration in River N is predominantly due to one spike in September not recorded downstream – otherwise similar each month for N & S
	River South	0.8	29	4.23	
Chemical Oxygen Demand (mg/l)	Canal North	7.3	350	45.7	Relatively consistent data (10-30mg/l both N & S) other than spike in November at 300mg/l in N and 170mg/l in S
	Canal South	3.9	170	28.9	
	River North	5.3	5000	963.9	Variable levels between N & S with upstream showing two significant spikes at 5000mg/l and 3100mg/l, compared with highest of 2000mg/l in S location
	River South	7.1	2000	562.6	
Biological Oxygen Demand (mg/l)	Canal North	1.1	11	3.2	Similar minimum, maximum and mean concentrations in Canal N and S during 2022 (although some monthly variations)
	Canal South	<1	8.1	2.55	
	River North	1.2	8.9	3.94	Similar minimum, maximum and mean concentrations in River N and S during 2022 in general (although some monthly variations)
	River South	1.6	11	3.61	
Phenol (mg/l)	Canal North	<0.0005	<0.0005	-	No phenol detected
	Canal South	<0.0005	<0.0005	-	
	River North	<0.0005	<0.0005	-	
	River South	<0.0005	<0.0005	-	

Parameter	Monitoring Location	Minimum	Maximum	Mean	Comments
Nitrate as NO_3 (mg/l)	Canal North	0.02	2.13	0.54	No significant differences between north & south in Canal or River locations (other than one result in Canal N at >2mg/l compared with all others <1mgl)
	Canal South	0.01	0.99	0.31	
	River North	0.02	0.59	0.18	
	River South	0.03	0.5	0.16	
Total Suspended Solids (mg/l)	Canal North	<2	1300	195.55	Highly variable data across the monitoring locations
	Canal South	<2	340	48.86	
	River North	29	1700	345.36	Highly variable data across the monitoring locations
	River South	<2	2300	323.27	

General Note - (Unless otherwise stated in the table above) when compiling summary statistics (e.g. mean values), where a parameter has not been detected at concentrations greater than the detection limit, the detection limit has been used in the calculations.

a) Canal North and Canal South

Surface water monitoring data was collected from Canal North and Canal South monthly throughout 2022 other than in June. Table 4D summarises the ammoniacal nitrogen concentration range in 2022 and compares with those observed during 2020 and 2021.

There were no exceedances of the control of trigger levels for Canal North.

For Canal South the trigger level was exceeded on one occasion - November 2022 at a significantly elevated 4mg/l, with the trigger level also exceeded in December 2022 at a value of 0.34mg/l. This is the first exceedance of either level since April 2021 at Canal South (at 0.91mg/l compared with the trigger of 0.5mg/l). The control level of 0.3mg/l was not exceeded at any other time of 2022.

The trends for ammoniacal nitrogen compared to the control and trigger levels for Canal North and Canal South can be observed graphically below.

Table 4D - Summary of Canal North and Canal South Monitoring Data

Monitoring Point	Ammoniacal Nitrogen Ranges (mg/l)		
	2020	2021	2022
Canal North	<0.015 - 0.48	<0.015 - 0.52	<0.015 - 0.53
Canal South	<0.015 - 0.55	0.019 - 0.91	<0.015 - 4

From the information in Tables 4C and 4D, and a review of the 2022 data in Appendix C the following observations can be made:

- The mean, minimum and maximum concentrations for nickel, biological oxygen demand and phenol are generally similar for the upstream (Canal North) and downstream (Canal South) monitoring locations. For the other components there are more significant differences:

  - For chemical oxygen demand the main difference is an elevated concentration at 350mg/l upstream in November. The highest reading downstream is also in November, although the result was lower at 170mg/l.
  - For nitrate the upstream sample recoded a more significantly elevated level of 2.13mg/l compared to all other results being <1mg/l. The monthly samples tend to show similar levels upstream and downstream or slightly higher concentrations upstream.
  - For total suspended solids the upstream and downstream samples record highly variable results with the highest concentrations in different months for the two monitoring locations. The upstream sample records higher concentrations leading to a higher mean concentration overall.
- The specific results that show a significant difference (of an order of magnitude or more) are:
  - Upstream higher than downstream
    - Ammoniacal nitrogen: March (0.53mg/l compared with <0.015mg/l downstream)
    - Nitrate nitrogen: November (2.13mg/l compared with 0.23mg/l downstream)
    - Suspended solids: January (570mg/l compared with 3mg/l downstream); February (13mg/l compared with <2mg/l downstream); September (150mg/l compared with <2mg/l downstream); November (1300mg/l compared with 120mg/l downstream)
  - Downstream higher than upstream
    - Ammoniacal nitrogen: January (0.25mg/l compared with 0.031mg/l upstream); November (4.0mg/l compared with 0.018mg/l upstream); December (0.34mg/l compared with 0.028mg/l upstream).
    - Suspended solids: December (340mg/l compared with 48mg/l upstream)

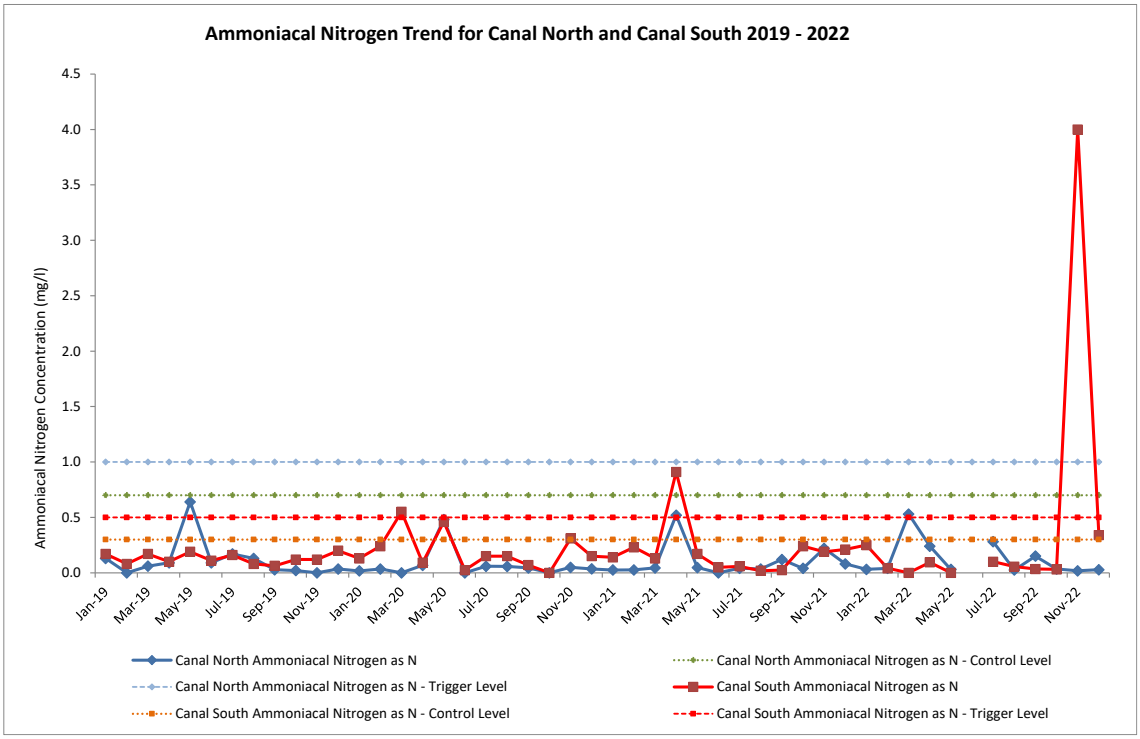
- When compared with 2021 most of the parameters show a slightly higher mean concentration in 2022 for both Canal North and Canal South concentrations. The most significant increases are for Canal North for nitrate and suspended solids (plus suspended solids for Canal South).

  Note - There is no control or trigger level set for the any of the parameters monitored at these monitoring locations except ammoniacal nitrogen.

Graphical analysis for the ammoniacal nitrogen concentrations in the upstream and downstream samples is provided below. The upstream and downstream results were within 0.2mg/l on all occasions in 2022 except in March, November and December.

For understanding the potential environmental impact of the site then the most important of these is when the downstream sample records significantly elevated levels – such as in November and December. For November, the downstream result of 4mg/l is significantly higher than any previous results. In general, the graph shows

that the downstream sample tends to record slightly higher ammoniacal nitrogen concentrations since October 2019 following a period of relatively good correlation. This may suggest some impact from the landfill.



Overall, the data at the end of 2022 raise concerns about the potential impact on the canal from the landfill and this should continue to be reviewed. The control and trigger levels set for ammoniacal nitrogen continue to be relevant for the monitoring locations.

b) River North and River South

Surface water monitoring data was collected from River North and River South monthly throughout 2022 other than in June. The River North and River South monitoring points are subject to both tidal influence (saltwater) and the flow of the river (freshwater). Both are sampled at high tide to minimise the safety risks posed to monitoring personnel – with both samples being taken within approximately 15mins of each other in the same tidal cycle. The samples tend to be taken from the downstream sampling point prior to the upstream, although there is no specific rule for this order.

During 2022 there was no exceedance of the trigger levels at either the River North or River South monitoring locations. This compares to a single breach of the trigger level in River North in April 2021.

For the control levels the following exceedances were recorded:

- **River North - Ammoniacal nitrogen**: The control level was exceeded in July at 0.34mg/ (compared with control level of 0.3mg/l).

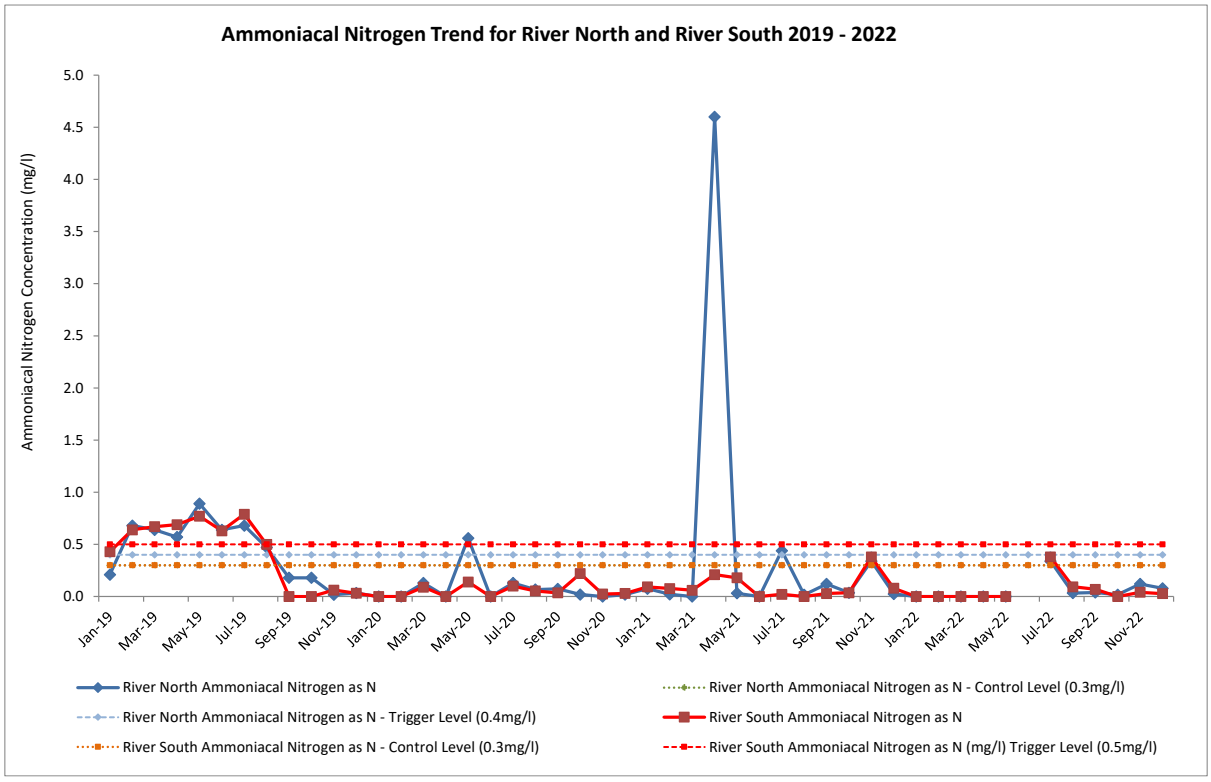
- **River South - Ammoniacal nitrogen:** The control level was exceeded in July at 0.38mg/ (compared with control level of 0.3mg/l).

Table 4E summarises the ammoniacal nitrogen concentration range in 2022 and compares with those observed during 2020 and 2021. The trend for ammoniacal nitrogen compared to the control and trigger levels for River North and River South can be observed graphically below.

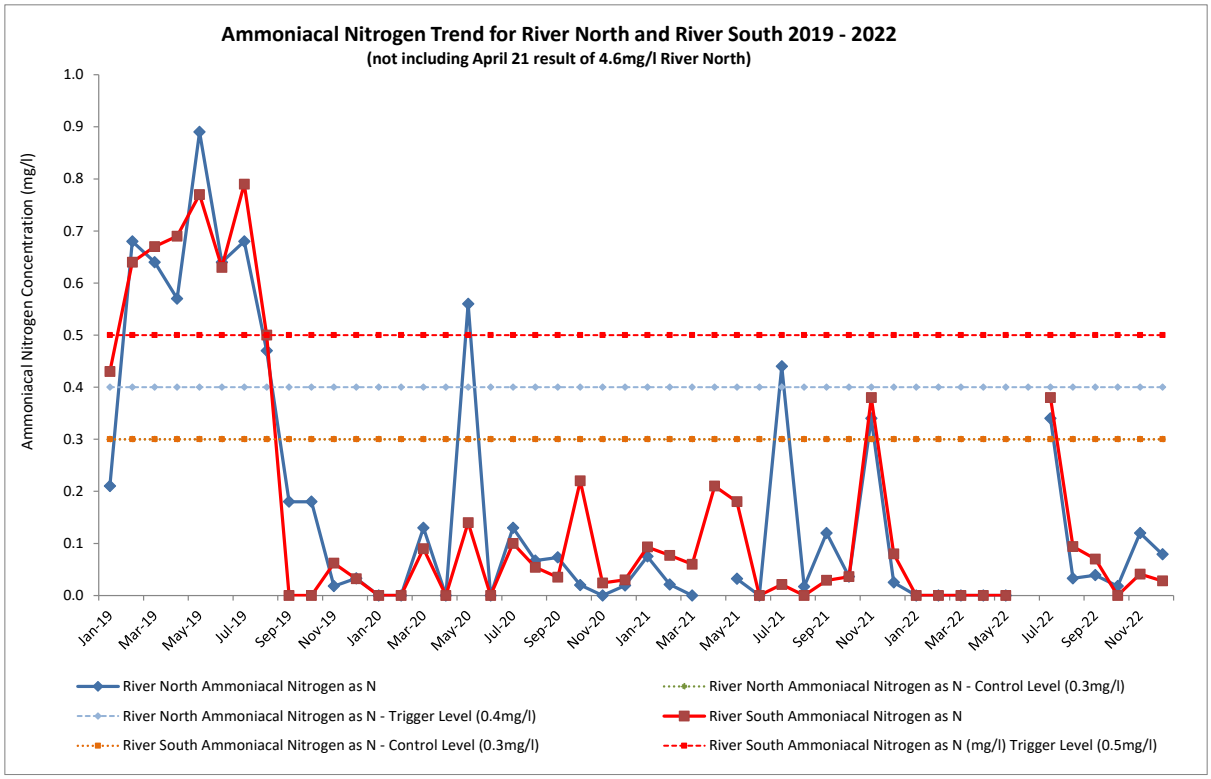
Table 4E - Summary of River North and River South Monitoring Data

Monitoring Point	Ammoniacal Nitrogen Ranges (mg/l)		
	2020	2021	2022
River North	<0.015 - 0.56	<0.015 - 4.6	<0.015 - 0.34
River South	<0.015 - 0.22	<0.015 - 0.38	<0.015 - 0.38

The ammoniacal nitrogen concentrations in the upstream and downstream samples were within 0.2mg/l on all occasions in 2022. There was no occasion where River South concentration exceeded the River North concentration by more than 0.1mg/l.



The following graph provides the above ammoniacal nitrogen results but without the significantly elevated value of 4.6mg/l for the River North sample in April 2021.



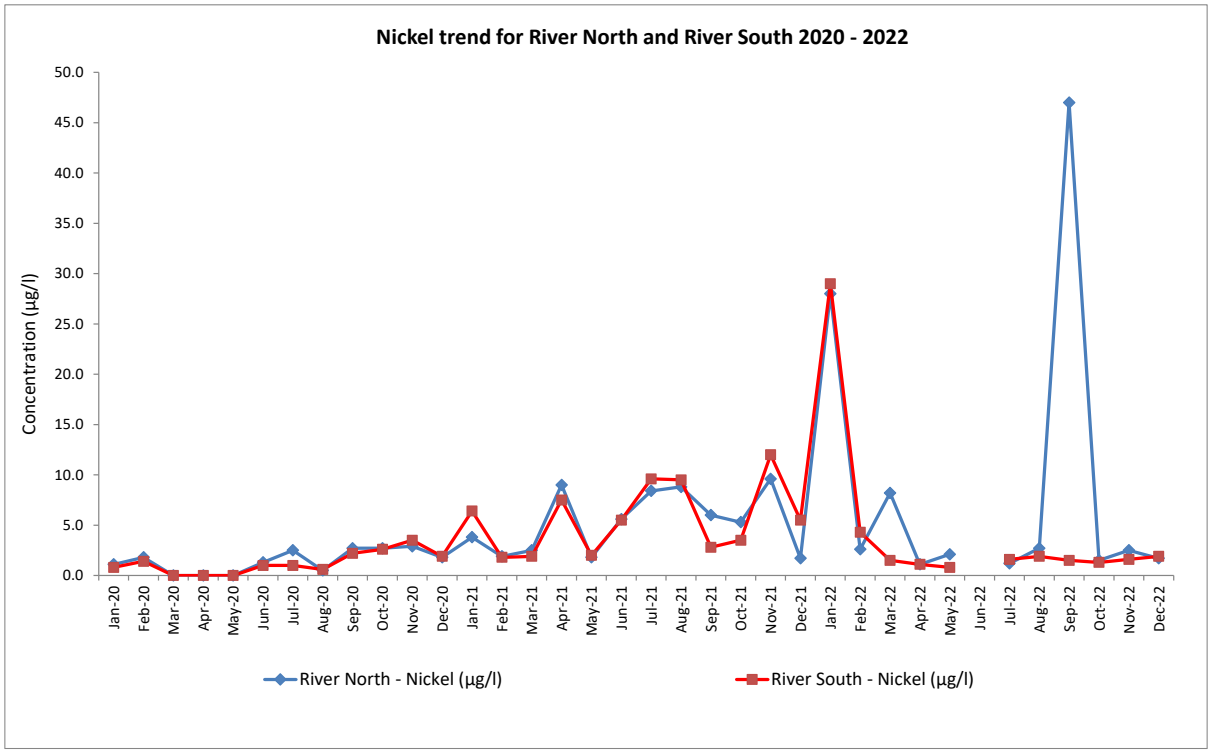
As can be seen from the graph the ammoniacal nitrogen concentrations at River North and River South correlate reasonably well during 2022 (all within 0.2mg/l).

The downstream samples are occasionally higher than upstream but, for 2022, are all within 0.2mg/l. The highest difference where downstream exceeds upstream is in August at 0.061mg/l. For the only time the downstream sample exceeds the control level, there is a similar concentration upstream (0.38mg/l and 0.34mg/l respectively). There is no evidence from 2022 that suggests an impact on the river Neath from ammoniacal nitrogen arising from the landfill.

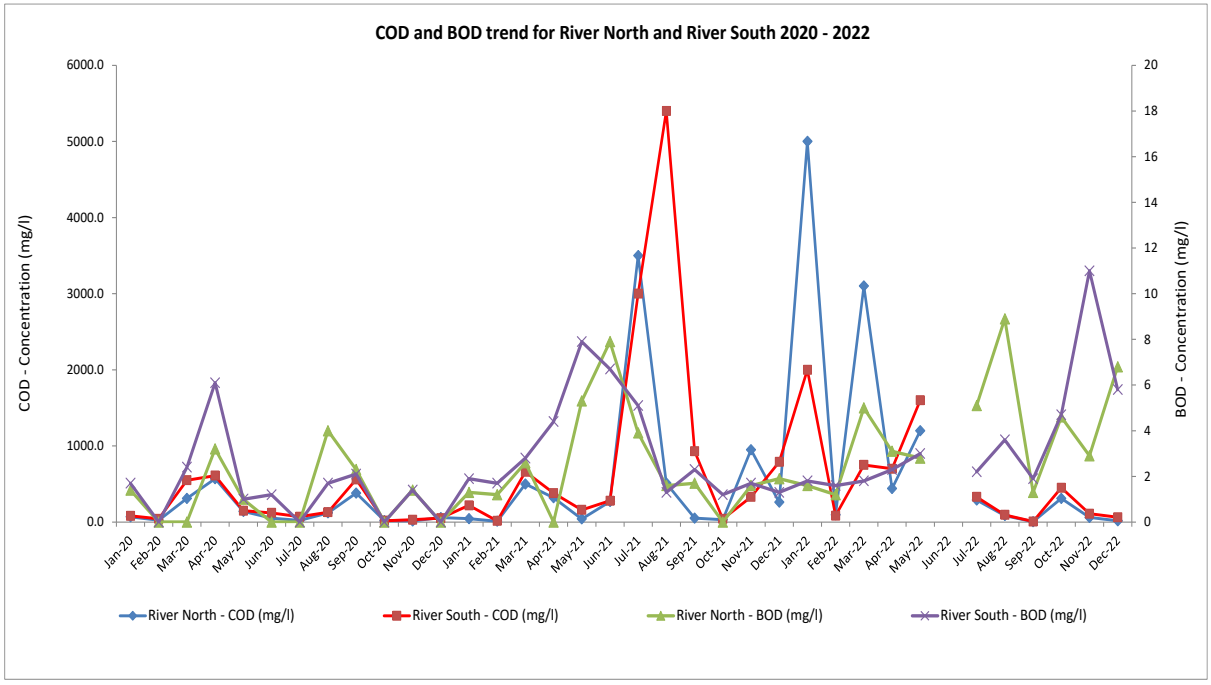
The ammoniacal nitrogen concentrations since September 2019 generally fall below the trigger and control levels – suggesting that the previously calculated and currently used control and trigger levels in the River sampling locations are fit for purpose.

For the other parameters, the maximum and mean concentrations were similar between upstream and downstream locations other than for nickel and chemical oxygen demand. For these two parameters the upstream samples recorded a higher mean concentration. For nickel the higher mean concentration is predominantly due to one significantly elevated result at 47µg/l (compared with downstream result of 1.5µg/l).

These two parameters, along with suspended solids also show increased mean concentrations when compared with 2021. Graphical analysis of these parameters is provided below to ascertain potential trends.



The nickel concentrations show a fluctuating but rising trend across mid-2020 to early 2022 with generally good correlation between upstream and downstream. Much lower concentrations on average have been recorded both upstream and downstream for the remainder of 2022 except for the significant spike in the upstream sample in September. Overall, the data continues to suggest elevated nickel concentrations are arising from north of the landfill.



The COD show significant spikes in 2021 and early 2022 compared with prior results although, in 2022, the upstream sample seems to record the higher concentrations.

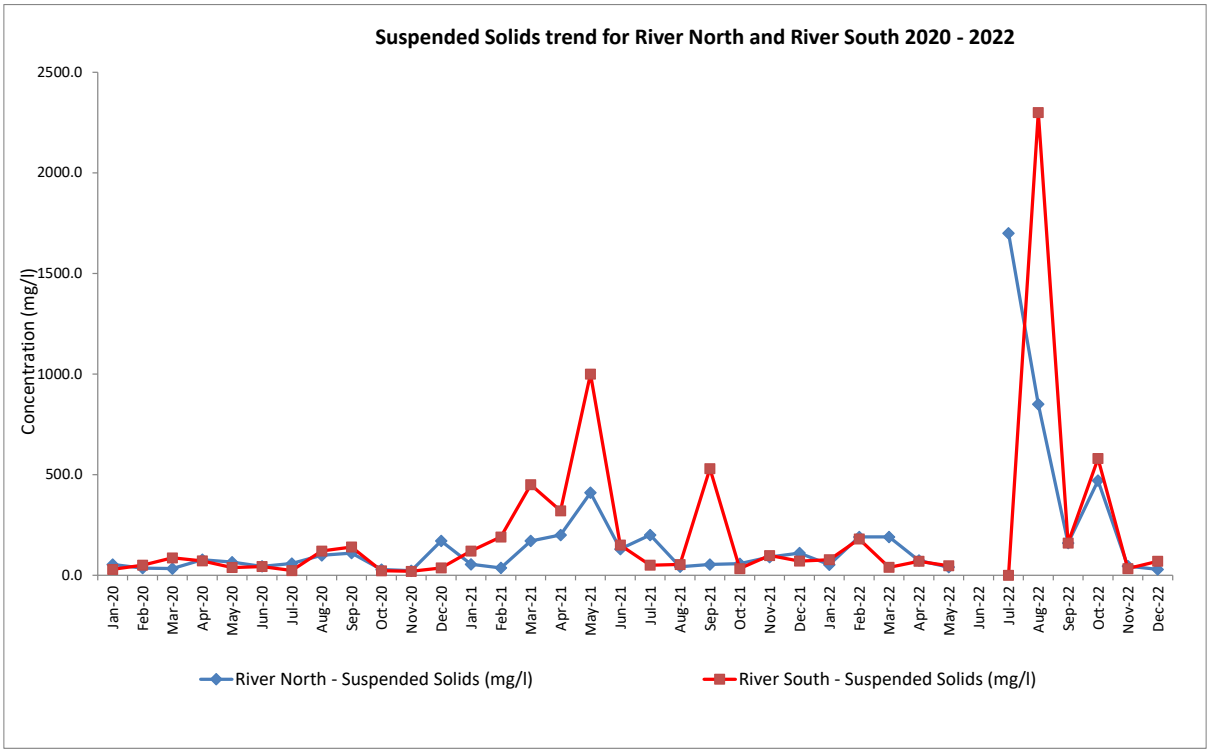
The COD towards the end of 2022 correlate well and are at much lower concentrations.

There is no order of magnitude differences between the COD results upstream and downstream. The most significant differences between the samples are:

- January: River North at 5000mg/l and River South at 3000mg/l
- March: River North at 3100mg/l and River South at 750mg/l

The BOD results have correlated well across recent years between River North and River South, although the results at the end of 2022 show some fluctuation.

The most recent data would suggest that a source north of the landfill is impacting on the COD results recorded.



Following low concentrations and good correlation in 2020, the suspended solids results show more fluctuation and elevated spikes in 2021, with even more significant spikes in 2022. The River South samples have typically recorded higher concentration than River North, although the most significant difference is in July where upstream recorded 1700mg/l and downstream <2mg/l. Although impact from the landfill cannot be discounted, the tidal nature of the river and the location of these monitoring points may be a factor.

Note - There is no control or trigger level set for the any of the parameters monitored at these monitoring locations except ammoniacal nitrogen.

4.5 Recommendations for Surface Water Monitoring

Based on the 2022 data the control and trigger levels for the River and Canal monitoring locations remain relevant. No recommendations to change the surface water monitoring is considered necessary.

5 Landfill Gas Monitoring

This section provides a summary of the perimeter gas monitoring at Giants Grave for 2022 as required by the environmental permit EPR/SP3298FT and Appendix A1 of the Landfill Aftercare Plan.

5.1 Landfill Gas Monitoring Locations

5.1.1 Perimeter Gas Monitoring Locations

Perimeter gas monitoring is undertaken from a total of 16 boreholes around the landfill site. The locations of these perimeter gas monitoring points are shown on the sampling location plan in Appendix E.

Perimeter gas is monitored from eleven boreholes to the north and east of the capped and restored area of the site. These boreholes are located as follows:

- Boreholes BH9B, BH7B, BH5B and BH3W are located on the northern boundary of the site in a clockwise direction from the northern tip of the site proceeding southeast along the northern boundary; and
- Boreholes BH1B, BH49W, BH47W, BH45B, BH43B and BH40B are located along the eastern boundary adjacent to the canal in a clockwise direction from the north-eastern tip of the site proceeding southwest along the eastern boundary.
- Borehole BH55B is located to the east of the site on the opposite side of the Neath Canal on latitude just north of BH45B.

The monitoring from along the western edge of the site comprises boreholes BH4, BH5 and BH8. These boreholes are located along the eastern boundary of the Western Extension Area (towards the bottom of the west bund of the Cut).

The monitoring from within the Southern Extension Area comprises boreholes BH12 and BH15. These boreholes are located as follows:

- Borehole BH12 is located towards the middle of the Southern Extension Area; and
- Borehole BH15 is located at the bottom of the river bund on the western edge of the extension area.

5.1.2 In-Waste Landfill Gas Monitoring Locations

It is understood that the in-waste landfill gas monitoring is conducted at the monitoring point locations Manifolds A to D, although this information has not been received or reviewed by C&P Environmental Ltd.

Annual report requirements for the landfill gas elements of the permit are provided in Appendix F.

5.2 Landfill Gas Monitoring Requirements

5.2.1 Perimeter Gas Monitoring Requirements

Tables 5A summarises the perimeter gas monitoring requirements of the environmental permit EPR/SP3298FT and Landfill Aftercare Plan.

Table 5A – Perimeter Landfill Gas Monitoring Schedule

Monitoring Point	Parameter	Monitoring Frequency
North: BH3W, BH9B, BH5B, BH7B East: BH1B, BH40B, BH43B, BH45B, BH47W, BH49W, BH55B South: BH12, BH15 West: BH4, BH5, BH8	Oxygen, Temperature, Atmospheric Pressure, Differential Pressure, Carbon Monoxide, Meteorological Conditions	Monthly
	Methane	Monthly
	Carbon Dioxide	Monthly

Some locations were unable to be monitored in June 2022 due to access issues. These are detailed below Table 5D and in Appendix D.

5.2.2 In-Waste Landfill Gas Monitoring Requirements

Tables 5B summarises the in-waste gas monitoring undertaken on a monthly schedule at Giants Grave landfill site (Schedule 3, Table 3.8 of the environmental permit). As no data is provided by the monitoring contractor for the in-waste landfill gas wells then it cannot be confirmed that the monitoring regime was complied with. Annual report requirements for the landfill gas elements of the permit are provided in Appendix F.

Table 5B – In-Waste Landfill Gas Monitoring Schedule

Monitoring Point	Parameter	Monitoring Frequency
All gas collection wells and any other (in-waste) gas monitoring points	Methane, Carbon Dioxide, Oxygen, Balance gas, Atmospheric Pressure, Differential Pressure, Carbon Monoxide, Meteorological Conditions	Monthly
	Hydrogen sulphide	Six-monthly

5.3 Perimeter Gas Control and Trigger Levels

The control and trigger levels for perimeter landfill gas monitoring for 2022 are presented as a single action level for carbon dioxide and an action and compliance level for methane. No methane action or compliance levels are currently applicable for unstable data – including for boreholes BH3W, BH40B, BH43B and BH45B. The environmental permit EPR/SP3298FT does not state any limits for carbon dioxide.

The compliance limits are detailed in Schedule 3, Table 3.6 of the environmental permit. These levels are presented in Table 5C below.

Table 5C – Perimeter Gas Emission Action and Compliance Levels

Borehole	Data Stability	CO_2 Action %	CH_4 Action %	CH_4 Compliance %
Northern boundary				
BH3W	Unstable	8.4 [2]	n/a [2]	n/a [2]
BH5B	Stable	1.4	0.9	1.4
BH7B	Stable	1.1	0.7	1.2
BH9B	Stable	1.2	0.7	1.2
Western boundary (Western Extension)				
BH4	Stable	2.0	0.7	1.2
BH5	Stable	3.5	0.7	1.2
BH8	Stable	1.6	0.7	1.2
Southern boundary (Southern Extension)				
BH12	Stable	1.9	0.7	1.2
BH15	Stable	3.1	0.7	1.2
Eastern boundary				
BH1B	Stable	2.7	3.6 (1.3)[1]	4.1 (1.8)[1]
BH40B	Unstable	4.7	n/a	n/a
BH43B	Unstable	12.8	n/a	n/a
BH45B	Unstable	13.9	n/a	n/a
BH47W	Stable	4.5	2.5	3.0
BH49W	Stable	4.8	0.9	1.4
BH55B	Stable	7.9	0.9	1.4

Note 1 – for BH1B the 2017 annual report recalculated the CH_4 compliance and action levels which indicated the concentrations of 1.3% and 1.8% respectively were more relevant. However, the permit remains at 4.1% as a compliance level for CH_4. The review of this gas quality below considers each of these levels.

Note 2 – for BH3W the 2017 annual report recalculated the action and compliance levels as: CH_4 action and compliance levels at 1.1% and 1.6% respectively; CO_2 action at 3.1%. However, the permit does not currently state a compliance level for CH_4. More recent data may suggest the carbon dioxide action level is no longer appropriate. These recalculated levels have not been included in the Table 5C. The gas quality in borehole BH3W is further discussed below.

There is no control and trigger levels for in-waste landfill gas monitoring, although the gas extraction system is subject to management and control systems as detailed by the Landfill Gas Management Plan.

5.4 Landfill Gas Monitoring Results and Data Assessment

5.4.1 Perimeter Landfill Gas Monitoring

A summary of the perimeter gas monitoring data obtained during 2022 is presented in Table 5D with the full results provided in Appendix D.

Table 5D – Summary of Perimeter Gas Monitoring

Borehole	Methane (%v/v)				Carbon Dioxide (%v/v)		
	Mean	Maximum	Action level breach	Compliance limit breach	Mean	Maximum	Action level breach
Northern Boundary							
BH3W	0.1	0.4	-	-	2.2	4.5	CO_2 >3.1% on 2 occasions (see Note 1)
BH5B	0.1	0.3	-	-	0.2	0.3	-
BH7B	0.1	0.3	-	-	0.3	0.6	-
BH9B	0.1	0.2	-	-	0.3	0.9	-
Western Boundary (Western Extension)							
BH4	0.1	0.2	-	-	1.4	4.2	Jan, Feb, Mar, Apr
BH5	0.1	0.3	-	-	2.2	5.7	Aug, Sept
BH8	0.1	0.3	-	-	1.5	3.5	Jan, Mar, Apr, Jul & Oct
Southern Boundary (Southern Extension)							
BH12	0.2	0.4	-	-	0.7	1.2	-
BH15	0.1	0.3	-	-	1.4	2.7	-
Eastern Boundary							
BH1B	0.1	0.4	-	-	0.7	1.7	-
BH40B	30.7	79.0	n/a	n/a	2.2	6.1	Apr
BH43B	57.8	89.6	n/a	n/a	8.5	12.5	-
BH45B	42	65.3	n/a	n/a	6.7	13.7	-
BH47W	0.1	0.4	-	-	0.5	1.4	-
BH49W	0.1	0.4	-	-	0.5	1.3	-
BH55B	0.1	0.3	-	-	5.2	7.9	-

General note – The mean concentrations for methane and carbon dioxide have been rounded to one decimal place.

NOTE 1 There is no permit compliance limit set for borehole BH3W as the gas data for this location has been unstable in the past. A compliance limit of 1.6% was calculated following the 2017 annual report review and this level was not exceeded during 2022. For carbon dioxide, the action level for BH3W was recalculated to be 3.1% (from 8.4%). This proposed revised action level has not been implemented into the Landfill Aftercare Plan but if it had been, then the carbon dioxide readings from January 2022 & February 2022 would have exceeded. Due to the change in gas conditions at this borehole then these revised levels may not be applicable but are further discussed below.

Locations and months where monitoring was unable to be completed fully:

- *Unable to access BH3W, BH5B, BH9B, BH47W & BH49W in July 2022 due to overgrown conditions*

Permit compliance limit breaches - methane

There were no permit compliance limit breaches for methane during 2022.

This follows no breaches in 2021 and 2020. The last breach of a perimeter gas compliance limit was in 2019 (BH12 in September).

Action level exceedances - methane

There were no action level exceedances for methane during 2022, as was the case for 2021 and 2020.

Action level exceedances – carbon dioxide

The action level for carbon dioxide was exceeded on several occasions in the boreholes around the perimeter of the site:

Northern Boundary

- Note – the aftercare action level of 8.4% for BH3W was not exceeded during 2022, although the 2017 recalculated action level of 3.1% would have been exceeded on two occasions during 2022 (January and February).

Western extension

- BH4 on four occasions: January through to April inclusive
- BH5 on two occasions: August and September
- BH8 on five occasions: January, March, April, July and October

Southern extension – no exceedance of the carbon dioxide action levels

Eastern boundary

- BH40B on one occasion - April

a) Northern boundary boreholes

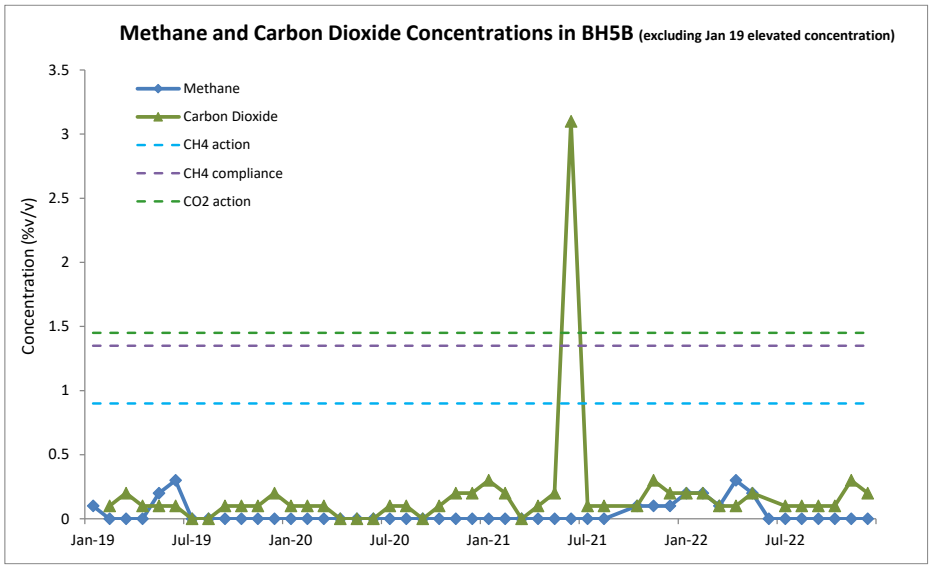
A review of the gas conditions in the northern boundary boreholes is provided below, although none of the locations recorded any exceedances of a permitted action or compliance level for methane.

Unless noted the carbon monoxide concentrations were at or below 1ppm throughout 2022.

Borehole BH5B

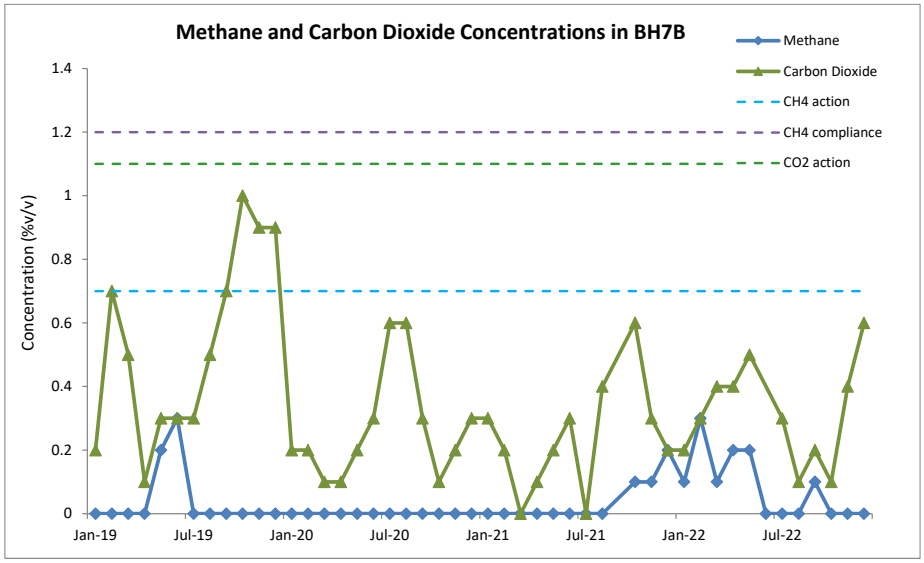
BH5B has not recorded any elevated carbon dioxide or methane in 2022 – and there has been no repeat of the elevated carbon dioxide spikes in January 2019 (21.1%) and June 2021 (3.1%). The highest methane reading was at 0.3% with all carbon dioxide at 0.3% or below. No adverse trends in gas conditions noted at this location.

Note that the graph below does not include the January 2019 level to allow the recent trends to be more clearly observed.



Borehole BH7B

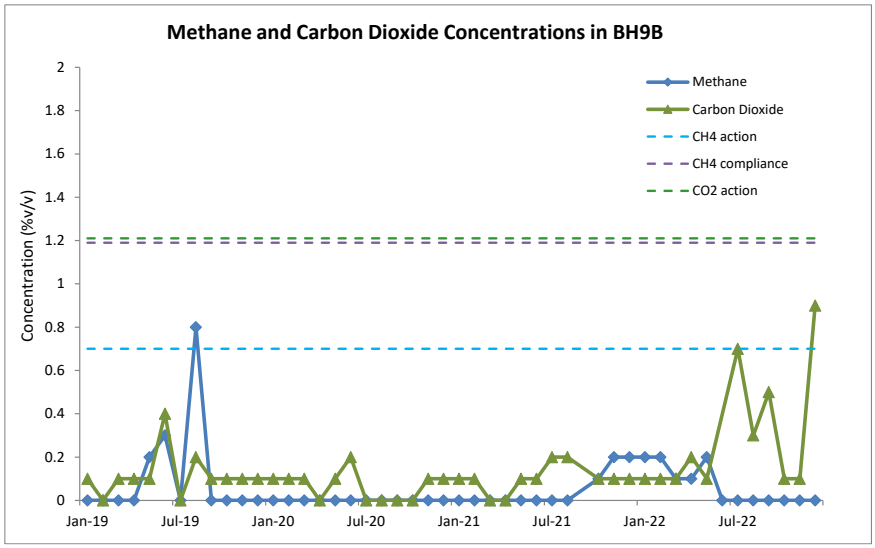
Methane has been recorded at this location at up to 0.3% in early 2022 although this remains well below the methane action level of 0.7% at this location. The carbon dioxide continues to show fluctuation but remains well below the action level of 1.1%. No adverse trends in gas conditions noted at this location.



Borehole BH9B

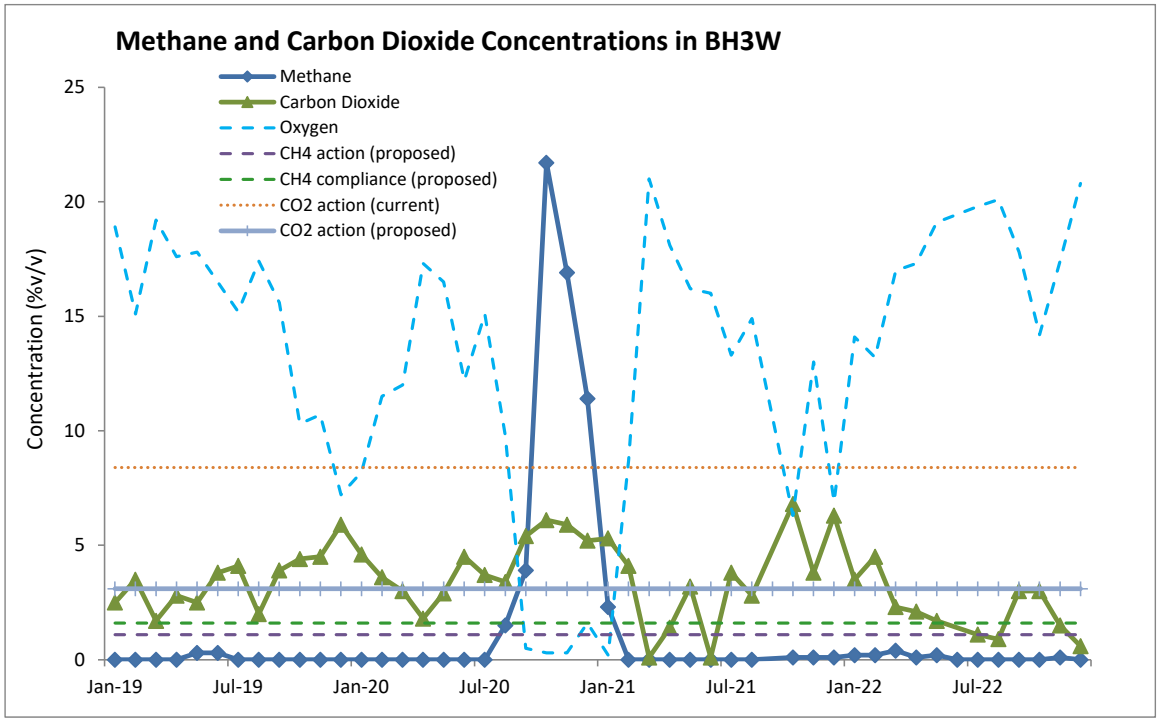
BH9B has recorded no elevated methane detection since the elevated concentration of 0.8% in August 2019, although several readings in 2022 of 0.2%.

The carbon dioxide concentrations remain generally low when compared with the action level of 1.2% with the highest being 0.8% in December. The most recent readings indicate a change in the gas conditions and more fluctuation in the results.



Borehole BH3W

The most significant perimeter gas concern across the site in recent years was the elevated methane presence in borehole BH3W. However, the 2022 data does not record any significantly elevated methane (with the highest being 0.4%). There is no permit compliance limit set for methane at this location and the 2022 data falls well below the potential recalculated levels from 2017.



The carbon dioxide concentrations were well below the current action level of 8.4% with the highest reading of 4.5%. The oxygen concentrations continue to fluctuate with the lower oxygen concentrations concurrent with the higher carbon dioxide concentrations. The lowest oxygen concentrations were at approximately 15% and were concurrent with the highest carbon dioxide readings.

The graph includes the Landfill Aftercare Plan carbon dioxide action level of 8.4% which, based on data since 2019, seems to be set at an appropriate level. The graph has also retained the proposed methane compliance limit at 1.6% which also appears to be an appropriate level. Future annual reports will consider against these two levels (even though there is no specific compliance limit in the permit).

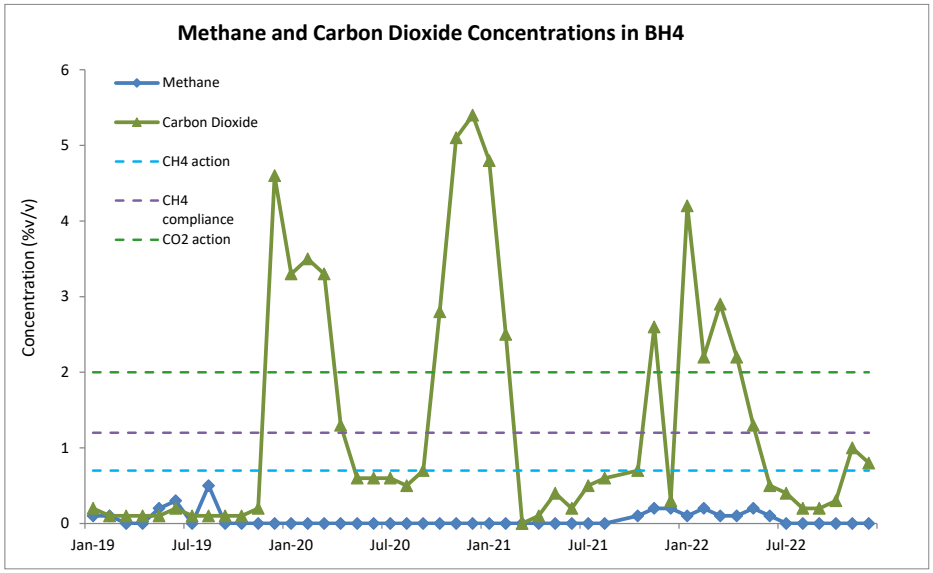
b) Western boundary boreholes

A review of the gas conditions in the western boundary boreholes is provided below, although none of the locations recorded any exceedances of a permitted action or compliance level for methane.

Unless noted the carbon monoxide concentrations were at or below 1ppm throughout 2022.

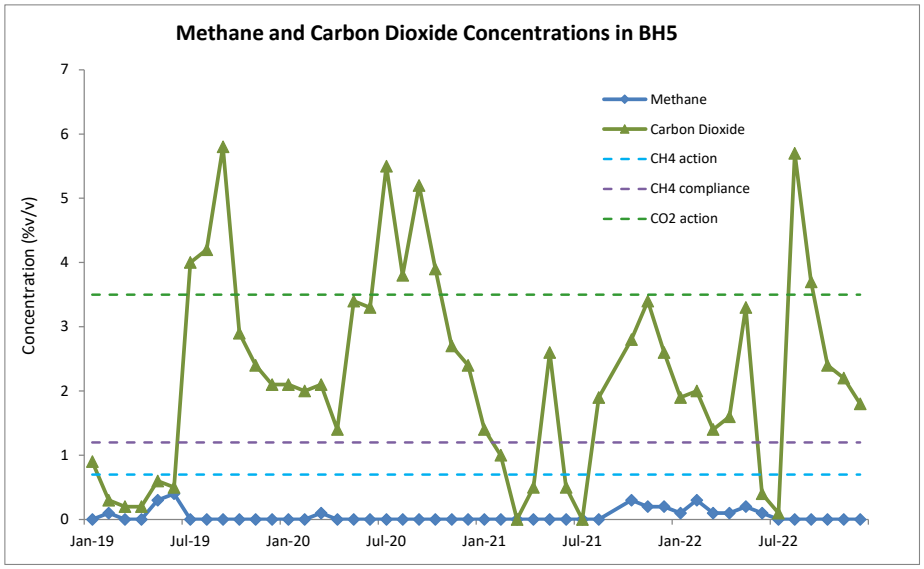
Borehole BH4

No elevated methane recorded in BH4 in 2022 with the highest at 0.2%. Elevated carbon dioxide at above the action level of 2.0% between January and April has been recorded, although subsequent readings were all at or below 1.3%. The elevated carbon dioxide shows a potential seasonal pattern of higher concentrations during the winter months. No adverse trends noted in the gas conditions at this location.



Borehole BH5

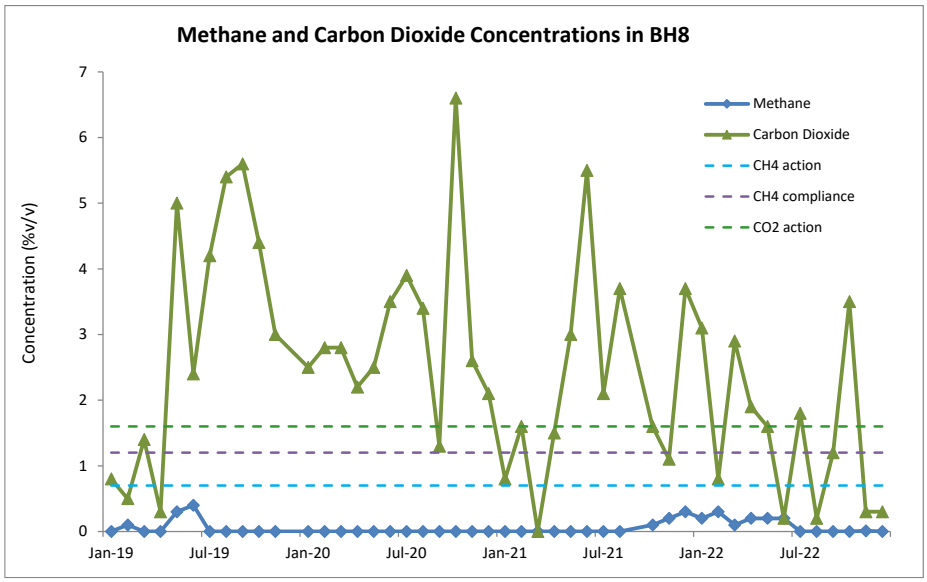
No methane detection at above 0.3% throughout 2022 and all readings from July at 0%. The carbon dioxide concentration continues to fluctuate considerably with two readings (August and September) exceeding the action level of 3.5%, although subsequent results recording lower concentrations. Overall, the 2022 data continues a similar pattern to recent years and no adverse trends noted.



Borehole BH8

No methane detection at above 0.3% throughout 2022, with the highest readings across the early part of the year (including the highest at 0.3% in February – which is like many other locations).

The carbon dioxide continues to fluctuate at concentrations that frequently exceed the carbon dioxide action level of 1.6% (five occasions during 2022). This pattern of elevated and fluctuating carbon dioxide has been observed since early 2019 and no adverse trends noted overall. A low oxygen level at 4.2% recorded in January but otherwise 16% or above.



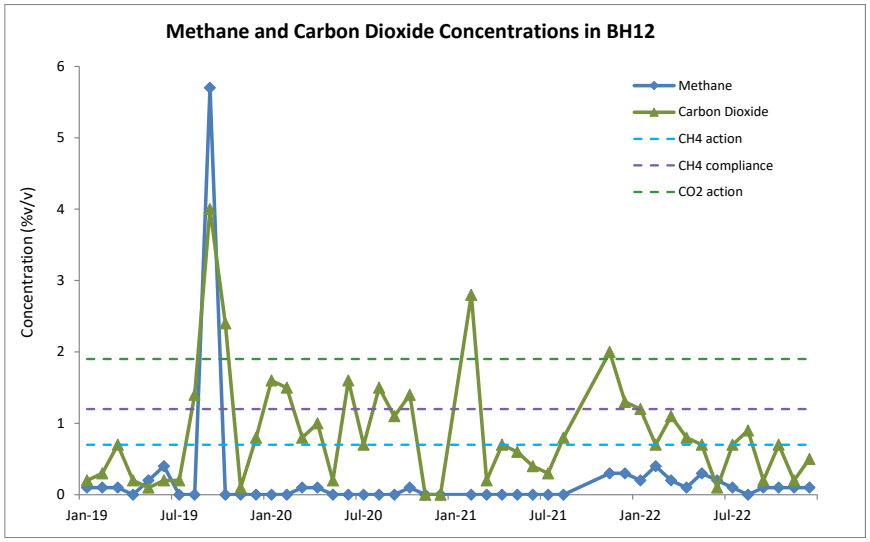
c) Southern boundary boreholes

A review of the gas conditions in the southern boundary boreholes is provided below, although none of the locations recorded any exceedances of a permitted action or compliance level for methane. All carbon monoxide concentrations were at or below 1ppm throughout 2022.

Borehole BH12

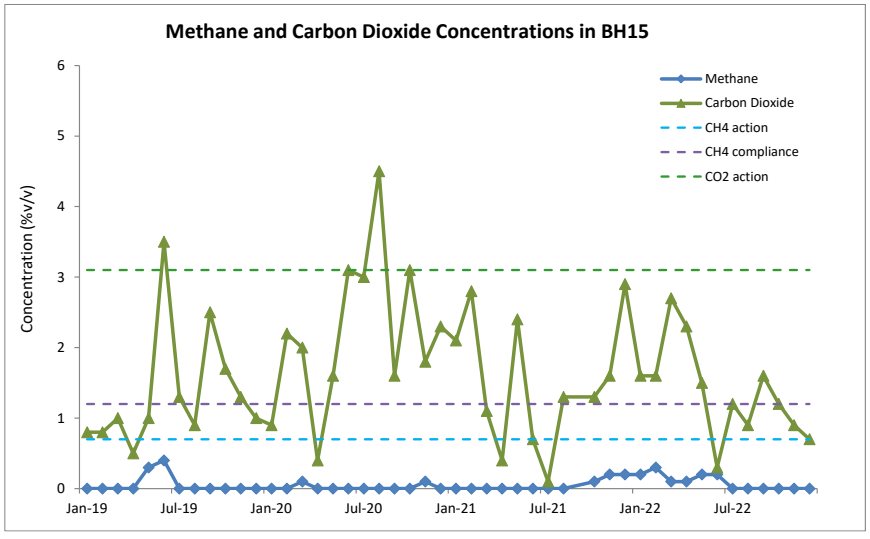
The elevated spike of methane recorded in 2019 has not been repeated since. The carbon dioxide concentrations continue to fluctuate with occasional detections above the action level over the years (although none in 2022). No adverse trends in gas conditions noted at this location.

Like several of the boreholes across the site, the methane is positively detected across early 2022 including the highest concentration of 0.4% in February.



Borehole BH15

No methane detection at above 0.3% throughout 2022 (and these detections were like other boreholes with the highest in February). The carbon dioxide concentration continues to fluctuate, although remained below the action level of 3.1%.



d) Eastern boundary boreholes

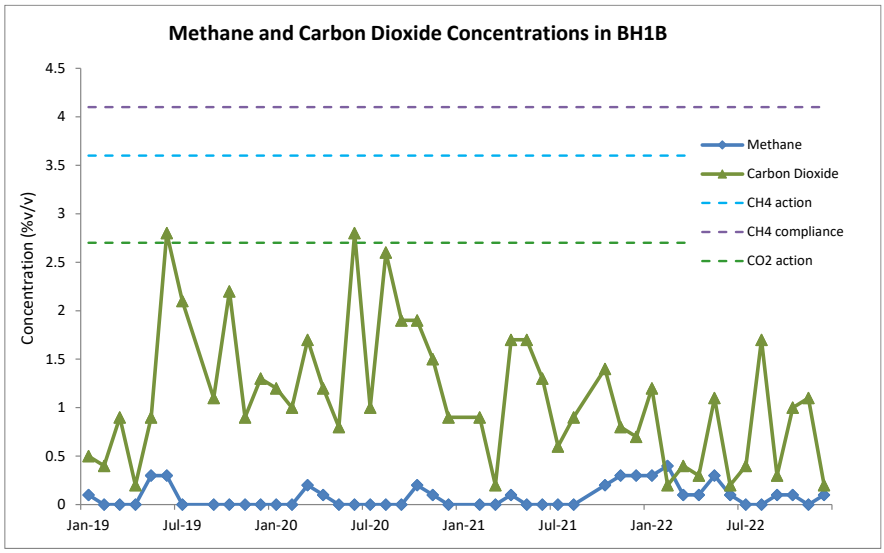
A review of the gas conditions in the eastern boundary boreholes is provided below, although none of the locations recorded any exceedances of a permitted action or compliance level for methane.

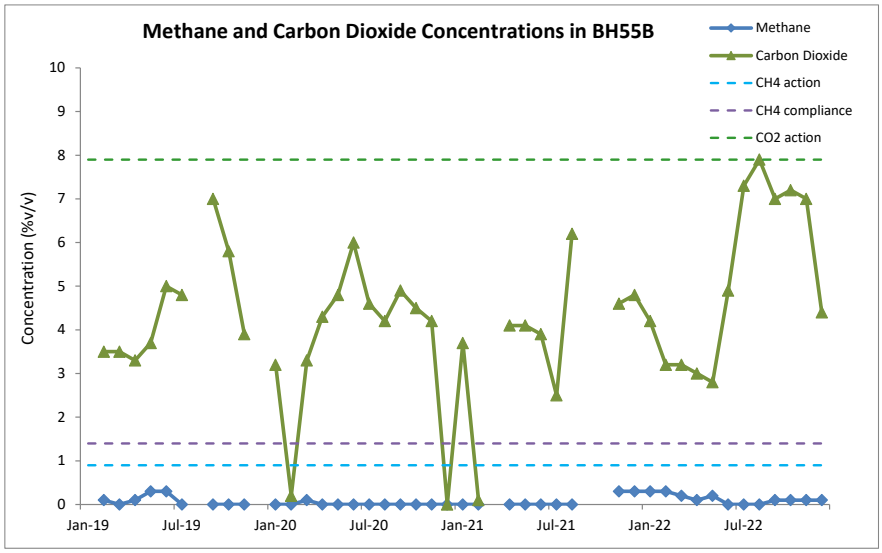
The locations BH40B, BH43B and BH45B recorded some detection of carbon monoxide as described below, although the remaining locations were all at or below 1ppm throughout 2022.

Boreholes BH1B and BH55B

Occasional trace presence of methane detected in BH1B (up to 0.4%) and BH55B (up to 0.3%) although the highest concentrations are at the start of the year (including February) as has been observed in many other locations. Overall, there is no adverse trend noted for the methane in these boreholes.

The carbon dioxide fluctuates in both locations, although remains below the action levels relevant to each borehole. Although for BH55B, the readings between July and November (7% or more including 7.9% in August) were elevated compared to recent years.





Note: for BH1B, the 2017 annual report recalculated the action and compliance levels for methane: action level of 1.3% and compliance level of 1.8% *(compared to those previous calculated at 3.6% and 4.1% respectively)*. The methane remained below these respective levels, and it continues to be recommended that the recalculated levels would be more appropriate for ongoing monitoring for this location and should be added into the next review of the Landfill Aftercare Plan.

Boreholes BH40B, BH43B and BH45B

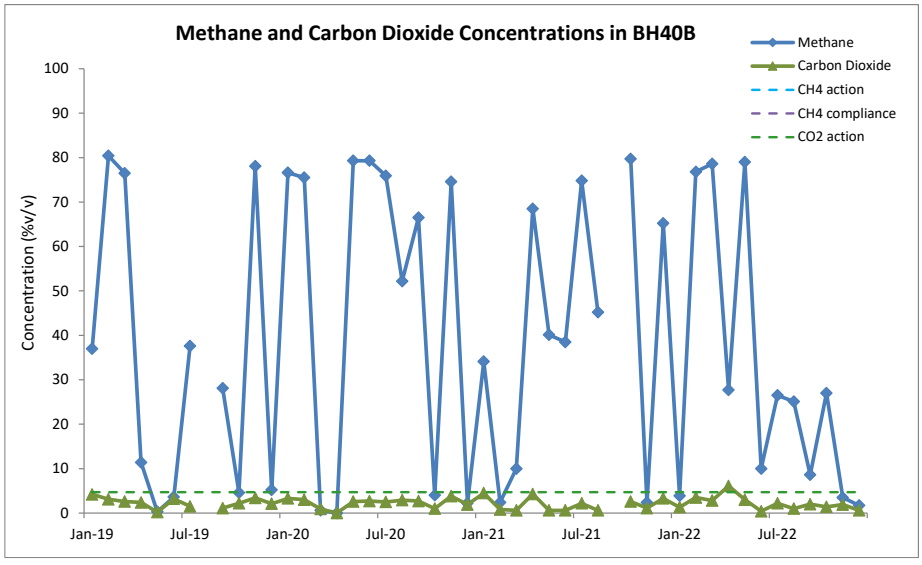
Elevated methane continues to be recorded in the boreholes BH40B, BH43B and BH45B as has been the case over recent years. These boreholes have continued the pattern of methane concentrations recorded in recent years, although borehole BH43B has recorded a more fluctuating pattern in 2022 compared with 2019 - 2021.

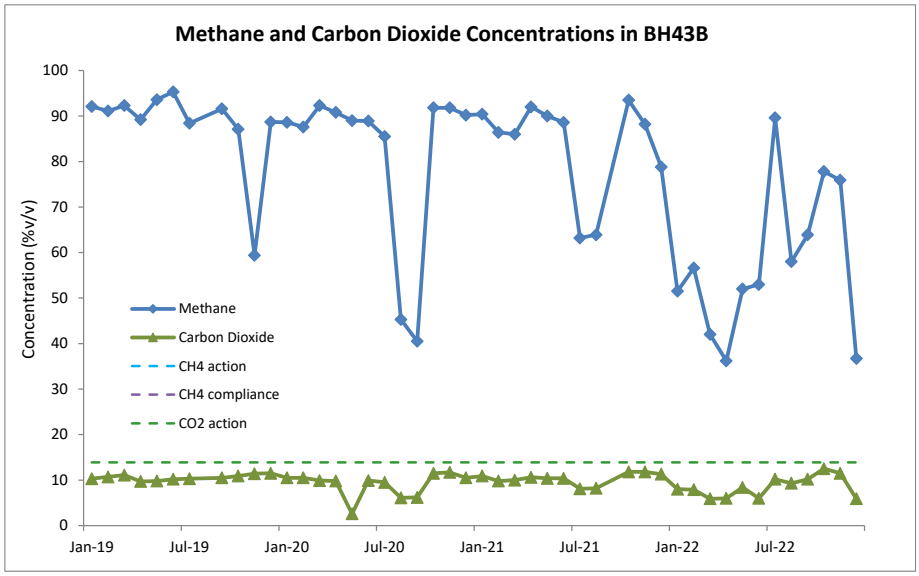
Elevated concentrations of methane have consistently been observed in these boreholes and this is in line with historic data. A risk assessment (repeated in 2013) has previously been undertaken which indicated the elevated concentrations did not pose a risk to human health. It is believed that the landfill gas measured in these wells is from waste buried beneath the surface outside the landfill boundary and therefore outside the influence of the on-site gas control infrastructure. Due to the elevated methane and unstable gas conditions, no action levels or compliance limits for methane have been set on these wells.

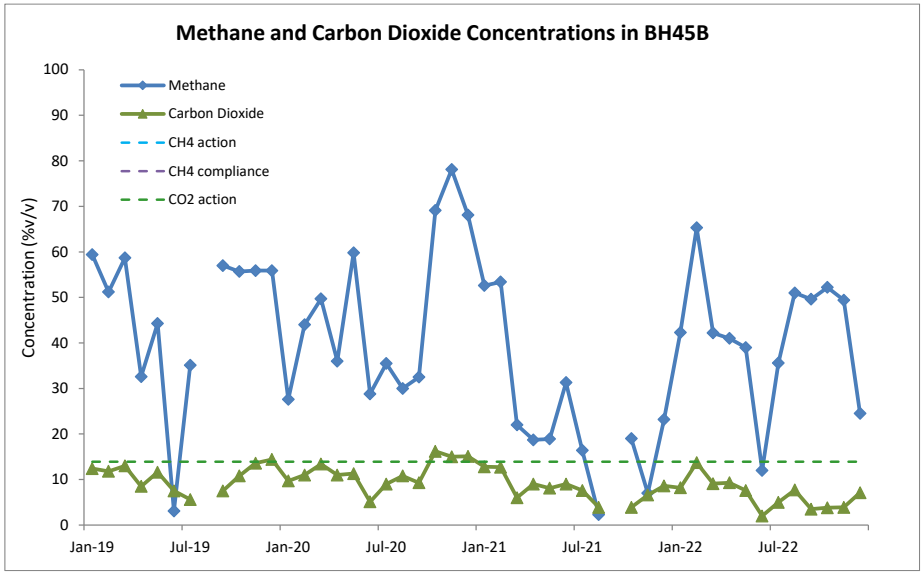
Each of these boreholes records relatively consistent and low carbon dioxide concentrations and (when elevated methane detected) an almost fully depleted oxygen gas regime. The elevated methane but lower carbon dioxide would suggest there is some carbon dioxide removal mechanism within the sub-surface.

Although no compliance or actions levels are set for methane, the boreholes have carbon dioxide action levels due to the relatively consistent carbon dioxide data. For 2022 there was a single exceedance of the action level in BH40B (April).

Carbon monoxide is recorded in BH40B and BH43B at up to 13ppm. Although not elevated these are the highest concentrations recorded across the site.



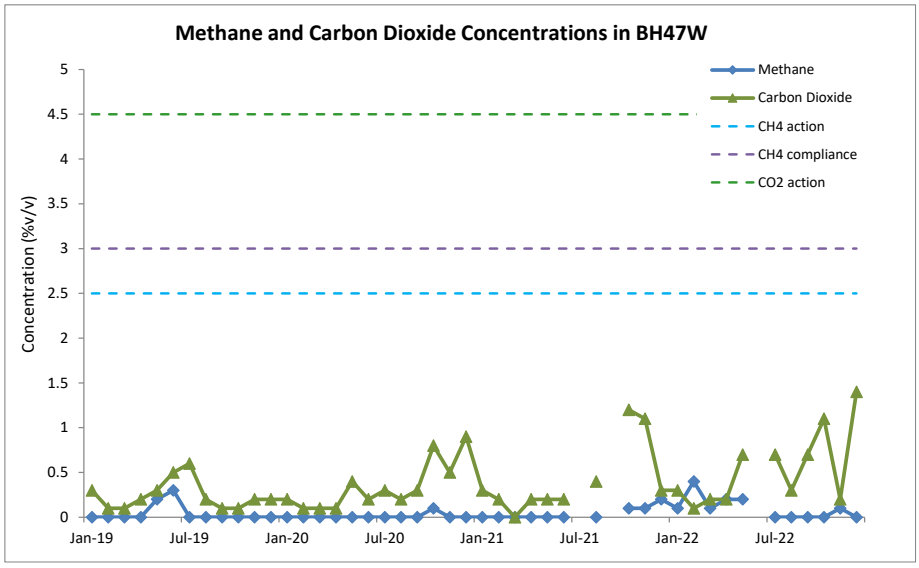


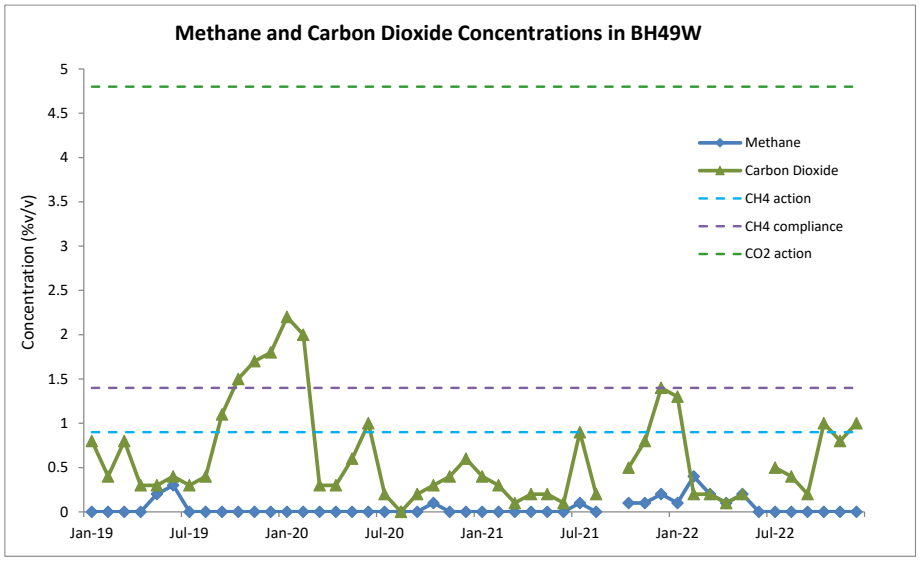


Boreholes BH47W and BH49W

Like several of the boreholes across the site, the methane is positively detected early in 2022 including the highest concentrations recorded in February at 0.4% at each location. The concentrations remain low and well below the methane action and compliance levels.

Both locations record a fluctuating carbon dioxide pattern with highest readings of 1.4% (BH47W) and 1.3% (BH49W) which remain well below the action levels at over 4.5%. No adverse trend in carbon dioxide is observed based on the 2022 data.


Methane and Carbon Dioxide Concentrations in BH47W
Concentration (%v/v)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Methane
Carbon Dioxide
CH4 action
CH4 compliance
CO2 action


Methane and Carbon Dioxide Concentrations in BH49W
Concentration (%v/v)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-19
Jul-19
Jan-20
Jul-20
Jan-21
Jul-21
Jan-22
Jul-22
Methane
Carbon Dioxide
CH4 action
CH4 compliance
CO2 action

5.4.2 In-Waste Landfill Gas Monitoring

Any data collected from the in-waste landfill gas wells during 2022 has not been provided for compilation of this annual report. Therefore, this report does not include any review of the in-waste gas data.

Appendix F includes the data collected on the following:

1. Annual Performance Report
2. Weekly, Monthly and Six-Monthly Monitoring Data
3. Annual Emissions Testing
4. Annual Trace Gas Analysis
5. Quarterly Engine Emissions
6. C&P - Surface Emissions Survey (results described in section 5.4.3)

5.4.3 Surface Emissions Monitoring

In accordance with the requirements in Table 3.7 of the permit and agreement with NRW, the annual surface emissions monitoring was undertaken, although this was during January 2023 rather than the calendar year 2022. This was in the form of a surface emissions survey undertaken by Enitial.

A TDL Laser Methane Detector instrument was used to undertake the survey which detects methane from 0ppm to 100% with a resolution of 1ppm. A Mobile Data Collector utilising a Differential GPS receiver was connected to the TDL providing continuous GPS and time stamped data logging.

The survey was undertaken as per the predetermined survey plan. During the survey, the surface was scanned at a distance not exceeding 5cm above the surface whilst a steady walking pace was maintained. In the event of excessive vegetation and / or other obstruction preventing surface scanning at <5cm, the TDL500 probe was held as close to the surface as possible. It is to be noted that some locations of the survey were inaccessible due to areas of dense vegetation, particularly on the southern and western slopes.

Landfill gas and leachate extraction / monitoring infrastructure was included in the survey. In surveying such features, all potential emission points of the feature were monitored. The data logging parameter was set to reflect if the surface or an infrastructure location was being surveyed to allow this data to be filtered out and assessed separately at the reporting stage.

The full report is provided in Appendix F.

Weather conditions encountered were predominantly medium level cloud or sunny intervals with light winds (with highest being at 11mph on day 3 of the monitoring). The ground conditions encountered were wet with a light frost at the start of day 2.

It is recommended that the surface emissions survey is completed in the summer to autumn months of the year.

It is to be noted that some locations of the survey were inaccessible due to areas of dense vegetation, particularly on the southern and western slopes. It is recommended to ensure access to as much of the site as possible prior to the next surface emissions survey.

Landfill surface emissions survey results

The reports from previous years averaged out readings for each 10m-by-10m grid and did not record many significant surface emission features. The readings from January 2023 do not include such averaging and record more frequent elevated single and multiple results.

A total of 30,373 methane concentration readings were recorded during the survey of the landfill surface of which 99.0% were <100ppm and within the assessment criteria outlined in Section 3.2 of the report.

Table 3.3 summarises the 11 discrete locations where concentrations were recorded ≥100ppm from the surface. This table is provided on page 8 of the report and reproduced below. The surface emission survey schematic highlights maximum concentrations across all accessible areas on site.

Table 3.3 Surface locations above Assessment Criteria

Data Ref	Reference	Easting	Northing	Peak Concentration (ppm)	Comment
5844	Surface 1	273639	195909	4,196	Isolated area of surface
11453	Surface 2	273482	195740	1,191	Isolated area of surface
27317	Surface 3	273155	195455	1,433	Areas of surface along base of slope
27396	Surface 4	273142	195456	389	Areas of surface along base of slope
27978	Surface 5	273185	195475	787	Isolated area of surface
28072	Surface 6	273184	195483	170	Multiple areas of surface
29201	Surface 7	273144	195601	390	Multiple areas of surface
29426	Surface 8	273138	195582	347	Multiple areas of surface
29465	Surface 9	273145	195585	1,115	Multiple areas of surface
30707	Surface 10	273156	195649	113	Isolated area of surface
30866	Surface 11	273155	195625	1,267	Isolated area of surface

Surface 1 and 2 locations are in the north-eastern area and central location of the site respectively, with Surface locations 3 to 11 being clockwise along the accessible areas of the southern and western flanks of the site.

The LFTGN07 guidance states that if a walkover survey demonstrates the cap is not consistent and there are discrete features emitting substantial amounts of landfill gas, remedial action is required as soon as practically possible.

Large surface fissures in landfill capping do not comply with current best practice for site restoration. Irrespective of the gas concentration close to these features, it should be assumed some remedial action will be necessary.

Therefore, it is recommended that an action plan is considered and implemented to remediate the discrete locations of the surface recording elevated methane. This should initially focus on surface areas 1 and 2 but also consider the potential issues and reasons for surface emissions along the flanks.

To understand the issues better, the actions should initially consider visual inspections and determining whether there are any obvious surface cracks or fissures or evidence of vegetation stress (photographical evidence should be obtained). Subsequent remediation measures should then be considered and implemented.

Note – the aftercare plan for the site does not specifically consider actions for discrete surface emissions features.

Overall, the average surface emissions from across the site are not elevated, but there are several discrete features of elevated methane emissions through the cap. The 2022 survey (undertaken in early 2023) has determined these features which were not found as part of the 2021 surface emissions monitoring.

Due to the determination of these discrete features then action plans must be considered and implemented to remediate the locations.

Infrastructure surface emissions survey results

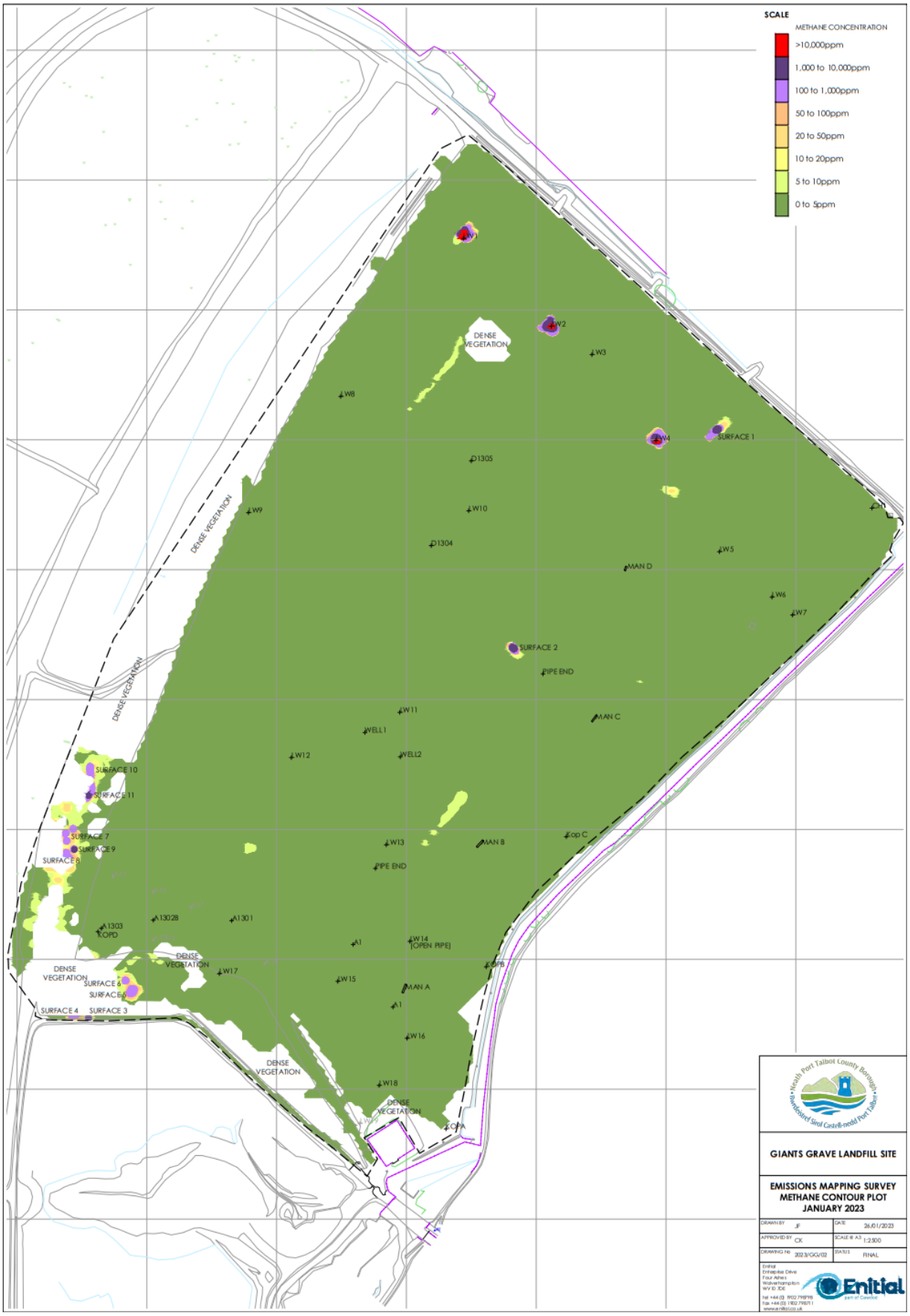
A total of 38 infrastructure locations were monitored during this survey. Table 3.4 summarises the 3 locations where concentrations were recorded ≥1,000ppm.

Table 3.4 Infrastructure locations above Assessment Criteria

Data Ref	Infrastructure ID	Easting	Northing	Peak Concentration (ppm)	Comment
6895	LW2	273512	195988	13,384	Around well / surface inside chamber
7080	LW1	273443	196056	30,732	Around base of outer HDPE chamber
7800	LW4	273593	195899	12,179	Around well / surface inside chamber

The survey found three discrete features being the leachate wells LW1, LW2 and LW4.

These leachate wells should be remediated to minimise the methane emissions from round these wells.


SCALE
METHANE CONCENTRATION
>10,000ppm
1,000 to 10,000ppm
100 to 1,000ppm
50 to 100ppm
20 to 50ppm
10 to 20ppm
5 to 10ppm
0 to 5ppm
DENSE VEGETATION
SURFACE 1
SURFACE 2
SURFACE 3
SURFACE 4
SURFACE 5
SURFACE 6
SURFACE 7
SURFACE 8
SURFACE 9
SURFACE 10
SURFACE 11
PIPE END
MAN A
MAN B
MAN C
MAN D
WELL1
WELL2
GIANTS GRAVE LANDFILL SITE
EMISSIONS MAPPING SURVEY
METHANE CONTOUR PLOT
JANUARY 2023
Enitial

5.5 Summary and Recommendations for the Perimeter Gas Monitoring Programme

There are no recommendations for change in the perimeter gas monitoring programme with respect to the frequency and parameters monitored.

Positive detections but low concentrations of methane were recorded in many locations at the start of 2022 with the highest readings typically in February. These higher readings are suspected to be due to gas analyser drift and was a continuation from the late 2021 readings.

No boreholes showed a significant adverse trend or spike in methane and no exceedances of the methane compliance or action levels were observed.

There were several locations that recorded an exceedance of the carbon dioxide action level on one or more occasions in 2022. These were:

- BH4, BH5 and BH8 (western boundary)
- BH40B (eastern boundary)

Although some fluctuating results and some spikes in carbon dioxide there were no obvious adverse trends noted.

It is recommended that the revised action levels and compliance limits for borehole BH1B are more appropriate for ongoing monitoring and to determine any significant change in gas quality. These revised concentrations ought to be included in the next revision of the Landfill Aftercare Plan.

Similarly, several locations seem to show a change in gas quality (specifically carbon dioxide) and the action levels should be considered for these to make sure they are fit for purpose. This would include the locations BH4, BH5 and BH8. The proposed methane action and compliance levels for BH3W would continue to be recommended for inclusion in the next revision to the Landfill Aftercare Plan.

For the surface emissions survey in 2022 (undertaken early 2023) there were several surface areas recording elevated methane emissions plus three discrete leachate wells (LW1, LW2 and LW4).

Actions should be implemented to first understand the locations of these elevated surface emissions and determine whether any obvious fissures and cracks present. Remediation of these locations should then be implemented to try and minimise such methane emissions.

The three leachate wells should be remediated to try and prevent any significant methane emissions.

Further recommendations from the surface emissions survey:

- It is recommended that the surface emissions survey is completed in the summer to autumn months of the year.

- It is to be noted that some locations of the survey were inaccessible due to areas of dense vegetation, particularly on the southern and western slopes. It is recommended to ensure access to as much of the site as possible prior to the next surface emissions survey.

Appendices

Appendix A - Leachate Monitoring Data

A1 - Leachate Level Monitoring Data

Monitoring location		Borehole Levels	Borehole Depth	Difference
		mbTOC	mbTOC	m
LW1	Jan-22	4.96	4.98	0.02
	Feb-22	4.95	4.98	0.03
	Mar-22	4.98	4.98	0
LW1	Apr-22	4.97	4.98	0.01
	May-22	4.96	4.98	0.02
	Jun-22	no results		
LW1	Jul-22	4.2	4.98	0.78
	Aug-22	dry	4.98	dry
	Sep-22	dry	4.98	dry
LW1	Oct-22	4.02	4.98	0.96
	Nov-22	4.13	4.98	0.85
	Dec-22	3.81	4.98	1.17
LW3	Jan-22	6.94	7.64	0.7
	Feb-22	7.03	7.64	0.61
	Mar-22	7.02	7.66	0.64
LW3	Apr-22	7.19	7.66	0.47
	May-22	7.35	7.64	0.29
	Jun-22	no results		
LW3	Jul-22	7.22	7.64	0.42
	Aug-22	6.95	7.64	0.69
	Sep-22	7	7.64	0.64
LW3	Oct-22	6.4	7.64	1.24
	Nov-22	6.71	7.64	0.93
	Dec-22	6.03	7.64	1.61
LW5	Jan-22	5.57	7.05	1.48
	Feb-22	5.93	7.05	1.12
	Mar-22	6.19	7.05	0.86
LW5	Apr-22	6.54	7.05	0.51
	May-22	6.74	7.05	0.31
	Jun-22	no results		
LW5	Jul-22	7.04	7.05	0.01
	Aug-22	7.02	7.05	0.03
	Sep-22	dry	7.05	dry
LW5	Oct-22	6.78	7.05	0.27
	Nov-22	6.8	7.05	0.25
	Dec-22	5.63	7.05	1.42
LW8	Jan-22	4.95	5.94	0.99
	Feb-22	4.55	5.94	**1.39**
	Mar-22	5.93	5.94	0.01
LW8	Apr-22	5.94	5.94	dry
	May-22	5.94	5.94	dry
	Jun-22	no results		
LW8	Jul-22	dry	5.94	dry
	Aug-22	5.9	5.94	0.04
	Sep-22	dry	5.94	dry
LW8	Oct-22	5.9	5.94	0.04
	Nov-22	5.91	5.94	0.03
	Dec-22	4.62	5.94	**1.32**
LW9	Jan-22	7.01	7.05	0.04
	Feb-22	6.82	7.05	0.23
	Mar-22	7.03	7.03	0
LW9	Apr-22	7.03	7.03	dry
	May-22	7.05	7.05	dry
	Jun-22	no results		
LW9	Jul-22	dry	7.05	dry
	Aug-22	dry	7.05	dry
	Sep-22	dry	7.05	dry
LW9	Oct-22	6.81	7.05	0.24
	Nov-22	6.89	7.05	0.16
	Dec-22	6.91	7.05	0.14
LW15	Jan-22	10.89	12.73	1.84
	Feb-22	10.83	12.73	1.9
	Mar-22	10.89	12.73	1.84
LW15	Apr-22	11	12.73	1.73
	May-22	11.59	12.73	1.14
	Jun-22	no results		
LW15	Jul-22	dry	12.73	dry
	Aug-22	dry	12.73	dry
	Sep-22	10.62	12.73	**2.11**
LW15	Oct-22	10.57	12.73	**2.16**
	Nov-22	10.87	12.73	1.86
	Dec-22	10.82	12.73	1.91
LW16	Jan-22	7.8	9.06	1.26
	Feb-22	7.93	9.06	1.13
	Mar-22	7.88	9.08	1.2
LW16	Apr-22	8.12	9.08	0.96
	May-22	8.4	9.06	0.66
	Jun-22	no results		
LW16	Jul-22	8.74	9.06	0.32
	Aug-22	8.74	9.06	0.32
	Sep-22	8.76	9.06	0.3
LW16	Oct-22	8.7	9.06	0.36
	Nov-22	8.91	9.06	0.15
	Dec-22	7.71	9.06	1.35
LW18	Jan-22	no results		
	Feb-22	8.6	10.17	1.57
	Mar-22	8.76	10.17	1.41
LW18	Apr-22	8.96	10.13	1.17
	May-22	9.27	10.17	0.9
	Jun-22	no results		
LW18	Jul-22	9.81	10.17	0.36
	Aug-22	9.58	10.17	0.59
	Sep-22	9.66	10.17	0.51
LW18	Oct-22	9.38	10.17	0.79
	Nov-22	9.5	10.17	0.67
	Dec-22	8.74	10.17	1.43
A1301	Jan-22	17.3	19.69	2.39
	Feb-22	17.27	19.69	2.42
	Mar-22	17.23	19.7	2.47
A1301	Apr-22	17.34	19.7	2.36
	May-22	17.62	19.69	2.07
	Jun-22	no results		
A1301	Jul-22	15.9	19.69	3.79
	Aug-22	17.15	19.69	2.54
	Sep-22	17.84	19.69	1.85
A1301	Oct-22	17.87	19.69	1.82
	Nov-22	17.98	19.69	1.71
	Dec-22	10.42	19.69	9.27
A1302	Jan-22	15.67	18.09	2.42
	Feb-22	15.66	18.09	2.43
	Mar-22	15.65	18.09	2.44
A1302	Apr-22	15.73	18.09	2.36
	May-22	15.9	18.09	2.19
	Jun-22	no results		
A1302	Jul-22	16.37	18.09	1.72
	Aug-22	16.14	18.09	1.95
	Sep-22	16.13	18.09	1.96
A1302	Oct-22	16.28	18.09	1.81
	Nov-22	16.43	18.09	1.66
	Dec-22	15.84	18.09	2.25

A1303	Jan-22	9.57	11.13	1.56
	Feb-22	9.74	11.13	1.39
	Mar-22	10.04	11.14	1.1
A1303	Apr-22	11.08	11.14	0.06
	May-22	11.13	11.13	dry
	Jun-22	no results		
A1303	Jul-22	10.1	11.13	1.03
	Aug-22	11.05	11.13	0.08
	Sep-22	10.44	11.13	0.69
A1303	Oct-22	10.87	11.22	0.35
	Nov-22	10.9	11.13	0.23
	Dec-22	8.96	11.13	2.17
A1304	Jan-22	12	14	2
	Feb-22	11.95	14	2.05
	Mar-22	12	14	2
A1304	Apr-22	12.12	14	1.88
	May-22	12.45	14	1.55
	Jun-22	no results		
A1304	Jul-22	12.78	14	1.22
	Aug-22	12.7	14	1.3
	Sep-22	12.65	14	1.35
A1304	Oct-22	12.7	14	1.3
	Nov-22	12.91	14	1.09
	Dec-22	11.87	14	2.13

A1305CV	Jan-22	10.75	13.18	2.43
	Feb-22	10.63	13.18	2.55
	Mar-22	10.6	13.18	2.58
A1305CV	Apr-22	10.62	13.18	2.56
	May-22	11.7	13.18	1.48
	Jun-22	no results		
A1305CV	Jul-22	11.95	13.18	1.23
	Aug-22	11.51	13.18	1.67
	Sep-22	11.29	13.18	1.89
A1305CV	Oct-22	11.21	13.18	1.97
	Nov-22	11.45	13.18	1.73
	Dec-22	10.51	13.18	2.67

The leachate levels were not obtained in June. LW17 is not able to be monitored or sampled due to a constriction in the well.

Leachate Levels (m above base of well) in 2022

Leachate Levels (m above base of well)													Leachate compliance level (from September 2020 onwards)
Leachate well	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	
LW1	0.02	0.03	0	0.01	0.02		0.78	dry	dry	0.96	0.85	1.17	
LW3	0.7	0.61	0.64	0.47	0.29		0.42	0.69	0.64	1.24	0.93	1.61	
LW5	1.48	1.12	0.86	0.51	0.31		0.01	0.03	dry	0.27	0.25	1.42	1.6
LW8	0.99	1.39	0.01	dry	dry		dry	0.04	dry	0.04	0.03	1.32	1
LW9	0.04	0.23	0	dry	dry		dry	dry	dry	0.24	0.16	0.14	
LW15	1.84	1.9	1.84	1.73	1.14		dry	dry	2.11	2.16	1.86	1.91	2.1
LW16	1.26	1.13	1.2	0.96	0.66		0.32	0.32	0.3	0.36	0.15	1.35	
LW18		1.57	1.41	1.17	0.9		0.36	0.59	0.51	0.79	0.67	1.43	
A1301	2.39	2.42	2.47	2.36	2.07		3.79	2.54	1.85	1.82	1.71	9.27	
A1302	2.42	2.43	2.44	2.36	2.19		1.72	1.95	1.96	1.81	1.66	2.25	3
A1303	1.56	1.39	1.1	0.06	dry		1.03	0.08	0.69	0.35	0.23	2.17	
A1304	2	2.05	2	1.88	1.55		1.22	1.3	1.35	1.3	1.09	2.13	
A1305	2.43	2.55	2.58	2.56	1.48		1.23	1.67	1.89	1.97	1.73	2.67	2.8

Empty cells signifies unable to be monitored

Yellow highlighted cells are leachate levels removed from previous graphs due to being potentially erroneous

Red text indicates exceedence of the (selected) well specific leachate level threshold (From September 2020)

A2 - Leachate Quality Monitoring - Quarterly Data

This data represents the quarterly data which consists of pH, ammoniacal nitrogen and nitrate, for example.

Monitoring location		pH	Temperature	Conductivity	Dissolved oxygen	Chloride	Ammoniacal nitrogen	Potassium
		-	°C	µS	%	mg/l	mg/l	mg/l
LW3	Jan-22	7.35	9.53	1041		40	17	21
	Feb-22							
	Mar-22							
LW3	Apr-22	6.64	16.45	734		66	33	24
	May-22							
	Jun-22							
LW3	Jul-22		19.97			24	11	13
	Aug-22							
	Sep-22							
LW3	Oct-22		18.4			17	2.6	12
	Nov-22							
	Dec-22							
LW5	Jan-22	7.08	8.57	732		12	1.2	9.4
	Feb-22							
	Mar-22							
LW5	Apr-22	6.37	16.4	855		220	2	160
	May-22							
	Jun-22							
LW5	Jul-22	dry						
	Aug-22							
	Sep-22							
LW5	Oct-22		18.5			14	0.26	13
	Nov-22							
	Dec-22							
LW8	Jan-22	could not get sample						
	Feb-22							
	Mar-22							
LW8	Apr-22	Dry - no leachate to sample						
	May-22							
	Jun-22							
LW8	Jul-22	Recorded as dry but sample sent to lab				12	82	9.9
	Aug-22							
	Sep-22							
LW8	Oct-22	dry						
	Nov-22							
	Dec-22							
LW9	Jan-22	could not get sample						
	Feb-22							
	Mar-22							
LW9	Apr-22	Dry - no leachate to sample						
	May-22							
	Jun-22							
LW9	Jul-22	dry						
	Aug-22							
	Sep-22							
LW9	Oct-22							
	Nov-22							
	Dec-22							
LW15	Jan-22	6.49	13.55	1623		200	180	130
	Feb-22							
	Mar-22							
LW15	Apr-22	6.75	17.81	3275		220	170	160
	May-22							
	Jun-22							
LW15	Jul-22	Recorded as dry but sample sent to lab				420	240	250
	Aug-22							
	Sep-22							
LW15	Oct-22		23.5			230	200	160
	Nov-22							
	Dec-22							
LW16	Jan-22	6.45	11.71	2364		380	150	240
	Feb-22							
	Mar-22							
LW16	Apr-22	6.71	17.12	2328		410	290	270
	May-22							
	Jun-22							
LW16	Jul-22		19.89			410	250	250
	Aug-22							
	Sep-22							
LW16	Oct-22	Insufficient leachate for sample (stated as being dry)						
	Nov-22							
	Dec-22							

LW18	Jan-22					21	48	18
	Feb-22							
	Mar-22							
LW18	Apr-22					15	32	11
	May-22							
	Jun-22							
LW18	Jul-22					26	98	21
	Aug-22							
	Sep-22							
LW18	Oct-22					23	56	16
	Nov-22							
	Dec-22							
A1301	Jan-22	could not get sample						
	Feb-22							
	Mar-22							
A1301	Apr-22	7.29	18.3	2998		490	340	260
	May-22							
	Jun-22							
A1301	Jul-22		27.67			770	400	300
	Aug-22							
	Sep-22							
A1301	Oct-22	no sample						
	Nov-22							
	Dec-22							
A1302	Jan-22	could not get sample						
	Feb-22							
	Mar-22							
A1302	Apr-22	7.35	18.25	1896		180	230	130
	May-22							
	Jun-22							
A1302	Jul-22		25.78			180	190	120
	Aug-22							
	Sep-22							
A1302	Oct-22	no sample						
	Nov-22							
	Dec-22							
A1303	Jan-22	could not get sample						
	Feb-22							
	Mar-22							
A1303	Apr-22	No results - insufficient leachate available						
	May-22							
	Jun-22							
A1303	Jul-22	Sample unable to be obtained						
	Aug-22							
	Sep-22							
A1303	Oct-22		22.2			190	i/s	i/s
	Nov-22							
	Dec-22							
A1304	Jan-22	could not get sample						
	Feb-22							
	Mar-22							
A1304	Apr-22	6.42	15.79	2529		130	190	100
	May-22							
	Jun-22							
A1304	Jul-22		20.88			170	190	120
	Aug-22							
	Sep-22							
A1304	Oct-22		17.8			96	150	79
	Nov-22							
	Dec-22							
A1305CV	Jan-22	could not get sample						
	Feb-22							
	Mar-22							
A1305CV	Apr-22	6.49	16.03	5103		370	150	240
	May-22							
	Jun-22							
A1305CV	Jul-22		22.22			480	170	190
	Aug-22							
	Sep-22							
A1305CV	Oct-22		17.8			460	280	280
	Nov-22							
	Dec-22							

Grey spaces indicate months where no site readings or laboratory analysis required.
Blanks indicate location not sampled. Note – LW18 is not required to be sampled on a quarterly basis.

A3 - Leachate Quality Monitoring - Annual Data

This data represents the annual data which consists of a range of metals, alkalinity, COD, BOD, TOC and nitrate etc.

Annual leachate analysis - October 2022

Determinand	Units	Monitoring location										
		LW3	LW5	LW8	LW15	LW16	LW18	A1301	A1302	A1303	A1304	A1305CV
Alkalinity expressed as CaCO3	mg/l	590	320		1900		550			1400	1400	3000
As (Dissolved)	µg/l	2.91	2.67		1.74		6.54				1.12	5.34
Biochemical Oxygen Demand	mg/l	31	15		66		28			28	14	9.4
Cd (Dissolved)	µg/l	0.05	0.65		<0.02		0.06				<0.02	<0.02
Calcium	mg/l	260	400		170		310				180	170
Chemical Oxygen Demand	mg/l	900	1600		120		4500			1900	300	330
Cr (Dissolved)	µg/l	<0.2	<0.2		2		1.6				1.2	3.7
Cu (Dissolved)	µg/l	2.2	12		1.8		1.8				<0.5	3.1
Iron	mg/l	0.065	0.036		0.14		0.1				0.25	0.26
Pb (Dissolved)	µg/l	0.5	1.3		<0.2		2.1				<0.2	<0.2
Magnesium	mg/l	36	52		84		24				51	150
Mn (Dissolved)	µg/l	3300	1300		430		960				590	290
Ni (Dissolved)	µg/l	130	310		9.5		71				5.3	32
Sodium	mg/l	25	24		270		18				110	550
Sulphate	mg/l	188	613		16.8		372				44.1	24.8
Total Organic Carbon	mg/l	9.73	13.6		42.4		10.7				25.4	93.8
Zn (Dissolved)	µg/l	110	1500		8.5		84				3	20

Blanks indicate location not sampled (due to lack of leachate present in well or insufficient sample)

A4 - Leachate Quality Monitoring - Discharge Flap Valve

Parameter	Units	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22
Ammoniacal Nitrogen	mg/l	<0.015	0.019	0.39	0.53	0.25		0.43	0.13	0.044	1.1	<0.015	21
As (dissolved)	µg/l	75	8.76	12.7	7.43	1.13		6.68	7.5	1.81	5.02	1.73	1.78
Cd (dissolved)	µg/l	0.08	0.04	0.02	0.02	<0.02		0.03	0.04	0.03	0.04	0.03	0.05
Cr (dissolved)	µg/l	6.1	2.2	5.9	<0.2	<0.2		0.5	0.4	<0.2	0.3	0.3	0.3
Cu (dissolved)	µg/l	<0.7	5.8	3.1	7.7	7.4	No sampling in June	3.6	5	2.9	4.8	3.5	4.2
Iron	mg/l	0.011	0.031	0.041	0.041	0.031		0.021	0.025	0.018	0.043	0.018	0.07
Pb (dissolved)	µg/l	<0.2	0.2	0.3	<0.2	<0.2		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Ni (dissolved)	µg/l	10	3.3	6	2.3	2.5		8	4.8	3.4	4.7	2.3	3.1
Zn (dissolved)	µg/l	5.1	5.5	7.9	1.2	4		4.8	9.9	3.2	4.1	5.5	7.6

Appendix B - Groundwater Monitoring Data

B1 - Groundwater Level Monitoring Data

Groundwater levels (mAOD)													
Borehole	Well Base (mAOD)	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22
Northern Boundary													
BH3W	-1.4	3.18	3.15	3.24	3.29	2.86		2.79	2.71	2.66	2.89	3.47	4.2
BH5B	-3.91	2.65	2.65	2.68	2.71	2.13		2.21	2.27	2.07	2.24	2.7	2.6
BH7B	-4.39	2.14	2.13	2.25	2.37	1.58		1.63	1.62	1.47	1.71	2.47	2.09
BH9B	-3.06	2.28	2.27	2.31	2.35	1.65		1.72	1.78	1.61	1.85	2.43	1.74
Eastern Boundary													
BH1B	-2.76	1.57	1.24	1.56	1.57	1.2	0.79	0.89	1.11	1.19	1.55	1.24	1.52
BH40B	-0.55	2.05	2.5	1.91	1.88	1.77		1.61	1.57	1.97	1.94	1.83	2.35
BH43B	-1.56	2.92	3.33	1.84	1.61	2.57		2.1	2.34	2.65	1.91	1.84	2.07
BH45B	-3.08	1.95	2.44	2.13	1.68	1.66	1.48	1.48	1.48	1.68	2.03	1.78	2.1
Western Extension													
BH4	0.31	2.56	2.4	2.51	2.6	2.15	1.36	1.57	1.81	1.62	2.06	2.79	2.41
BH5	-0.51	2.41	2.1	2.22	2.42	1.56	1.03	1.2	1.39	1.18	1.55	2.52	2.36
BH6	-0.42	2.09	2.09	1.66	1.91	2.02		0.81	1	1.06	1.33	2.38	1.91
BH7	-1.58	1.04	0.64	1.05	1.01	0.93	-0.23	0.31	0.22	0.2	0.17	0.98	0.89
BH8	-0.82	2.26	1.97	2.55	2.24	1.99	1.23	1.54	1.53	1.19	1.6	2.63	2.27
Southern Extension													
BH12	0.43	1.57	1.41	1.77	1.78	0.63	0.43	0.52	0.66	0.43	0.51	1.99	0.9
BH15	0.5	2.13	1.93	2.22	2.28	1.74	1.06	1.38	1.31	1.15	1.33	2.27	1.96

B2 - Groundwater Quality Monitoring - Monthly Data

Monitoring location		pH	Temperature	Conductivity	Chloride	Ammoniacal nitrogen	Potassium
		-	°C	µS	mg/l	mg/l	mg/l
BH5	Jan-22	6.45	7.57	2130	220	0.064	12
	Feb-22	7.19	9.61	606	24	<0.015	7.2
	Mar-22	6.56	11.22	377	22	<0.015	6
BH5	Apr-22	6.31	14.47	265	22	<0.015	7
	May-22	7.68	16.36	737	38	0.032	41
	Jun-22	No sample taken in June					
BH5	Jul-22		19.69		30	0.31	18
	Aug-22	Unable to obtain a sample					
	Sep-22		15.5		26	<0.015	7.2
BH5	Oct-22		15.8		36	<0.015	7.9
	Nov-22	8.3	12.4	620	31	0.038	7.8
	Dec-22	7.3	9.8	610	29	<0.015	7.1
BH8	Jan-22	6.2	8.3	1044	67	<0.015	12
	Feb-22	6.63	9.94	1006	67	<0.015	4.5
	Mar-22	6.56	11.38	962	130	0.75	17
BH8	Apr-22	6.3	14.76	265	56	<0.015	6.1
	May-22	6.52	13.2	1341	250	5.9	110
	Jun-22	No sample taken in June					
BH8	Jul-22		19.6		470	21	72
	Aug-22		20.1		530	35	83
	Sep-22		14.8		590	35	100
BH8	Oct-22		10.3		660	38	98
	Nov-22	7.5	12.8	1400	230	<0.015	9.8
	Dec-22	7.3	11.3	620	39	<0.015	3.3
BH12	Jan-22	8.63	9.18	373	13	<0.015	6.1
	Feb-22	7.06	10.09	255	38	0.024	4
	Mar-22	6.86	12.05	237	16	<0.015	5.2
BH12	Apr-22	6.33	14.19	489	46	0.66	18
	May-22	7.24	15.35	731	83	1.5	30
	Jun-22	No sample taken in June (although monitoring location effectively dry)					
BH12	Jul-22	Insufficient groundwater for sampling					
	Aug-22	Insufficient groundwater for sampling					
	Sep-22	Dry					
BH12	Oct-22		16.1		58	0.12	10
	Nov-22	8.2	13.4	230	11	<0.015	3.8
	Dec-22	7.4	14.3	180	7.1	0.031	5.2
BH15	Jan-22	7.65	8.66	1167	39	0.4	35
	Feb-22	6.78	10.06	828	28	<0.015	24
	Mar-22	6.46	11.68	1288	37	0.68	38
BH15	Apr-22	6.71	13.92	2704	42	0.71	45
	May-22	7.27	14.82	593	29	<0.015	7.8
	Jun-22	No sample taken in June					
BH15	Jul-22		18.89		32	<0.015	37
	Aug-22		19.6		31	<0.015	37
	Sep-22		15.2		81	<0.015	36
BH15	Oct-22		14.5		61	0.027	44
	Nov-22	7.5	12.9	930	35	<0.015	26
	Dec-22	7	12.3	1100	43	<0.015	29

Monitoring location		pH	Temperature	Conductivity	Chloride	Ammoniacal nitrogen	Potassium
		-	°C	µS	mg/l	mg/l	mg/l
BH9B	Jan-22	7.05	8.44	11150	3300	0.8	110
	Feb-22	6.4	11.11	10030	3900	0.79	130
	Mar-22	6.5	11.72	8305	2700	0.72	89
BH9B	Apr-22	6.21	15.05	4282	3700	0.82	100
	May-22	7.24	15.71	12500	3700	0.78	100
	Jun-22	no access - overgrown conditions					
BH9B	Jul-22		19.58		1800	0.55	74
	Aug-22		18.7		3100	0.78	95
	Sep-22		16.3		3600	**1.8**	130
BH9B	Oct-22		15.7		3900	**1.1**	140
	Nov-22	7.2	12.3	12000	3600	0.61	110
	Dec-22	7.1	12.2	9100	3200	0.13	98
BH1B	Jan-22	7.15	9.75	2885	370	1.5	29
	Feb-22	7.08	10.83	176	21	0.021	2.5
	Mar-22	7.54	13.49	976	150	0.024	11
BH1B	Apr-22	6.98	18.65	2889	220	<0.015	17
	May-22	7.43	16.21	2440	290	0.69	28
	Jun-22	No sample taken in June					
BH1B	Jul-22		19.85		340	0.2	31
	Aug-22		19.8		410	0.89	30
	Sep-22		15.8		320	0.04	28
BH1B	Oct-22		15.9		260	0.034	25
	Nov-22	7.8	13.8	130	8	<0.015	1.7
	Dec-22	7.5	13.2	140	12	<0.015	7.8
BH45B	Jan-22	6.86	9.68	1077	130	**88**	77
	Feb-22	6.55	11.06	1025	110	**96**	64
	Mar-22	6.89	13.12	1794	210	**86**	69
BH45B	Apr-22	7.05	17.91	2010	120	**65**	72
	May-22	6.7	14.92	2077	230	**74**	72
	Jun-22	No sample taken in June					
BH45B	Jul-22		18.71		72	**41**	31
	Aug-22		19.9		110	36	68
	Sep-22		15.6		22	15	15
BH45B	Oct-22		11.1		18	14	14
	Nov-22	7.3	13.3	1600	110	**51**	39
	Dec-22	7.1	13.2	2400	260	**81**	57
BH43B	Jan-22	7.11	9.19	1364	83	47	49
	Feb-22	6.43	10.94	653	120	37	70
	Mar-22	6.96	12.91	1529	99	**85**	55
BH43B	Apr-22	no results - cover was needed for this sample and test was mistakenly missed					
	May-22	6.78	16.45	1867	110	**78**	67
	Jun-22	No sample taken in June					
BH43B	Jul-22		17.87		120	**84**	70
	Aug-22		19.3		30	**86**	30
	Sep-22		16.8		96	61	61
BH43B	Oct-22		16.2		86	39	47
	Nov-22	7.1	13.1	1300	62	29	38
	Dec-22	7	11.7	1800	100	**95**	54

Number in orange font indicate exceedance of a Control level

Number in red font indicate exceedance of a Trigger level

B3 - Groundwater Quality Monitoring - Six- Monthly Data

April 2022

Determinand	Units	Monitoring location							
		BH5	BH8	BH12	BH15	BH9B	BH1B	BH43B	BH45B
Alkalinity expressed as CaCO3	mg/l	300	400	390	850	620	680	No sample taken in April for this location	1100
As (Dissolved)	µg/l	1.11	1	6.33	2.27	0.8	11.3		3.27
Biochemical Oxygen Demand	mg/l	< 1.0	1.4	2.9	4.3	2	6.3		4.3
Cd (Dissolved)	µg/l	< 0.02	0.1	0.05	0.03	< 0.02	0.09		0.03
Calcium	mg/l	97	170	56	100	130	22		130
Chemical Oxygen Demand	mg/l	18	22	200	26	95	280		400
Cr (Dissolved)	µg/l	0.3	0.6	< 0.2	< 0.2	< 0.2	2		0.2
Cu (Dissolved)	µg/l	18	13	20	18	12	9.6		6.2
Iron	mg/l	0.006	0.01	0.013	0.017	0.017	1.2		0.082
Pb (Dissolved)	µg/l	< 0.2	< 0.2	1.1	< 0.2	< 0.2	2.4		< 0.2
Magnesium	mg/l	11	33	32	66	220	13		71
Mn (Dissolved)	µg/l	1.5	2.3	140	250	1200	150		2300
Mercury	µg/l	< 0.0050	< 0.0050	0.0088	0.0052	0.0065	0.0112		< 0.0050
Ni (Dissolved)	µg/l	0.9	2.1	3.5	6.2	1.1	2.2		5.7
Sodium	mg/l	27	57	110	340	2300	520		160
Sulphate	mg/l	20.7	133	6.71	346	687	9.54		4.2
Total Organic Carbon	mg/l	3.79	4.79	12.9	9.04	10.8	57.2		21.7
Zn (Dissolved)	µg/l	4.4	1.7	6.8	5.9	< 0.5	38		14

October 2022

Determinand	Units	Monitoring location							
		BH5	BH8	BH12	BH15	BH9B	BH1B	BH43B	BH45B
Alkalinity expressed as CaCO3	mg/l	390	1500	140	540	700	1100	860	340
As (Dissolved)	µg/l	1.35	18.2	2.99	1.81	0.65	4.6	3.32	0.7
Biochemical Oxygen Demand	mg/l	3.8	49	18	5.4	3.7	7.6	15	4.6
Cd (Dissolved)	µg/l	0.03	0.16	< 0.02	0.07	< 0.02	0.03	< 0.02	< 0.02
Calcium	mg/l	140	55	48	260	180	20	120	75
Chemical Oxygen Demand	mg/l	34	3100	230	54	55	230	110	19
Cr (Dissolved)	µg/l	0.3	1.2	< 0.2	< 0.2	< 0.2	3.1	0.3	< 0.2
Cu (Dissolved)	µg/l	8.6	7.2	4.3	4.1	0.9	1.3	0.8	0.8
Iron	mg/l	0.01	0.25	0.02	0.012	0.12	3.5	0.051	0.015
Pb (Dissolved)	µg/l	< 0.2	< 0.2	0.3	< 0.2	< 0.2	1.5	< 0.2	< 0.2
Magnesium	mg/l	15	100	11	87	370	16	61	15
Mn (Dissolved)	µg/l	2.6	360	55	58	1900	160	2700	340
Mercury	µg/l	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050
Ni (Dissolved)	µg/l	1.8	16	2.7	6	1.7	6.6	5.6	0.6
Sodium	mg/l	67	970	57	140	3800	740	130	27
Sulphate	mg/l	54	12.8	13.7	612	727	8.09	3.55	1.17
Total Organic Carbon	mg/l	6.19	36.6	10.6	9.09	4.97	74.1	16.2	6.71
Zn (Dissolved)	µg/l	12	4.5	5.7	16	5.3	33	7.4	8

Appendix C - Surface Water Monitoring Data

Canal North - 2022 - Surface Water Quality Monitoring													
Parameter	**Unit**	**Jan-22**	**Feb-22**	**Mar-22**	**Apr-22**	**May-22**	**Jun-22**	**Jul-22**	**Aug-22**	**Sep-22**	**Oct-22**	**Nov-22**	**Dec-22**
pH	**-**	8.43	6.75	7.78	7.5	7.35						6.8	7.5
Electrical conductivity	**µs/cm**	201	265	312	252	1122						180	280
Ammonical Nitrogen as N	**mg/l**	0.031	0.04	0.53	0.24	0.03		0.28	0.025	0.15	0.034	0.018	0.028
BOD	**mg/l**	3.1	1.1	1.7	1.5	1.1		3.5	1.7	1.9	2.5	11	6.3
COD	**mg/l**	7.3	15	13	11	13		27	8.6	8.4	16	350	33
Nickel	**µg/l**	1.4	2.1	2.2	0.8	4.8		6.5	1.5	2.4	1.4	2	2.4
Nitrate as NO_3	**mg/l**	0.67	1.29	0.46	0.02	0.19		0.07	0.05	0.09	0.26	2.13	0.76
Phenol	**µg/l**	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Suspended Solids	**mg/l**	570	13	<2	<2	<2		56	2	150	6	1300	48

Number in orange font indicate exceedance of a Control level
Number in red font indicate exceedance of a Trigger level

Blank space - not determined

Canal South - 2022 - Surface Water Quality Monitoring													
Parameter	**Unit**	**Jan-22**	**Feb-22**	**Mar-22**	**Apr-22**	**May-22**	**Jun-22**	**Jul-22**	**Aug-22**	**Sep-22**	**Oct-22**	**Nov-22**	**Dec-22**
pH	**-**	8.77	6.5	7.62	7.68	7.11						6.8	7
Electrical conductivity	**µs/cm**	266	116	209	226	321						200	400
Ammonical Nitrogen as N	**mg/l**	0.25	0.041	<0.015	0.094	<0.015		0.1	0.056	0.034	0.031	**4**	**0.34**
BOD	**mg/l**	1.9	<1	1.5	1.2	1.4		3.4	2.5	1.2	3.5	2.4	8.1
COD	**mg/l**	10	13	9.1	12	9.5		19	15	3.9	19	170	37
Nickel	**µg/l**	2.5	2.4	2.5	0.7	1.7		1.6	1.8	2	1.8	8.8	2.5
Nitrate as NO_3	**mg/l**	0.68	0.88	0.15	0.01	0.14		0.07	0.07	0.01	0.19	0.23	0.99
Phenol	**µg/l**	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Suspended Solids	**mg/l**	3	<2	2.5	<2	4		34	18	<2	10	120	340

Number in orange font indicate exceedance of a Control level
Number in red font indicate exceedance of a Trigger level

Blank space - not determined

River North - 2022 - Surface Water Quality Monitoring													
Parameter	**Unit**	**Jan-22**	**Feb-22**	**Mar-22**	**Apr-22**	**May-22**	**Jun-22**	**Jul-22**	**Aug-22**	**Sep-22**	**Oct-22**	**Nov-22**	**Dec-22**
pH	**-**	7.52	5.93	7.13	6.69	6.89						7.7	7.6
Electrical conductivity	**µs/cm**	40910	2216	38040	23000	38360						5000	210
Ammonical Nitrogen as N	**mg/l**	<0.015	<0.015	<0.015	<0.015	<0.015		0.34	0.033	0.039	0.018	0.12	0.079
BOD	**mg/l**	1.6	1.2	5	3.1	2.8		5.1	8.9	1.3	4.6	2.9	6.8
COD	**mg/l**	5000	95	3100	440	1200		290	85	5.3	310	61	17
Nickel	**µg/l**	28	2.6	8.2	1.1	2.1		1.2	2.7	47	1.5	2.5	1.7
Nitrate as NO_3	**mg/l**	0.06	0.33	0.14	0.04	0.13		0.08	0.06	0.02	0.24	0.24	0.59
Phenol	**µg/l**	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Suspended Solids	**mg/l**	52	190	190	73	40		1700	850	160	470	45	29

Number in orange font indicate exceedance of a Control level
Number in red font indicate exceedance of a Trigger level

Blank space - not determined

River South - 2022 - Surface Water Quality Monitoring													
Parameter	**Unit**	**Jan-22**	**Feb-22**	**Mar-22**	**Apr-22**	**May-22**	**Jun-22**	**Jul-22**	**Aug-22**	**Sep-22**	**Oct-22**	**Nov-22**	**Dec-22**
pH	**-**	7.43	5.99	6.72	6.41	7.4						7.9	7.7
Electrical conductivity	**µs/cm**	40710	5665	28630	37210	40830						9000	780
Ammonical Nitrogen as N	**mg/l**	<0.015	<0.015	<0.015	<0.015	<0.015		0.38	0.094	0.07	<0.015	0.041	0.028
BOD	**mg/l**	1.8	1.6	1.8	2.3	3		2.2	3.6	1.9	4.7	11	5.8
COD	**mg/l**	2000	84	750	700	1600		330	95	7.1	450	110	63
Nickel	**µg/l**	29	4.3	1.5	1.1	0.8		1.6	1.9	1.5	1.3	1.6	1.9
Nitrate as NO_3	**mg/l**	0.06	0.22	0.15	0.05	0.11		0.07	0.07	0.03	0.22	0.27	0.5
Phenol	**µg/l**	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Suspended Solids	**mg/l**	77	180	39	69	47		<2	2300	160	580	33	69

Number in orange font indicate exceedance of a Control level
Number in red font indicate exceedance of a Trigger level

Blank space - not determined

Appendix D - Perimeter Gas Monitoring Data

Monitoring location	Month	Methane	Carbon dioxide	Oxygen	Carbon monoxide	Atmosheric pressure	Differential pressure
		%	%	%	ppm	mbar	mbar
BH4	Jan-22	0.1	4.2	17.2	0	1036	0.02
	Feb-22	0.2	2.2	17.6	0	1000	-0.02
	Mar-22	0.1	2.9	16.2	0	1028	-0.02
BH4	Apr-22	0.1	2.2	16.5	0	1029	-0.04
	May-22	0.2	1.3	18.3	0	1013	-0.02
	Jun-22	0.1	0.5	20.4	1	1020	
BH4	Jul-22	0	0.4	20.6	1	1017	-0.02
	Aug-22	0	0.2	20.7	0	1015	0.03
	Sep-22	0	0.2	20.4	0	1019	-0.02
BH4	Oct-22	0	0.3	20.7	0	1005	0.03
	Nov-22	0	1	20.5	0	988	0.03
	Dec-22	0	0.8	21	0	1013	-0.02
BH5	Jan-22	0.1	1.9	15.5	0	1036	0.08
	Feb-22	0.3	2	20	0	1000	-0.02
	Mar-22	0.1	1.4	17.3	0	1028	-0.02
BH5	Apr-22	0.1	1.6	17.1	0	1029	-0.02
	May-22	0.2	3.3	13.5	0	1013	0.05
	Jun-22	0.1	0.4	20.6	1	1020	-0.09
BH5	Jul-22	0	0.1	20.7	0	1017	-0.03
	Aug-22	0	5.7	16.3	0	1015	0
	Sep-22	0	3.7	16.6	0	1019	0
BH5	Oct-22	0	2.4	18	0	1005	-0.03
	Nov-22	0	2.2	19.7	0	988	0
	Dec-22	0	1.8	19.3	0	1013	-0.04
BH8	Jan-22	0.2	3.1	4.2	0	1036	0.02
	Feb-22	0.3	0.8	20.4	0	1000	-0.1
	Mar-22	0.1	2.9	16.2	0	1028	0
BH8	Apr-22	0.2	1.9	16.5	0	1029	-0.03
	May-22	0.2	1.6	18.6	0	1011	0
	Jun-22	0.2	0.2	20.8	0	1020	-0.07
BH8	Jul-22	0	1.8	19.5	0	1017	0.02
	Aug-22	0	0.2	20.6	0	1016	0.07
	Sep-22	0	1.2	19.7	0	1019	-0.1
BH8	Oct-22	0	3.5	17.6	0	1005	0.02
	Nov-22	0.1	0.3	20.6	0	988	-0.03
	Dec-22	0	0.3	19.3	0	1013	-0.03
BH12	Jan-22	0.2	1.2	18.9	0	1036	0
	Feb-22	0.4	0.7	20.2	0	1000	0
	Mar-22	0.2	1.1	18.6	0	1028	-0.03
BH12	Apr-22	0.1	0.8	17.5	0	1029	-0.03
	May-22	0.3	0.7	20.1	0	1006	0
	Jun-22	0.2	0.1	20.7	0	1020	-0.03
BH12	Jul-22	0.1	0.7	20.3	0	1017	-0.02
	Aug-22	0	0.9	19.9	0	1014	0.02
	Sep-22	0.1	0.2	20.8	0	1019	0.02
BH12	Oct-22	0.1	0.7	20	0	1005	0.02
	Nov-22	0.1	0.2	20.3	0	988	-0.03
	Dec-22	0.1	0.5	20.1	0	1012	-0.05

Monitoring location	Month	Methane	Carbon dioxide	Oxygen	Carbon monoxide	Atmosheric pressure	Differential pressure
		%	%	%	ppm	mbar	mbar
BH15	Jan-22	0.2	1.6	18.9	0	1036	0
	Feb-22	0.3	1.6	19.3	0	1000	0.07
	Mar-22	0.1	2.7	17	0	1028	-0.03
BH15	Apr-22	0.1	2.3	20	0	1029	-0.02
	May-22	0.2	1.5	19.1	0	1011	-0.02
	Jun-22	0.2	0.3	20.6	0	1020	0.02
BH15	Jul-22	0	1.2	19.3	0	1017	-0.05
	Aug-22	0	0.9	19.5	0	1014	0.02
	Sep-22	0	1.6	17.6	0	1019	0
BH15	Oct-22	0	1.2	19.4	0	1005	-0.02
	Nov-22	0	0.9	19.8	0	988	0
	Dec-22	0	0.7	19	0	1012	-0.07
BH9B	Jan-22	0.2	0.1	20.5	0	1036	-0.02
	Feb-22	0.2	0.1	20.4	0	1000	0
	Mar-22	0.1	0.1	20.3	0	1028	-0.03
BH9B	Apr-22	0.1	0.2	19.8	0	1029	-0.01
	May-22	0.2	0.1	20.7	0	1013	0.02
	Jun-22	no access - overgrown conditions					
BH9B	Jul-22	0	0.7	20.8	0	1017	-0.05
	Aug-22	0	0.3	20.7	0	1015	0.02
	Sep-22	0	0.5	20.3	0	1019	0.03
BH9B	Oct-22	0	0.1	20.9	0	1003	0.03
	Nov-22	0	0.1	20.8	0	988	-0.02
	Dec-22	0	0.9	21.1	0	1013	-0.05
BH7B	Jan-22	0.1	0.2	20.8	0	1036	-0.12
	Feb-22	0.3	0.3	20.5	0	1000	-0.02
	Mar-22	0.1	0.4	20.5	0	1028	-0.02
BH7B	Apr-22	0.2	0.4	20.2	0	1029	-0.05
	May-22	0.2	0.5	20	0	1013	0
	Jun-22	no access - overgrown conditions					
BH7B	Jul-22	0	0.3	20.6	1	1017	0.02
	Aug-22	0	0.1	20.8	2	1015	-0.02
	Sep-22	0.1	0.2	20.5	0	1019	-0.05
BH7B	Oct-22	0	0.1	20.9	0	1003	0.02
	Nov-22	0	0.4	20.9	0	988	0.4
	Dec-22	0	0.6	20.5	0	1013	0
BH5B	Jan-22	0.2	0.2	20.8	0	1036	0.02
	Feb-22	0.2	0.2	20.7	0	1000	0.05
	Mar-22	0.1	0.1	20.8	0	1029	-0.04
BH5B	Apr-22	0.3	0.1	17.3	0	1030	-0.03
	May-22	0.2	0.2	21	0	1013	0
	Jun-22	no access - overgrown conditions					
BH5B	Jul-22	0	0.1	21	1	1017	0
	Aug-22	0	0.1	21	0	1015	0
	Sep-22	0	0.1	20.7	0	1019	0.02
BH5B	Oct-22	0	0.1	21	0	1005	0
	Nov-22	0	0.3	21.1	0	988	0
	Dec-22	0	0.2	21.1	0	1013	-0.07

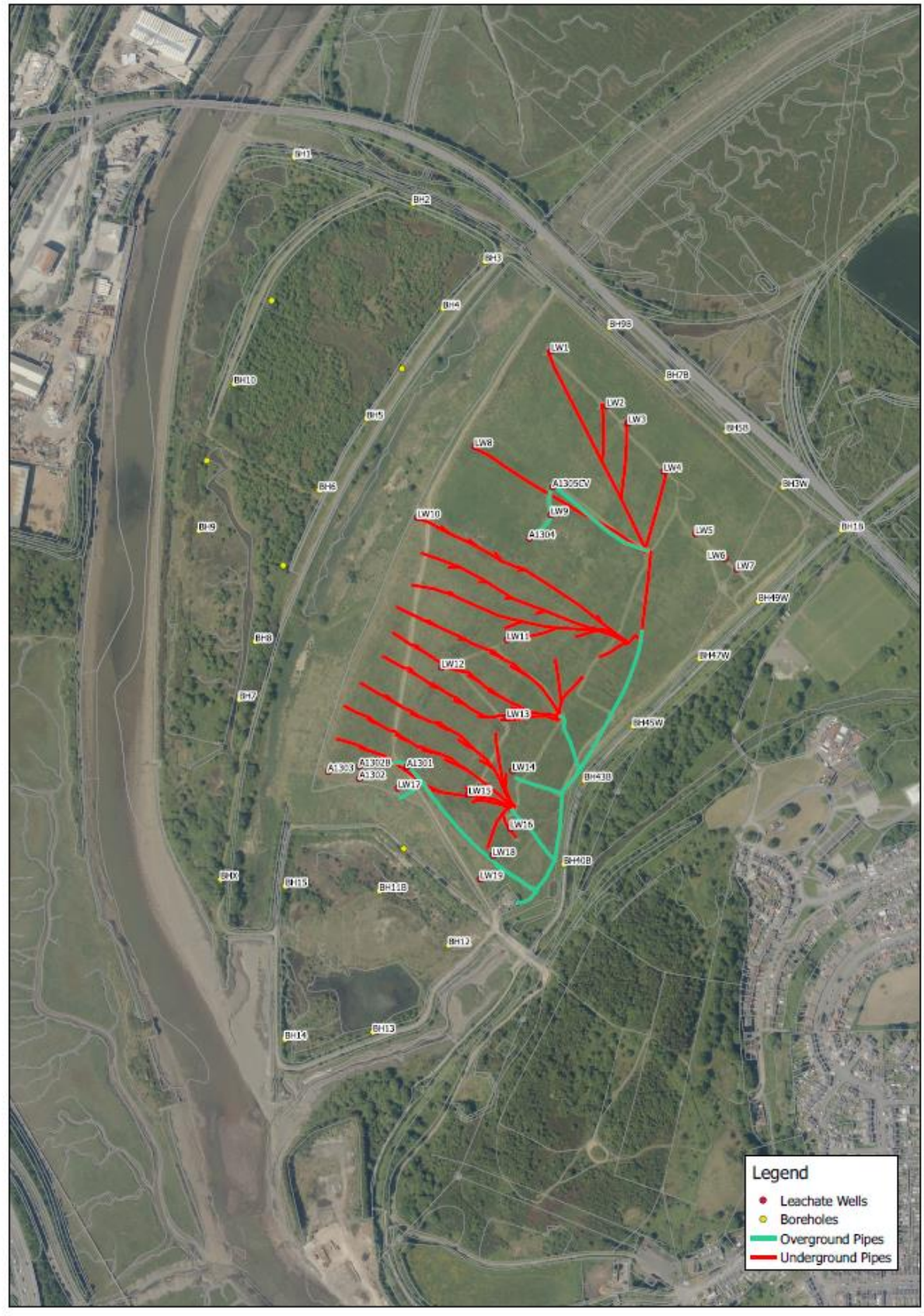
Monitoring location	Month	Methane	Carbon dioxide	Oxygen	Carbon monoxide	Atmosheric pressure	Differential pressure
		%	%	%	ppm	mbar	mbar
BH3W	Jan-22	0.2	3.5	14.1	0	1036	-0.03
	Feb-22	0.2	4.5	13.2	0	1000	0.03
	Mar-22	0.4	2.3	17	0	1030	0
BH3W	Apr-22	0.1	2.1	17.3	0	1030	-0.03
	May-22	0.2	1.7	19.1	0	1013	0.02
	Jun-22	no access - overgrown conditions					
BH3W	Jul-22	0	1.1	19.8	1	1017	-0.02
	Aug-22	0	0.9	20.1	1	1015	-0.02
	Sep-22	0	3	17.8	0	1019	0.02
BH3W	Oct-22	0	3	14.2	0	1005	-0.03
	Nov-22	0.1	1.5	17.4	0	988	0
	Dec-22	0	0.6	20.8	0	1013	0.03
BH1B	Jan-22	0.3	1.2	19.7	0	1033	0.04
	Feb-22	0.4	0.2	21	0	1017	0
	Mar-22	0.1	0.4	20	0	1023	-0.02
BH1B	Apr-22	0.1	0.3	20.3	0	1030	-0.02
	May-22	0.3	1.1	19.5	0	1010	-0.07
	Jun-22	0.1	0.2	20.7	1	1020	-0.03
BH1B	Jul-22	0	0.4	19.8	0	1022	0
	Aug-22	0	1.7	18.6	0	1012	0.03
	Sep-22	0.1	0.3	20.2	0	1007	-0.02
BH1B	Oct-22	0.1	1	19.3	0	1007	-0.03
	Nov-22	0	1.1	21	0	1002	-0.01
	Dec-22	0.1	0.2	20.6	0	1007	0.03
BH49W	Jan-22	0.1	1.3	19.5	0	1036	0
	Feb-22	0.4	0.2	21	0	1018	0.16
	Mar-22	0.2	0.2	20.4	0	1030	-0.02
BH49W	Apr-22	0.1	0.1	20	0	1030	-0.02
	May-22	0.2	0.2	21.1	0	1013	0.03
	Jun-22	no access - overgrown conditions					
BH49W	Jul-22	0	0.5	20.7	1	1017	0
	Aug-22	0	0.4	20.8	0	1015	0.03
	Sep-22	0	0.2	20.5	0	1019	0.02
BH49W	Oct-22	0	1	15.6	0	1005	0.02
	Nov-22	0	0.8	20.4	0	988	0
	Dec-22	0	1	20.4	0	1013	0
BH47W	Jan-22	0.1	0.3	21.3	0	1036	0.03
	Feb-22	0.4	0.1	21.4	0	1018	0.08
	Mar-22	0.1	0.2	20	0	1030	0
BH47W	Apr-22	0.2	0.2	19.9	0	1030	-0.03
	May-22	0.2	0.7	21	0	1013	0
	Jun-22	no access - overgrown conditions					
BH47W	Jul-22	0	0.7	20.8	1	1017	-0.03
	Aug-22	0	0.3	20.9	1	1015	0
	Sep-22	0	0.7	20	0	1019	0
BH47W	Oct-22	0	1.1	19.9	0	1005	0
	Nov-22	0.1	0.2	21.2	0	988	0
	Dec-22	0	1.4	20.4	0	1013	0

Monitoring location	Month	Methane	Carbon dioxide	Oxygen	Carbon monoxide	Atmosheric pressure	Differential pressure
		%	%	%	ppm	mbar	mbar
BH55B	Jan-22	0.3	4.2	17.9	0	1032	0
	Feb-22	0.3	3.2	19.7	0	1016	0
	Mar-22	0.2	3.2	19.1	0	1023	0.02
BH55B	Apr-22	0.1	3	18.8	0	1030	-0.03
	May-22	0.2	2.8	17.5	0	1011	0.01
	Jun-22	0	4.9	15.7	1	1020	-0.17
BH55B	Jul-22	0	7.3	12.2	0	1014	0
	Aug-22	0	7.9	11.2	0	1012	-0.02
	Sep-22	0.1	7	16.1	0	1019	0.05
BH55B	Oct-22	0.1	7.2	12.8	0	1010	0.02
	Nov-22	0.1	7	13.5	0	1002	0.01
	Dec-22	0.1	4.4	16	0	1004	0.02
BH45B	Jan-22	42.3	8.2	8.3	0	1033	-0.02
	Feb-22	65.3	13.7	2.5	0	1017	-0.02
	Mar-22	42.2	9.1	6.5	0	1023	0.02
BH45B	Apr-22	41	9.3	6.1	0	1027	0.05
	May-22	39	7.6	7.8	0	1010	0.02
	Jun-22	12	2	16	1	1020	-0.16
BH45B	Jul-22	35.6	5	7.4	1	1022	-0.02
	Aug-22	51	7.7	1.3	0	1012	0.02
	Sep-22	49.6	3.5	1.1	0	1007	-0.02
BH45B	Oct-22	52.2	3.8	1	4	1008	0
	Nov-22	49.4	3.9	2	3	1002	-0.02
	Dec-22	24.5	7.1	10	0	1007	-0.02
BH43B	Jan-22	51.5	8	7.8	0	1033	-0.05
	Feb-22	56.6	7.9	7.5	0	1017	-0.07
	Mar-22	42	5.9	9.9	1	1023	0.03
BH43B	Apr-22	36.2	6	10.8	2	1028	-0.05
	May-22	52	8.4	6.2	3	1011	0.07
	Jun-22	53	6	6	6	1020	-0.14
BH43B	Jul-22	89.6	10.2	0.2	1	1022	-0.02
	Aug-22	58	9.3	5.9	13	1012	-0.02
	Sep-22	63.9	10.2	5.3	4	1007	-0.03
BH43B	Oct-22	77.8	12.5	2.3	3	1008	0
	Nov-22	75.9	11.5	2.1	3	1002	0
	Dec-22	36.7	5.9	14.4	0	1007	0.03
BH40B	Jan-22	3.9	1.3	16.9	0	1033	-0.03
	Feb-22	76.8	3.5	0.2	7	1017	-0.07
	Mar-22	78.6	2.8	0.3	10	1023	0
BH40B	Apr-22	27.7	6.1	2.5	1	1028	0.02
	May-22	79	3	0.4	13	1011	0.05
	Jun-22	10	0.4	3	3	1020	-0.14
BH40B	Jul-22	26.5	2.2	10.4	1	1022	-0.07
	Aug-22	25.1	1	13.9	6	1012	-0.03
	Sep-22	8.6	2	0.1	11	1007	0
BH40B	Oct-22	27	1.4	17.8	0	1008	-0.02
	Nov-22	3.5	1.9	19.1	0	1002	-0.01
	Dec-22	1.7	0.6	11	0	1007	0

Notes

Locations and months where monitoring was unable to be completed fully: Several locations inaccessible in June due to overgrown conditions

Appendix E – Sampling point location plan



Appendix F – Landfill Gas

The following appendix is available as a separate document to this annual report.

This separate document has the following contents:

1. Annual Performance Report
2. Weekly, Monthly and Six-Monthly Monitoring Data
3. Annual Emissions Testing
4. Annual Trace Gas Analysis
5. Quarterly Engine Emissions
6. C&P - Surface Emissions Survey

File name:
'Giants Grave SEM - Report January 2023'

Report title
Surface Emissions Monitoring Report
Giants Grave Landfill Site
Neath Port Talbot Borough Council
January 2023

Notes for 2021 and 2022:

During 2021 the Gas Utilisation Contract was terminated, and a new Operation and Maintenance Contract was put in place.

The annual data has been collated where possible with data from both the outgoing and incoming contractor.

There is some mismatch of monitoring frequencies resulting from the changeover, which should settle out in 2022.