

Gwynedd Council

Ffridd Rasmus Landfill

Annual Environmental Report for January - December 2014



April 2015

Amec Foster Wheeler Environment
& Infrastructure UK Limited



Report for

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Document revisions

No.	Details	Date
1	Final Report	30 April 2015

Executive summary

Purpose of this report

Ffridd Rasmus Landfill (the site) is located approximately 3 km north of Harlech and is operated by Gwynedd Council. During the reporting period the site received wastes from the whole of the County of Gwynedd. Area 2 of the landfill received waste between 1981 and 2007 and is capped and in its aftercare phase. Area 2 is regulated under the conditions of EP ref PP3294FJ/V008 (dated 21 May 2013). Area 3 commenced accepting waste in April 2007 and is regulated under the conditions of EP ref GP3330BY (latest Variation Notice number QP3134LY/V004 dated 21 March 2013). The periods of filling and capping in Area 3 were as follows:

- ▶ Cells 1 and 2: filled between 2007 and 2011, with capping works completed in June 2011;
- ▶ Cell 3: filled between January 2011 and June 2012 with capping works completed in February 2013; and
- ▶ Cells 4A and 4B: filled up to closure on 6 January 2014. Cell 4 capping was completed on 2 April 2014.

This report provides the January December 2014 annual monitoring report for Ffridd Rasmus Landfill in accordance with the requirements of Condition 4.2 of the site's Environmental Permit. It comprises the following:

- ▶ Summary of the results of environmental monitoring as specified in the site's Environmental Permits and any relevant operational improvements;
- ▶ Review of the most recent hydrogeological, landfill gas and stability risk assessments in light of 2014 monitoring data;
- ▶ Summary of energy consumption and production/treatment (where applicable) volumes of leachate and landfill gas generated at the site;
- ▶ Assessment of waste settlement and remaining landfill capacity.

Environmental Monitoring Data

Leachate level and quality are currently monitored in Area 2 and Area 3. All of the leachate wells in Area 2 continued to be dry. Leachate levels in Area 3 during 2014 did not exceed the Environmental Permit compliance level of 1.5 m above base. In Area 3, samples of leachate are collected individually from each of the four cells. Leachate quality data for Area 3 showed chloride and ammoniacal nitrogen concentrations were variable over the year but generally within the range of previous data. Ammoniacal nitrogen concentrations were similar across all 4 cells within the range of 622 mg/l to 2130 mg/l. Similarly, chloride concentrations were in the range of 718 mg/l to 2230 mg/l across the 4 cells.

Groundwater level variations during 2014 remained consistent with previous data and typically show seasonal effects, with higher levels recorded in winter compared to summer. During the earlier part of 2014, levels were seasonally high and started to fall steadily from January onwards. There was a slight increase in the levels recorded in October and November before dropping again in December. Levels were similar to those recorded in the previous year.

All of the downgradient boreholes are contaminated to some degree with leachate from the dilute and disperse Area 2 landfill. Borehole BH27, located between Areas 2 and 3, typically records the highest contaminant concentrations and provides evidence of this continuing impact on groundwater from Area 2. The groundwater quality compliance limits for chloride and ammoniacal-nitrogen specified in the EP continue to be exceeded at a number boreholes. These exceedances reflect variability in the data associated with contaminant migration from the Area 2. The compliance limits will be reviewed in the site's HRA Review due in 2015.

Ammoniacal nitrogen and chloride concentrations at the surface water monitoring locations varied as follows during 2014: concentrations at SW1 (Area 1 permitted discharge), the pipe adjacent to SW1 and SW3 (ditch exiting the downstream boundary of Area 3) continue to show variability but remained within historical data (except for an isolated chloride peak at SW3); and concentrations at SW2 (ditch flowing south along downstream boundary of Area 3) continue to show elevated peaks exceeding the baseline (possible reasons for the increased levels are under investigation).

Landfill gas monitoring has shown that methane and carbon dioxide concentrations in the perimeter monitoring boreholes during 2014 are consistent with previous data and have not exceeded their Environmental Permit compliance limits ('trigger levels').

Review of Hydrogeological, Landfill Gas and Stability Risk Assessments

- ▶ **Hydrogeological Risk Assessment (HRA):** Overall the conceptual model for Area 3 has not changed from the 2011 LandSim update considering monitoring data for 2014, except for an increase in leachate strength (as ammonium, chloride and mecoprop) and a slight reduction in unsaturated sand thickness underlying the site. On this basis it is proposed to re-assess the risks to groundwater in the next six yearly review of the site's HRA which will be undertaken in 2015.
- ▶ **Landfill Gas Risk Assessment:** The GasSim model was last updated in February 2015 for Area 3. The GasSim model was updated with actual waste inputs for 2014 and the output graph is included as Appendix F. The GasSim model predicts that a maximum of 189.28 m³/hr (at the 95th percentile) landfill gas was produced by the wastes in Cells 1 3, 4A and 4B in Area 3 in 2014 although the model does not include production from waste in the first year of operation.
- ▶ **Stability Risk Assessment:** As a part of the detailed design phase undertaken for the capping to Cells 1 to 4, a review of the capping stability was undertaken based on the proposed final slope profiles. This review was submitted to the Environment Agency as part of the Design Report submitted in advance of capping works for each cell. These assessments conclude that the restored capping slopes will remain stable during construction and in the long term. A CQA verification report which details geosynthetics interface testing undertaken as part of Cell 4 capping was submitted to NRW.

Energy Consumption

At the time of issue of this report, Gwynedd Council has been unable to get an update on the total energy consumed by the site between January and December 2014.

Production/ Treatment Volumes

A total of 7,369.08 tonnes of leachate was disposed off-site during 2014. Leachate was removed by tanker for treatment and disposal.

Surface runoff from the site continued to be discharged into surface water at the two consented discharge points. The Environmental Permit does not set a limit on discharge flow rate.

Average flow rate at the flare during 2014 was 318.19 m³/hour. This equates to combustion of some 2,759,471 m³ of landfill gas from Areas 2 and 3 during the year.

Waste Settlement and Remaining Landfill Capacity

The landfill closed to receipt of waste on 6 January 2014 and there is no residual capacity. A total of 549.72 tonnes of waste were received at the site between 1st to 5th January 2014. Cell 4 capping was completed on 2 April 2014 and a topographical survey was undertaken in July 2014.

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Appendix D	Surface Water Quality Plots
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1. Introduction

Ffridd Rasmus Landfill Site is located approximately 3 km north of Harlech and receives wastes from the surrounding area. Since March 2012, the site has been receiving wastes from the whole of the County of Gwynedd. The site is operated by Gwynedd Council. Area 2 of the landfill received waste between 1981 and 2007 and is capped and in its aftercare phase. Area 2 is regulated under the conditions of EP ref: PP3294FJ/V008 (dated 21 May 2013). Area 3 commenced accepting waste in April 2007 and is regulated under the conditions of EP ref: GP3330BY (latest Variation Notice number QP3134LY/V004 dated 21 March 2013). The periods of filling and capping in Area 3 were as follows:

- ▶ Cells 1 and 2: filled between 2007 and 2011, with capping works completed in June 2011;
- ▶ Cell 3: filled between January 2011 and June 2012 with capping works completed in February 2013; and
- ▶ Cells 4A and 4B: filled up to closure on 6 January 2014. Cell 4 capping was completed on 2 April 2014.

Area 1 comprises the main elements of the site infrastructure - it covers approximately 1.5 hectares (ha) and comprises the Household Waste Recycling Centre (HWRC), the In Vessel Composting (IVC) facility, the weighbridge and site control office, the former waste pulveriser building and associated reception hall (since closure of the landfill on 6 January 2014 now operating as a waste transfer station) and workshop. Area 1 has not been subject to waste disposal (Figure 1.1). The environmental monitoring requirements under the site's EP's are summarised in Sections 1.1 to 1.4 below.

This report provides the January December 2013 annual monitoring report for Ffridd Rasmus Landfill in accordance with the requirements of Condition 4.2 of the site's EP. It comprises a summary of the results of environmental monitoring as specified in the site's EP's and any relevant operational improvements (Section 2), a review of the hydrogeological, landfill gas and stability risk assessments in light of 2012 monitoring data (Section 3), a summary of energy consumption (Section 4) and production/ treatment volumes of landfill leachate, landfill gas and surface water (Section 5) at the site and a review of waste settlement/remaining capacity (Section 6).

1.1 Leachate Monitoring

When conditions allow, leachate quality and level are monitored six-monthly at locations LW4a, LW5a, LW6a and LW13 in Area 2 as per the requirements of the EP ref: PP3294FJ/V008. For a long period, levels have been too low to obtain samples from these monitoring points. In Area 3, leachate head measurements are taken weekly and leachate samples are collected monthly from Cells 1-4 as per the requirements of the EP ref: GP3330BY. The leachate sampling regime at Ffridd Rasmus is shown in Table 1.1. Monitoring locations are shown on Figure 1.1.

Table 1.1 Leachate Monitoring Regime

Monitoring Location	Frequency	Parameter
Area 2 LW4a, LW5a, LW6a, LW13	Six Monthly	Level, Temperature, Cl, pH, EC, NH ₄ , Ca, Mg, K, Na, Alkalinity, TOC, SO ₄ , TON, phenol, COD, BOD.
	Annually	As six monthly plus Cd, Cr, Cu, Fe, Pb, Mn, Ni, Zn and hazardous substances.
Area 3 LM1/1, LM1/2, LM2/1, LM2/2, LM3/1, LM3/2*	Monthly	Temperature, leachate level, pH, EC, NH ₄ and Cl.
	Quarterly	As monthly plus Ca, Mg, K, Na, Alkalinity, TOC, SO ₄ , TON, phenol, COD, BOD and Cd.
	Annually	As quarterly plus Cr, Cu, Fe, Pb, Mn, Ni, Zn and hazardous substances.

Note: * Leachate samples were generally taken from the leachate collection tank, with the cell source identified. As of January 2013, samples of leachate are collected individually from each of the four cells. Wells LM1/1, LM1/2, LM2/1, LM2/2, LM3/1, LM3/2 were connected to the gas extraction system in August 2013 and are no longer monitored. Leachate levels have been monitored at LCP1, LCP2, LCP3, LCP4/2 and LCP4/B since August 2013.

1.2 Groundwater Monitoring

Groundwater quality and level are monitored six monthly in Area 2 and monthly in Area 3 in accordance with the requirements of the EP ref PP3294FJ/V008 and EP ref GP3330BY, respectively. The groundwater sampling regime is presented in Table 1.2.

Three additional boreholes were installed during March 2012. Boreholes BH34 BH36 were drilled along the western margin of Area 2 as replacements for the previously lost boreholes BH7, BH26 and NRA2 (see Figure 1.1). Sampling of these boreholes began in April 2012.

Table 1.2 Groundwater Monitoring Regime

Monitoring Location	Frequency	Parameter
Area 2 BH1, BH15, BH18A, BH18B, BH19A, BH19B, BH19C, BH20A, BH20B, BH21A, BH21B, BH23, BH24, BH27- BH36 and NRA3	Quarterly	Water level, DO, pH, EC, NH ₄ , Cl, Ca, Mg, K, Na, Alkalinity, TOC, SO ₄ , TON, phenol and Cd.
	Annually	As quarterly plus Cr, Cu, Fe, Pb, Mn, Ni and Zn.
Area 3 BH1, BH15, BH18A, BH18B, BH19A, BH19B, BH19C, BH20A, BH20B, BH21A, BH21B, BH23, BH24, BH27- BH36 and NRA3	Monthly	Level, Temperature, pH, EC, NH ₄ , Cl and DO.
	Quarterly	As monthly plus
	Annually	Ca, Mg, K, Na, Alkalinity, TOC, SO ₄ , TON, phenol and Cd.

1.3 Surface Water Monitoring

Surface water quality is monitored six-monthly in Area 2 and monthly in Area 3 at locations SW1, SW2 and SW3 as required by EP ref: PP3294FJ/V008 and EP ref: GP3330BY, respectively. The surface water sampling regime is identified in Table 1.3. Weekly observations of the appearance of the water are also made at locations SW1 and SW3. Sampling of the discharge from a pipe near to location SW1 has also been included in the monitoring regime since October 2011. Since the installation of the new interceptor, both sampling points SW1 and SW1 (pipe) have been relocated westwards, to the discharge point of the new operational interceptor (see Figure 1.1). Sampling at this new location began in December 2012.

Table 1.3 Surface Water Monitoring Regime

Monitoring Location	Frequency	Parameter
Area 2 SW1, SW2 and SW3	Six-monthly	Cl, COD, DO, EC, NH ₄ , pH and Temperature.
Area 3 SW1*, SW2 and SW3	Monthly	Cl, COD, DO, EC, NH ₄ , pH and Temperature.

*Discharge from pipe adjacent to SW1 also sampled if flowing.

1.4 Gas Monitoring

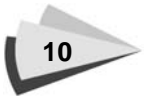
Landfill gas is monitored in boreholes located around the site perimeter: two locations for Area 2 and five locations for Area 3 as required by EP ref PP3294FJ/V008 and EP ref GP3330BY, respectively.

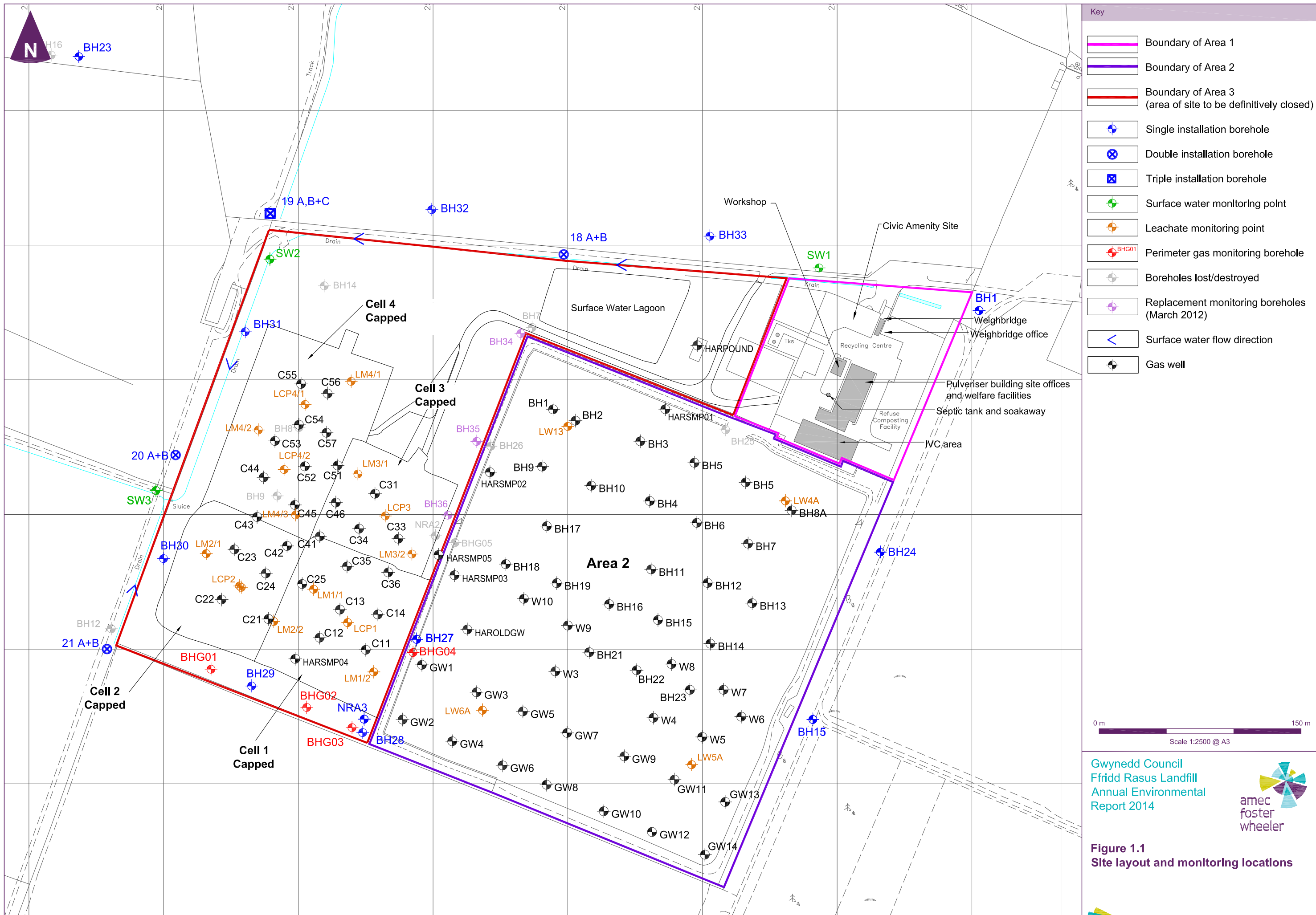
The gas monitoring regime is shown in Table 1.4. The locations of all monitoring points are shown on Figure 1.1.

Table 1.4 Gas Monitoring Regime

Monitoring Location	Frequency	Parameter
Area 2 BHG03 and BHG04	Six-monthly	Methane and carbon dioxide.
Area 3 BHG01 to BHG05	Monthly	Methane and carbon dioxide.

Note: Borehole BHG05 has been destroyed.





Gwynedd Council
 Ffridd Rasmus Landfill
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Figure 1.1
 Site layout and monitoring locations

2. Review of Monitoring Data

2.1 Introduction

This section presents a summary of the results of environmental monitoring as specified in the site's EP's (see Sections 1.1 to 1.4) and any relevant operational improvements carried out at the site during 2014. Where appropriate, the details in this section are drawn from the site's quarterly monitoring reports for 2014 (Amec Foster Wheeler report references: rr869i2 - January to March 2014, rr890i2 - April to June 2014, rr905i2 - July to September 2014 and rr928i2 - October to December 2014 which include the full monitoring results.

Surface water, groundwater, leachate and landfill gas monitoring at the site was undertaken by Gwynedd Council during 2013. Surface water, groundwater and leachate samples were sent to ALS Environmental (formerly known as Severn Trent Services (STS)) for analysis.

2.2 Leachate Levels and Quality

Area 2 -Leachate Levels

Leachate sumps LW4A, LW5A, LW6A or LW13 were recorded as dry in April and September 2014.

Area 3 – Leachate Levels

Leachate levels in Cells 1, 2, 3 and 4 were measured weekly during the monitoring period at LCP1, LCP2, LCP3, LCP 4/2 and LCP 4/B. Time-series plots for weekly leachate levels since January 2012 are shown in Appendix A. Leachate head measurements for January to December 2014 are shown in Table 2.1. The data shows:

- ▶ Leachate levels were below the EP compliance level of 1.5 m above the base across all four cells;
- ▶ Cell 1: Gradual increase in levels from January up to March falling back down again to lowest level in October (0.95metres above the base) before increasing slightly through November and December 2014. Levels at the monitoring point remained fairly consistent (0.95m to 1.35m above the base) and the results are similar to those recorded for the previous year;
- ▶ Cell 2: Levels in Cell 2 saw an increase from January to May followed by stable levels at 0.93m above the base during May and June. There was a gradual increase from July to the end of September, followed by a dip in levels during October before increasing again up to December when a maximum level of 1.14m above the base was reached. Levels in Cell 2 were lower than those in Cell 1 (0.85m to 1.14m above the base);
- ▶ Cell 3: levels in Cell 3 were variable and within the range 0.82 1.47 m above base. Levels were variable across the year with the highest level (1.47m above base) recorded in January and lowest (0.82m above base) in July. A downward trend was observed in the Spring and Summer months followed by an upward trend in the Autumn and Winter:
- ▶ Cell 4A: Levels in Cell 4A were variable across the year and were generally above 1 m above the base with the exception of June, July and October when levels dipped just below 1 m above base. Levels ranged from 1.4m above the base (January) to 0.87m above base (July);
- ▶ Cell 4B: Levels in Cell 4B varied from 1.42m above in January to 0.78m above base in May. During the first part of the year levels were generally higher than the latter part of the year with levels in excess of 1m above base regularly recorded.

Table 2.1 Leachate Level data for monitoring period January- December 2014

Monitoring Point	Leachate Level (m above base)		
	Min	Mean	Max
Cell 1 (LCP1)	0.95	1.16	1.35
Cell 2 (LCP2)	0.85	0.98	1.14
Cell 3 (LCP3)	0.82	1.09	1.47
Cell 4A (LCP4/2)	0.87	1.14	1.40
Cell 4B (LCP4/B	0.78	1.05	1.42
EP Compliance level	-	-	1.5

Area 2 Leachate Quality

Leachate sampling and analysis are required to be undertaken quarterly in Area 2 at LW4A (northeast corner), LW5A (southeast corner), LW6A (southwest corner) and LW13 (northwest corner). Monitoring points LW4A, LW5A, LW6A and LW13 in Area 2 were recorded as dry in January 2013. Previous data collected during the period 2006 2008 have indicated an improving trend in leachate quality in this area of the site, as shown on the data plots in Appendix A. More recent data have not been collected since the monitoring points have been dry for a long period following capping of Area 2.

Area 3 Leachate Quality

Selected analytical results for the samples collected from Area 3 during 2014 are presented in Table 2.2. Time series plots for ammoniacal nitrogen and chloride concentrations (key leachate indicators) since February 2009 are shown in Appendix A. The data between January and December 2014 shows:

- ▶ Cell 1: Chloride concentrations range between 953 mg/l and 1240 mg/l and Ammoniacal Nitrogen concentrations range between 718 mg/l and 994 mg/l which are slightly lower than the concentrations recorded for the previous year. Highest concentrations were recorded for both in January;
- ▶ Cell 2: Chloride concentrations range between 1630 mg/l and 1770 mg/l and Ammoniacal Nitrogen concentrations range between 1470 mg/l and 1700 mg/l which are similar to concentrations recorded for the previous year. Highest concentrations for both were recorded in March although both showed limited variability throughout the year;
- ▶ Cell 3: Chloride concentrations range between 754 mg/l and 1310 mg/l and Ammoniacal Nitrogen concentrations range between 668 mg/l and 1200 mg/l which are lower than the concentrations recorded for the previous year. The highest concentrations were recorded for both in October; and
- ▶ Cell 4A: Chloride concentrations range between 718 mg/l and 2230 mg/l and Ammoniacal Nitrogen concentrations range between 622 mg/l and 2130 mg/l. Concentrations for both increased as the year went on with highest concentrations for both being recorded in October.

Table 2.2 Selected Leachate Quality Data for Monitoring Period January – December 2014

Cell	pH			Electrical Conductivity (µS/cm)			Ammoniacal Nitrogen (mg/l)			Chloride (mg/l)			Temperature (°C)		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Cell 1	7.6	7.8	8.1	8630	9551	10700	718	816	994	953	1053	1240	18.6	20.3	23.1
Cell 2	7.7	7.8	8.1	13900	15030	15900	1460	1531	1700	1620	1673	1770	20.6	22.7	25.7
Cell 3	7.5	7.7	8	7170	10501	12900	668	941	1200	754	1132	1360	19.5	24.8	30.1
Cell 4A	7.5	7.8	8.1	7670	15226	20700	622	1534	2230	718	1705	2340	20.7	24.0	27.8

Note: Monthly monitoring. Not measured in November 2014

The annual extended analytical suite as required by the EP for Area 3 was carried out in June 2014. The majority of determinands were below the laboratory detection limits (full results can be found in the quarterly report for April to June, ref: rr890i2). Substances in the monthly and annual monitoring recorded above the detection limits in the leachate included:

- ▶ Pesticides/herbicides: mecoprop (0.0226-0.0777 mg/l), dichlorprop (0.00067-0.00256 mg/l), chlorpyrifos (<0.000014-0.000016 mg/l) and MCPB (<0.0005-0.00821 mg/l);
- ▶ Extractable hydrocarbon bands: C8-C10 (<0.1-0.109 mg/l), C10-C16 (0.334-0.513 mg/l) and C6-C40 (0.334-0.555 mg/l);
- ▶ Other organics: 2,4,6-trichlorophenol (<0.004-0.013 mg/l) and di-n-butylphthalate (<0.01-0.02 mg/l);
- ▶ Metals: cadmium (<0.0006-0.0012 mg/l); and
- ▶ Anions: cyanide: (0.031-0.065 mg/l).Groundwater Levels.

2.3 Groundwater Levels

Table 2.3 shows the range of groundwater levels recorded during 2014.

Table 2.3 Summary of Groundwater Levels recorded for monitoring period January – December 2014

Groundwater Monitoring Borehole	Datum (m AOD)	Groundwater Levels (m AOD)		
		Min	Mean	Max
BH1	7.88	5.42	5.99	7.30
BH15	8.15	5.40	6.11	6.83
NRA3	6.78	4.33	4.95	6.03
BH18A	6.72	4.29	4.84	5.74
BH18B	6.75	4.90	5.40	5.83
BH19A	5.82	4.08	4.52	4.82
BH19B	5.95	4.07	4.50	5.17
BH19C	5.92	3.98	4.44	4.76

Groundwater Monitoring Borehole	Datum (m AOD)	Groundwater Levels (m AOD)		
BH20A	5.07	3.98	4.19	4.39
BH20B	5.07	3.93	4.18	4.67
BH21A	5.19	3.89	4.28	4.63
BH21B	5.2	3.94	4.33	4.80
BH23	4.47	2.89	3.28	3.69
BH24	7.36	4.77	5.43	6.16
BH27	9.81	4.20	4.72	5.36
BH28	7.35	4.33	4.91	5.64
BH29	6.01	4.03	4.61	5.59
BH30	5.6	3.74	4.01	4.31
BH31	5.49	3.98	4.19	4.43
BH32	6.36	4.02	4.49	5.78
BH33	7.22	4.79	5.38	6.71
BH34	6.42	5.01	5.51	6.12
BH35	6.55	5.02	5.55	6.09
BH36	7.22	4.93	5.46	6.06

Groundwater levels are presented graphically in Appendix B for the period February 2000 to December 2014. The groundwater monitoring boreholes have been split into three groups for ease of presenting the data as follows:

- ▶ Boreholes drilled prior to 2004 - BH1, BH15 and NRA3;
- ▶ Boreholes drilled during 2004 - BH18A, BH18B, BH19A, BH19B and BH19C, BH20A, BH20B, BH21A, BH21B, BH23 and BH24; and
- ▶ Boreholes drilled during 2006 (BH27 to BH33) and 2012 (BH34 to BH36).

Groundwater level variations during 2014 remained consistent with previous data and typically show seasonal effects, with higher levels recorded in winter compared to summer. During the earlier part of 2014, levels were seasonally high and started to fall steadily from January onwards. There was a slight increase in the levels recorded in October and November before dropping again in December. Levels were similar to those recorded in the previous year.

2.4 Groundwater Quality

Analytical results for ammoniacal nitrogen, chloride, cadmium and temperature are presented graphically in Appendix C. Monitoring data for selected parameters (ammoniacal nitrogen, chloride, cadmium and temperature) during 2014 are presented in Table 2.4. The groundwater monitoring boreholes have been split into three groups for ease of presenting the data as follows:

- ▶ Boreholes drilled prior to 2004 - BH1, BH15 and NRA3;
- ▶ Boreholes drilled during 2004 - BH18A, BH18B, BH19A, BH19B and BH19C, BH20A, BH20B, BH21A, BH21B, BH23 and BH24; and

- Boreholes drilled during 2006 (BH27 to BH33) and 2012 (BH34 to BH36).

Ammoniacal nitrogen concentrations for boreholes BH20A, BH20B, BH21A and BH21B have been graphed separately as concentrations are higher than measured in other boreholes within that group.

Table 2.4 Selected Groundwater Quality Data for Monitoring Period January – December 2014

Borehole	Ammoniacal Nitrogen (mg/l)			Chloride (mg/l)			Cadmium (µg/l)			Temperature (°C)		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Upgradient of Areas 2 and 3												
BH1	<0.27	0.58	5.58	20.8	28.11	35.8	<0.6	<0.6	<0.6	8.8	11.9	15.4
BH15	<0.27	0.33	0.85	8.75	15.53	24.2	<0.6	<0.6	<0.6	8.88	12.06	14.7
BH24	<0.27	<0.27	<0.27	29.2	30.4	34.2	<0.6	<0.6	<0.6	8.7	10.9	12.4
Downgradient of Area 2 and Upgradient of Area 3												
BH27	162	169	187	253	278	339	<0.6	1.9	2.6	14.8	23.8	113.2
BH34	<0.27	0.81	1.64	38.9	56.4	70.0	<0.6	1	1.8	9.4	11.5	12.8
BH35	<0.27	18.07	46.4	55	121	169	<0.6	0.66	0.7	10.6	13.4	15.7
BH36	86.8	113	127	159	182	207	1.2	1.5	1.7	11.8	14.0	15.6
NRA3	<0.27	1.12	5.36	15	22	38	<0.6	<0.6	<0.6	9.4	11.9	13.7
Lateral to Groundwater Flow												
BH18A	<0.27	0.28	0.36	37.5	52.6	94.8	<0.6	0.67	0.8	9.7	11.6	12.8
BH18B	<0.27	0.88	5.88	39.8	52.9	81.9	<0.6	0.67	0.8	10.4	12.1	13.8
BH28	<0.27	0.32	0.66	14.8	27.6	37.0	<0.6	0.6	0.6	8.6	10.3	12.1
BH29	<0.27	1.0	2.36	11.7	21.5	33.4	<0.6	0.73	1	9	10.7	14.5
BH32	<0.27	<0.27	<0.27	15.8	19.9	36.2	<0.6	0.63	0.7	10.1	11.6	13.1
BH33	<0.27	<0.27	<0.27	11	13.8	15.4	<0.6	<0.6	<0.6	8.9	11.6	12.8
Downgradient of Areas 2 and 3												
BH19A	<0.27	1.08	3.55	17	35.8	48.7	<0.6	0.88	1.2	10.4	11.4	12.4
BH19B	<0.27	0.31	0.6	36.8	85.9	213	<0.6	<0.6	<0.6	10.8	11.5	12.8
BH19C	<0.27	1.2	4.78	46.1	136	252	<0.6	0.6	0.7	10.2	11.7	13.0
BH20A	26.9	59.0	77.2	134	402	486	<0.6	0.8	1.5	9.8	11.6	12.9
BH20B	21.2	195.8	227.0	170	336	390	<0.6	0.87	1.5	8.4	11.8	13.0
BH21A	21.9	39.9	71.8	108	230	447	<0.6	0.65	0.8	9.3	10.4	11.6
BH21B	24.9	56.6	207	42	125	367	<0.6	0.85	1.2	8.4	10.3	11.8
BH29	<0.27	1.0	2.36	11.7	21.5	33.4	<0.6	0.73	1	9	10.7	14.5
BH30	168	184	206	264	284	302	<0.6	1.5	2.3	14.2	16.1	17.7

Borehole	Ammoniacal Nitrogen (mg/l)			Chloride (mg/l)			Cadmium (µg/l)			Temperature (°C)		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Downgradient of Areas 2 and 3												
BH31	69.3	77.8	84.2	46.6	73.9	106	<0.6	1.3	1.9	10.3	12.5	15.1

Up Gradient Boreholes

Boreholes BH1, BH15 and BH 24 are situated upgradient of Areas 2 and 3 and provide an indication of local background groundwater quality. Boreholes BH27, BH34 to BH36 and NRA3 are situated downgradient of Area 2 and upgradient of Area 3 and provide an indication of any potential impact from Area 2 (see Figure 1). Monitoring data for selected parameters (ammoniacal nitrogen, chloride, cadmium and temperature) at these boreholes during 2014 are presented in Table 2.4. Data for ammoniacal nitrogen, chloride and cadmium at these boreholes show that:

- ▶ Local background groundwater quality (BH1, BH15 and BH24):
 - ▶ Ammoniacal Nitrogen concentrations continue to be below the laboratory detection limit (0.27 mg/l) except for isolated peaks and are consistent with previous data. A peak of 5.58 mg/l recorded at BH1 in July appears to be anomalous as subsequent data dropped to 0.76 mg/l. A peak of 0.85 mg/l was recorded at BH 15 in September but concentrations at then dropped to below the laboratory detection limit by the last quarter of the year;
 - ▶ Chloride concentrations in boreholes BH1, BH15 and BH24 continue to be low and broadly consistent with previous measurements. Concentrations are consistently lower in borehole BH15 than in boreholes BH1 and BH24; and
 - ▶ Cadmium concentrations have remained below the detection limit of 0.6 µg/l.
- ▶ Groundwater quality downgradient of Area 2 and upgradient of Area 3 (BH27, BH34 to BH36 and NRA3):
 - ▶ Concentrations of ammoniacal nitrogen and chloride continue to be above local background concentrations at boreholes BH27, BH35 and BH36, which are located within the central part of the downgradient boundary of Area 2. Ammoniacal nitrogen concentrations measured in boreholes BH34 to BH36 continue to be lower than measured at borehole BH27 and to show increasing concentrations southwards towards borehole BH27;
 - ▶ Concentrations at NRA3, located on the edge of the downgradient boundary of Area 2 continued to be low; and
 - ▶ Cadmium concentrations showed little variability and remained within the range of concentrations measured in previous monitoring.

Boreholes Situated lateral to the Groundwater Flow Direction

Boreholes BH18 (A and B), BH28, BH29, BH32 and BH33 are situated in a lateral direction from the site. Groundwater monitoring results for selected parameters (ammoniacal nitrogen, chloride and cadmium), for the period up to December 2014, are presented graphically in Appendix C. Results of these parameters for the 2014 are summarised in Table 2.4 above. The data for the reporting period shows:

- ▶ Concentrations of contaminants in these boreholes continue to be generally consistent with the results of previous monitoring;
- ▶ There is little or no evidence of contamination (time-series plots in Appendix C) except for the slightly elevated chloride concentrations measured in boreholes BH18A and BH18B. Concentrations recorded at BH18A and BH18B are associated with leaching from marine dredgings used as part of the engineered cap to Area 2 (dredgings produced a saline runoff

during wet periods, with the discharge to the surface water lagoon resulting in an impact on groundwater quality as measured in the nearby boreholes BH18A and BH18B). Following the decline trend from the elevated peaks recorded at the end of 2011 (810 mg/l in BH18A and 619 mg/l in BH18B), concentrations have continued to decrease and remained within the range 37.5 to 94.8 mg/l in BH18A and 39.8 to 89.1 mg/l in BH18B since January 2014. Over time this effect is diminishing, however, these concentrations still exceed typical baseline values for these boreholes (about 25 mg/l);

- ▶ Ammoniacal-nitrogen concentrations continue to be within local background levels except for BH29, on the southern edge of Area 3, which continues to show slightly higher concentrations (<0.27-2.36 mg/l) consistent with historical data. Concentrations at BH18B showed an isolated peak of 5.88 mg/l in November; and
- ▶ Cadmium concentrations in lateral boreholes were below 1.0 µg/l with exception of BH20 where a concentration of 1.0 µg/l was recorded in January 2014.

Downgradient Boreholes

Boreholes BH19 (A, B and C), 20 (A and B), 21 (A and B), 29, 30 and 31 are located downgradient of Areas 2 and 3. Compliance limits listed in the EP ref: QP3134LY and EPR/PP3294FJ/V008 for ammoniacal nitrogen, chloride and cadmium in the downgradient boreholes are presented in Table 2.5.

Table 2.5 EP Compliance Limits for Groundwater Quality

Borehole	EP (ref PP3294FJ) Compliance Limit for Area 2 and Civic Amenity			EP (ref GP3330BY) Compliance Limit for Areas 1 & 3		
	Chloride (mg/l)	Ammoniacal Nitrogen (mg/l)	Cadmium (µg/l)	Chloride (mg/l)	Ammoniacal Nitrogen (mg/l)	Cadmium (µg/l)
Reporting Frequency	6 Monthly	6 Monthly	6 Monthly	Monthly	Monthly	Quarterly
BH19A	250	3.6	5.5	29	3.6	5.5
BH19B	34	3.0	5.5	28	3.0	5.5
BH19C	34	3.0	5.5	30	3.0	5.5
BH20A	504	5.0	5.5	310	5.0	5.5
BH20B	504	230	5.5	424	230	5.5
BH21A	387	266	5.5	270	5.10	5.5
BH21B	215	69.7	5.5	411	69.7	5.5
BH29	19.8	19.8	5.5	-	-	-
BH30	504	266	5.5	-	-	-
BH31	179	102	5.5	-	-	-

During 2014, the EP compliance limits were not exceeded for cadmium in any borehole.

The compliance limits (Table 2.5) for ammoniacal-nitrogen and chloride specified in the EP (ref PP3294FJ) for Area 2 and Civic Amenity, were exceeded as follows (6-monthly reporting):

- ▶ BH19B - chloride compliance limit (34 mg/l) in January (68.9 mg/l), February (43.3 mg/l), March (45.0 mg/l), April (47.9 mg/l) and October (213 mg/l);

- ▶ BH19C - chloride compliance limit (34 mg/l) in January (46.1 mg/l), February (127 mg/l), March (172 mg/l), April (95.0 mg/l) and October (200 mg/l).
- ▶ The ammoniacal-nitrogen compliance limit (3 mg/l) in October (3.25 mg/l);
- ▶ BH20A - ammoniacal-nitrogen compliance limit (5 mg/l) in January (35.7 mg/l), February (44.4 mg/l), March (48.2 mg/l), April (54.4 mg/l) and October (76.6 mg/l); and
- ▶ BH29 - chloride compliance limit (19.8 mg/l) in January (27.2 mg/l), March (33.4 mg/l) and April (29.1 mg/l); and
- ▶ BH29 - chloride in January (27.2 mg/l) and March (33.4 mg/l).

The compliance limits (Table 2.5) for ammoniacal-nitrogen and chloride specified in the EP (ref GP3330BY) for Area 1 and 3 were exceeded as follows (monthly reporting):

- ▶ BH19A - chloride compliance limit (29 mg/l) in May (45.4 mg/l), June (45.6 mg/l), July (48 mg/l), August (46 mg/l) and September (35 mg/l);
- ▶ BH19B – chloride compliance limit (28 mg/l) for all monthly monitoring - January (68.9 mg/l), February (43.3 mg/l), March (45.0 mg/l), April (47.9 mg/l), May (49.8 mg/l), June (42.1 mg/l), July (37 mg/l), August (149 mg/l), September (163 mg/l), October (213 mg/l), November (87.4 mg/l) and December (85.1 mg/l);
- ▶ BH19C – chloride compliance limit (30 mg/l) for all monthly monitoring - January (46.1 mg/l), February (127 mg/l), March (172 mg/l), April (95 mg/l), May (68.1 mg/l), June (69.3 mg/l), July (77 mg/l), August (144 mg/l), September (173 mg/l), October (200 mg/l), November (252 mg/l) and December (209 mg/l).

The ammoniacal-nitrogen compliance limit (3 mg/l) was exceeded in September (4.78 mg/l) and October (3.25 mg/l).

- ▶ BH20A – chloride compliance limit (310 mg/l) in April (394 mg/l), May (405 mg/l), June (420 mg/l), July (425 mg/l), August (441 mg/l), September (439 mg/l), October (439 mg/l) and November (486 mg/l).

The ammoniacal-nitrogen compliance limit (5 mg/l) was exceeded for all monthly monitoring - January (35.7 mg/l), February (44.4 mg/l) and March (48.2 mg/l) April (54.4 mg/l), May (60.2 mg/l), June (64 mg/l), July (71 mg/l), August (75 mg/l), September (74 mg/l), October (76.6 mg/l), November (77.2 mg/l) and December (26.9 mg/l).

- ▶ BH21A – chloride compliance limit (270 mg/l) in February (310 mg/l), March (254 mg/l) and December (447 mg/l).

The ammoniacal-nitrogen compliance limit (5.1 mg/l) was exceeded for all monthly monitoring - January (32.1 mg/l), February (25.7 mg/l), March (31.7 mg/l), April (43.6 mg/l), May (50.1 mg/l) and June (52.1 mg/l). July (50 mg/l), August (36 mg/l) and September (27 mg/l). October (36.3 mg/l), November (21.9 mg/l) and December (71.8 mg/l); and

- ▶ BH21B – ammoniacal-nitrogen compliance limit (69.7 mg/l) in December (207 mg/l).

The Groundwater Contingency Action Plan for the site (AMEC report reference: 04602N1857) details measures to be taken in the event that compliance limits are exceeded. Notices of these exceedances were provided to Natural Resources Wales by the submission of Schedule 6 notifications (copies included in the relevant quarterly monitoring reports). There were no exceedances in BH's 20B, 30 and 31. These exceedances continue to reflect variability in the data associated with contaminant migration from the unlined landfill Area 2 as discussed below:

- ▶ EP compliance limits for chloride continue to be exceeded at boreholes BH19A, BH19B and BH19C (EP ref GP3330BY), in the northwest corner of Area 3, which monitor the sand aquifer at different depths. These elevated concentrations, above typical baseline values and the EP compliance limits reflect the downgradient migration of a leachate plume derived from the unlined Area 2. Monitoring data for 2014 indicates that:

- ▶ Chloride and ammoniacal-nitrogen concentrations at the shallowest installation BH19C showed some variability across the reporting period but there was an increase on concentration for both parameters towards the end of the year with ammoniacal nitrogen exceeding the EP compliance limit (3 mg/l, EP ref GP3330BY) on two occasions in September (4.78 mg/l) and October (3.25 mg/l). Chloride concentrations ranged from 46.1 to 252 mg/l and exceeded the EP compliance limit (30 mg/l, EP ref GP3330BY) at all monthly monitoring rounds;
- ▶ Chloride concentrations at the mid-depth installation BH19B (36.8-213 mg/l) continue to exceed the EP compliance limit (28 mg/l in EP ref GP3330BY) but remained within historical data (16-227 mg/l). Ammoniacal-nitrogen concentrations continue to be low (<0.27-0.6 mg/l); and
- ▶ Chloride concentrations at the deepest installation BH19A ranged from 17 mg/l to 48.7 mg/l exceeding the compliance limit on seven occasions and the typical baseline (about 15 mg/l). Ammoniacal-nitrogen concentrations at this borehole remained below the compliance limit (3.6 mg/l ref GP3330BY).
- ▶ Ammoniacal-nitrogen (26.9-77.2 mg/l) and chloride (134-486 mg/l) concentrations at BH20A continue to show an upward trend and exceed the compliance limits (5.0 mg/l and 310 mg/l, respectively in EP ref GP3330BY). This is associated with the downgradient migration of a leachate plume originating from Area 2; and
- ▶ Ammoniacal-nitrogen (21.9 mg/l to 71.8 mg/l) and chloride (108 mg/l to 447 mg/l) concentrations at BH21A also show an upward trend with ammoniacal nitrogen exceeding the compliance limit of 5.1 mg/l on all monitoring occasions (EP re GP3330BY). The compliance limit for chloride (270 mg/l) was exceeded in December 2014 (EP ref GP3330BY). This reflects the downgradient migration of a leachate plume originating from Area 2.

Overall, the leachate plume derived from Area 2 is having an impact on groundwater quality downgradient of Areas 2 and 3. The development of the site, including capping and associated drainage of completed areas is likely to also be affecting groundwater quality. However, the overall effect on groundwater quality is expected to be a continued improvement due to a combination of the following:

- ▶ Reduction in leachate concentration as a result of waste stabilisation; and
- ▶ Dilution by groundwater migrating beneath the landfill from the east.

Leachate and groundwater quality will continue to be monitored. The Contingency Action Plan for the site (Table 4.1 in Closure Report, May 2007) identifies a number of actions subject to the number of exceedances of groundwater control and trigger limits, including review of monitoring information, review of conceptual model assumptions and review of existing control and compliance limits. The compliance limits will be reviewed in the site's Hydrogeological Risk Assessment (HRA) review due in 2015.

Temperature Measurements

Temperature measurements for the reporting period are consistent with seasonal trends. There is no major variability in temperature measurements between upgradient/lateral boreholes and downgradient boreholes with the following exceptions:

- ▶ Borehole BH27 (downgradient of Area 2 only), which has consistently recorded temperatures up to 5°C higher than most of the other monitoring locations, possibly reflecting ongoing waste degradation activity in Area 2 of the landfill;
- ▶ Borehole BH30, on the western edge of Area 3, which also records temperatures 3-6°C higher than most other locations. This borehole is downgradient of borehole BH27; and
- ▶ Boreholes BH35 and BH36 (downgradient of Area 2 only), the more southerly of the boreholes on the downgradient edge of Area 2, have continued to record temperatures that are slightly higher than most other locations (except boreholes BH27 and BH30).

2.5 Surface Water Quality

Surface water monitoring is a requirement of the EP for Areas 2 and 3 at monitoring locations SW1, SW2 and SW3 (Section 1.3). SW1 is located in the vicinity of the site's permitted discharge and SW2 and SW3 are located in the ditch to the west (downstream) of Area 3, as shown on Figure 1.1. As a consequence of some contamination identified in this part of the site in late 2010, in addition to the regular sampling at location SW1, samples are also taken whenever possible from the pipe which discharges to the drain near this point. The pipe discharges surface water runoff from hardstanding around the site buildings in Area 1 after it has passed through an oil water separator.

Analytical results for ammoniacal nitrogen, chloride, electrical conductivity (EC) and temperature are summarised in Table 2.6 and presented (excluding EC but including chemical oxygen demand (COD)) graphically combined with long term water quality data in Appendix D.

Table 2.6 Selected Surface Water Quality for Monitoring Period January to December 2014

	SW1 ¹			SW1 ² (pipe)			SW2 ³			SW3 ⁴		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Ammoniacal Nitrogen (mg/l)	<0.27	6.02	11.6	0.37	3.69	11	<0.27	3.12	6.52	<0.27	2.22	3.85
Chloride (mg/l)	14.3	38.9	68.2	19.6	38	59	3.13	109	257	49.1	91.9	149
Electrical Conductivity (µS/cm)	224	345	465	243	325	403	45.6	807	1510	637	825	1330
Temperature (°C)	8.7	13.4	22.1	9.4	11.9	15.2	7.2	11.8	17.1	6.7	11.5	16.7
COD (mg/l)	11	151	433	27	220	1040	21	1100	9450	24	1333	8200

¹ SW1 dry in July, August and September

² SW1 (pipe) dry in June, July, August and December

³ SW2 dry in August and September

⁴ SW3 dry in June

Ammoniacal-nitrogen concentrations at SW1 were below detection limit (<0.27 mg/l) from February through to May and increased to 8.19 mg/l in June. In July, August and September SW1 was dry and concentrations in October reached a peak of 11.6 mg/l, dropping in November to 3.52 mg/l before increasing again to 6.47 mg/l in December. Chloride measurements at SW1 increased from 37.1 mg/l in January to 68.2 mg/l in February dropping slightly in March and April (66.6 mg/l and 61.3 mg/l respectively). It was noted that a small amount of road salt was used near the weighbridge during this period. By June concentrations had dropped to 14.3 mg/l rising slightly in the latter quarter of the year to 20.4-22.2 mg/l. In general concentrations remained within historical data which showed a number of elevated peaks. Similar concentrations were measured at the adjacent pipe discharge.

Ammoniacal nitrogen concentrations at SW2 dropped from 0.56 mg/l in January to below the detection level of <0.27 mg/l in February, March and April before rising to 3.71 mg/l in June and 6.4 mg/l in July (sampling point was dry in August and September). Concentrations continued to show elevated peaks (6.52 mg/l in November) before dropping below the detection limit in December 2014. Chloride concentrations continued to show significant variability ranging from 73.6-77.6 mg/l in the first quarter of the year before increasing to 257 mg/l in May and then decreasing to 197 mg/l in June and 112 mg/l in July. Towards the end of the year concentrations continued to show elevated peaks (148 mg/l in October).

These concentrations continue to be higher than the average concentrations measured previously of <0.3 mg/l ammoniacal-nitrogen (data for 2005 to 2012) and 23 mg/l chloride (data for 2005-2009). There are a number of possible explanations for the increased concentrations at SW2 which are under investigation including:

- ▶ Former storage of compost taken from the IVC facility which ceased operation in 2013 (some site derived compost has been applied to the Cell 4 final capped soil profile);
- ▶ Sludge spraying and muck spreading on adjacent agricultural land;
- ▶ Saline groundwater baseflow contribution to the perimeter ditch during periods of high groundwater levels: groundwater quality in the northern part of the site (cross-gradient to the landfill) has been affected, particularly during 2011 to 2013, by the passage of a saline “slug” associated with runoff from the marine dredgings used as part of the engineered cap to Area 2. The elevated chloride peaks recorded at SW2 since 2012 are likely to reflect baseflow of saline groundwater (time-series charts in Appendix D). The occasional ammoniacal-nitrogen peaks in SW2 in 2013-2014 (24.6 mg/l in August 2013, 15.3 mg/l in December 2013, 6.4 mg/l in July 2014 and 6.52 mg/l in November 2014) may be associated with desorption of ammoniacal-nitrogen from the sand aquifer by potassium (ion exchange) associated with the saline “slug”.

SW3 represents the main surface water discharge from the site. Data obtained during 2014 shows:

- ▶ Ammoniacal nitrogen show variability but remained within historical range. Measurements showed an initial increase to 2.31 mg/l in February before dropping for the first quarter and were below the detection level (<0.27 mg/l) in May. There was a slight increase to 3.7 mg/l in July before falling again in August (1.33 mg/l) and October (1.15 mg/l) (sample point was dry in September). An increase in November to 3.85 mg/l was followed by a fall in December to below detection limit (<0.27 mg/l);
- ▶ Chloride concentrations decreased from 87.2 mg/l in January, down to 66.3 mg/l in May and remained within historical data. An increase to 223 mg/l in August and above the historical range (21.5-113 mg/l) is noted but concentrations decreased to 149 mg/l in October and fell again to 0.1 mg/l in December;
- ▶ EC values measured during 2014 were slightly higher than in previous years, with a range between 637 – 1300 $\mu\text{S}/\text{cm}$;
- ▶ COD measurements during previous years were generally below 60 mg/l during the winter months with isolated peaks and similar results were seen in 2014. The highest value (8 200 mg/l) was recorded in August.
- ▶ Temperature measurements are consistent with seasonal trends, recording winter lows in all monitoring locations with little difference between the values measured at all the monitoring locations.

Visual observations of the state of the water at locations SW1 (Area 1 discharge) and SW3 (site discharge near sluice) are also undertaken on a weekly basis. Site records of these observations are included in the quarterly reports.

2.6 Landfill Gas

Perimeter Gas Monitoring (Area 3)

Landfill gas monitoring in the perimeter boreholes is a requirement of the EP for Area 3 to identify any off site migration. Five landfill gas monitoring boreholes were installed around the perimeter of Cell 1, Area 3 in September 2006, as shown on Figure 1. Borehole BG05 was lost during engineering works. Monitoring results for Boreholes BG01 to BG04 for 2014 are presented in Table 2.7 together with compliance limits for methane and carbon dioxide. These show levels consistent with previous monitoring and show no evidence of off-site landfill gas migration. None of the compliance limits were exceeded during the reporting period.

Meteorological data (daily measurements of rainfall, temperature and wind speed) for the months of January to December 2014 were included in the relevant quarterly monitoring reports.

Table 2.7 Monitoring Results from Perimeter Landfill Gas Boreholes for the Monitoring Period January to December 2014

Date	BHG01			BHG02			BHG03			BHG04		
	CH4 (%v/v)	CO2 (%v/v)	O2 (%v/v)	CH4 (%v/v)	CO2 (%v/v)	O2 (%v/v)	CH4 (%v/v)	CO2 (%v/v)	O2 (%v/v)	CH4 (%v/v)	CO2 (%v/v)	O2 (%v/v)
27/01/2014	0	0.3	20.2	0	0.2	20.7	0	0.1	20.9	0	0.1	20.8
25/02/2014	0.1	0.3	21.5	0.1	0.6	20	0.1	3.1	18.6	0.1	0.1	21.8
28/03/2014	0.1	0.2	22.1	0.1	0.1	22.1	0.1	2.9	19.5	0.1	0.1	22.2
30/04/2014	0	0.4	21.4	0	0.1	21.6	0	1.3	20.3	0	0.1	21.4
16/05/2014	0	0.3	20.5	0	0.4	20.5	0	3.2	17.5	0	0.1	20.5
26/06/2014	0	0.2	21.4	0	0.5	21	0	1.2	20.5	0	0.1	21.2
31/07/2014	0.5	0.4	21.2	0.5	0.4	21.3	0.5	0.1	21.6	0.5	0.1	21.6
14/08/2014	0.1	0.5	20.5	0.1	0.6	20.5	0.1	2.6	18.7	0.1	0.1	20.9
15/09/2014	0	0	20.8	0	0.3	20.6	0	1.9	19.3	0	0.1	20.7
16/10/2014	0	0.6	20.6	0	0.4	20.8	0.1	1.3	20	0.1	0.1	21.1
18/11/2014	0.2	0.7	21	0.2	0.6	20.8	0.2	2.6	19.1	0.2	0.1	21.1
09/12/2014	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.
Compliance Limits	1	1.5	-	1	1.6	-	1	5.1	-	14.8	11.1	-

n.m – not measured

In-Waste Gas Monitoring (Area 3)

In waste gas monitoring has also been carried out within Area 3 in accordance with the site EP. Monitoring during this reporting period was from combined leachate and gas monitoring wells:

- ▶ LM1/1 and LM1/2 in Cell 1;
- ▶ LM2/1 and LM2/2 in Cell 2;
- ▶ LM3/1 in Cell 3, LM4/2 in Cell 4A;
- ▶ leachate manholes (LCP1, LCP2, LCP3, LCP4A and LCP4B in Cells 1, 2, 3, 4A and 4B, respectively); and
- ▶ gas wells C11 to C14 in Cell 1, C21 to C25 in Cell 2, C31 to C36 in Cell 3, C41 to C46 in Cell 4A and C51 to C57 in Cell 4B.

The location of the monitoring wells is shown on Figure 1. The results of the gas monitoring undertaken during 2014 are presented in Tables 2.8 to 2.11.

Active gas extraction was undertaken from all Cells during 2014. The data show that wastes in Cells 1 to 4 are producing landfill gas. In Cell 1, methane concentrations ranging from 0.0% v/v to 73.8% v/v and carbon dioxide concentrations ranging from 2.0% v/v to 38.4% v/v were detected. Landfill gas concentrations recorded in Cell 2, ranging between 3.6% v/v to 67.2% v/v for methane and 13.4% v/v to 39.6% v/v for carbon dioxide. Landfill gas levels recorded in Cell 3, ranging between 0.6% v/v to 64.0% v/v for methane and 0.7% v/v to 41.7% v/v for carbon dioxide. In Cell 4, methane concentrations ranging from 42.8% v/v to 64.4% v/v and carbon dioxide concentrations ranging from 33.4% v/v to 43.6% v/v were detected.

Table 2.8 Monitoring Results for In-Waste Landfill Gas Monitoring Boreholes in Cell 1 (January-December 2014)

Date	AP (mb)	LM1/1				LM1/2				LCP1			
		CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO
27 and 28/01/2014	977-984	n.m.	n.m.	n.m.	n.m.	4.3	8.8	12.4	2	22.1	16.8	3.6	0
25/02/2014	994	65.8	29.6	0	1	23.9	23.3	0.4	0	73.8	24.9	0	0
12/03/2014	1030-1033	42.8	29.3	0.5	10	9.9	17.2	1.4	3	16.3	14.5	2.6	7
22/04/2014	1008-1012	52.0	34.9	0	11	17.0	21.6	0.5	2.0	35.6	20.8	0.4	8.0
20/05/2014	1007-1014	44.3	25.4	0.4	19	37.4	26.0	0.2	16.0	50.7	34.0	0.5	14.0
18/06/2014	1028	32.5	22.8	0.1	12	0.1	2.0	17.6	1.0	44.4	20.5	0.7	5.0
29/07/2014	1018 – 1021	38.4	28.2	0.1	1.0	0.1	7.8	11.7	0	67.3	25.3	0.1	0
13/08/2014	1008 - 1013	38.7	27.5	0	2.0	17.4	21.5	0.2	10.0	24.7	17.4	0.7	1.0
18/09/2014	1013 - 1015	3.7	15.4	2.9	6.0	0	3.7	16	1.0	17.4	17.3	0.7	3.0
16/10/2014	1008 – 1012	10.7	20.9	0.2	1.0	0.1	2.8	18.3	0	37	21	0.7	1.0
10/11/2014	997 - 1006	12.9	20.9	0.5	4.0	0.2	7.9	11.7	0	70.5	25.9	0.1	1.0
09/12/2014	1018	2.2	15	4.3	5.0	0	3.3	15.8	1.0	6.9	17.3	0.6	1.0

Table 2.8 (continued) Monitoring Results for In-Waste Landfill Gas Monitoring Boreholes in Cell 1 (January-December 2014)

Date	AP (mb)	C11				C12				C13				C14			
		CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO
28/01/2014	977	29.5	20.1	0	0	17.2	19.6	0.1	0	31.4	23.2	0.4	0	25.2	21.5	0.3	0
25/02/2014	994	38.3	19.8	0	0	57.4	22.2	0	0	51.9	24.7	0	1	36.8	20.8	0	0
12/03/2014	1031	35.4	18.4	0.4	9	10.2	15.6	0.7	16	31.9	20.5	0.1	9	15.7	15.3	2.3	11
22/04/2014	1010-1013	64.2	37.2	0	7.0	63.9	37.7	0	12.0	59.9	36.5	0.3	12.0	56.8	34.2	0.1	13.0
20/05/2014	1006-1008	54.9	35.4	0.9	15.0	59.2	38.4	0	25.0	48.1	29.8	4.1	17.0	58.5	35.8	0.1	15.0
18/06/2014	1028	61.0	36.0	0.1	9.0	56.4	35.8	0	16.0	41.3	25.2	6.1	14.0	61.5	37.3	0.1	16.0
29/07/2014	1021 – 1022	34.3	18.9	0	5.0	40.0	20.7	0	5.0	46.9	25.8	0	4.0	13.7	18.3	0.6	8.0
13/08/2014	1007 – 1009	31.6	23.0	0	6.0	20.4	21.3	0	6.0	42.7	27.3	0.1	6.0	18.7	22.5	0.5	8.0
18/09/2014	1010 – 1013	20.1	21.0	0.1	6.0	12.6	19.2	0	8.0	22.9	21.6	0.1	8.0	14.2	16.2	4.5	7.0
16/10/2014	1008-1014	37.5	23.3	0	2.0	35.9	22.4	0	3.0	41.5	23.4	0	2.0	23.8	20.5	0.9	7.0
10/11/2014	1000 - 1002	29.6	22.5	0	4.0	25.6	22.1	0	4	40.3	25.4	0.1	4	33.1	23.1	0.3	8
09/12/2014	1018	20.9	20.8	0.4	4.0	11.3	19.6	0.1	8.0	18.8	20.3	0.6	4.0	12.1	15.5	3.8	13

Notes: AP- Atmospheric Pressure.

CH₄, CO₂ and O₂ in %v/v and CO in ppm.

n.m.- not measured

Table 2.9 Monitoring Results for In-Waste Landfill Gas Monitoring Boreholes in Cell 2 (January-December 2014)

Date	AP (mb)	LM2/1				LM2/2				LCP2				C21			
		CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO
28/01/2014	977-984	54	36.3	0.2	2	22.6	21.4	1.4	0	n.m.	n.m.	n.m.	n.m.	28.5	25.4	0	0
25/02/2014	994-995	65.2	39.3	0	0	65.2	37.6	0.3	1	65.3	37.7	0.3	0	67.2	33.7	0	1
12/03/2014	1030-1034	n.m.	n.m.	n.m.	n.m.	22.4	21.5	3.5	6	53.3	34.7	0.8	9	42.2	29.6	0.4	6
22/04/2014	1010	62.6	38.8	0	13.0	58.2	34.1	0.4	9.0	62.3	39.1	0	6.0	57.2	31.8	0.2	11.0
20/05/2014	1008	59.6	39.3	0.1	23.0	57.2	35.6	0	15.0	56.9	37.5	0.7	17.0	n.m.	n.m.	n.m.	n.m.
18/06/2014	1028	39.9	28.7	0	17.0	29.9	23.5	0	13.0	61.6	37.5	0	10.0	64.7	32.7	0.2	10.0
29/07/2014	1020 – 1022	64.2	37.7	0	10.0	33.9	28.4	0	4.0	58.7	37.1	0.7	6.0	54.6	33.5	0.1	6.0
13/08/2014	1006 - 1007	45.2	33.9	0	5.0	46.3	33.1	0	6.0	55.8	36.0	0.9	4.0	35.9	29.6	0.1	6.0
18/09/2014	1009 - 1017	60.9	37.0	0.1	12.0	12.8	20.7	0.8	6.0	42.9	31.6	0.9	9.0	25.0	25.2	0.1	9.0
16/10/2014	1008-1012	16.4	21.6	0.3	2.0	7.7	16.3	5.2	1.0	51.3	34.3	1.1	3.0	66.7	32.5	0.2	5.0
10/11/2014	997 - 1006	64.7	39.2	0.1	6.0	3.6	13.4	6.9	3.0	49.3	34.3	1.3	5.0	25.4	25.3	0.2	4.0
09/12/2014	1014-1018	18.2	23.2	0.7	8.0	45.2	31.7	0.1	6.0	32.7	27.9	1.4	3.0	65.5	31.2	0.6	4.0

Table 2.9 (continued) Monitoring Results for In-Waste Landfill Gas Monitoring Boreholes in Cell 2 (January-December 2014)

Date	AP (mb)	C22				C23				C24				C25			
		CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO
28/01/2014	977-984	29.3	28.3	0	0	40.8	31.4	0.1	1	58.2	39	0.2	0	28	26.5	0.5	1
25/02/2014	994-995	65.6	36.9	0.3	0	63.3	36.9	0	2	42.5	28.8	6.1	1	64.3	39.6	0.1	1
12/03/2014	1030-1034	39.1	30.8	0.4	6	n.m.	n.m.	n.m.	n.m.	56.4	34.3	2.6	14	34.3	29.4	0.2	11
22/04/2014	1010-1013	64.2	37.2	0	7.0	63.9	37.7	0	12.0	59.9	36.5	0.3	12.0	56.8	34.2	0.1	13.0
20/05/2014	1006-1008	54.9	35.4	0.9	15.0	59.2	38.4	0	25.0	48.1	29.8	4.1	17.0	58.5	35.8	0.1	15.0
18/06/2014	1028	61.0	36.0	0.1	9.0	56.4	35.8	0	16.0	41.3	25.2	6.1	14.0	61.5	37.3	0.1	16.0
29/07/2014	1018 - 2022	48.5	33.6	1.3	5.0	56.9	37.1	0	15	45.8	28.2	5.4	3.0	60.1	35.9	0	6.0
13/08/2014	1006 - 1011	38.6	31.5	1.4	3.0	50.0	35.6	0	13	41.5	26.4	6.6	7.0	55.4	36.0	0	8.0
18/09/2014	1009 - 1017	33.8	26.6	1.7	7.0	47.5	33.3	0.1	21	34.6	22.4	8.0	6.0	29.5	27.1	0.2	11.0
16/10/2014	1008-1014	60.7	36.2	0.7	4.0	35.9	32.5	0	11	35.7	23.1	8.1	4.0	51.8	32.8	0.2	6.0
10/11/2014	999 - 1005	38.0	30.8	1.4	4.0	53.3	36.5	0	12	28.2	17.9	11.5	3.0	38.7	30.6	0.1	5.0
09/12/2014	1014-1018	61.2	35.8	0.7	3.0	19.3	25	0	4.0	39	29.4	3.1	6.0	14.9	21.8	0.3	5.0

Notes: AP- Atmospheric Pressure.

CH₄, CO₂ and O₂ in %v/v and CO in ppm.

n.m.- not measured

Table 2.10 Monitoring Results for In-Waste Landfill Gas Monitoring Boreholes in Cell 3 (January-December 2014)

Date	AP (mb)	LM3/1				LCP3				C31				C32			
		CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO
28/01/2014	977-978	n.m.	n.m.	n.m.	n.m.	51.7	37.1	1.4	2	43.7	32	5.1	0	62.7	39.9	0	0
25/02/2014	994	50.2	37	0.5	1	59.6	39.2	0.9	0	28.7	22.9	7.4	2	34.7	30.1	0	1
12/03/2014	1030-1034	38.6	31.7	0.4	8	61.2	38.9	0.4	8	60.0	39.3	0.2	25	61.7	38.1	0.2	13
22/04/2014	1008-1013	62.1	40.8	0	16.0	61.6	40.2	0.1	12.0	61.2	41.1	0	31	46.3	33.4	2.7	15.0
20/05/2014	1006-1010	58.8	39.1	0	22.0	55.6	36.4	1.2	14.0	56.3	38.1	0	41	40.4	29.3	1.4	41.0
18/06/2014	1028-1029	43.2	33.1	0.8	10.0	56.8	37.0	1.0	9.0	43.4	34.7	0	40	5.5	10.9	10.0	14.0
29/07/2014	1021 - 1022	7.5	18.6	1.3	2.0	37.9	26.8	6.2	1.0	50.9	36.6	0	25	2.7	4.6	15.7	12.0
13/08/2014	1006 - 1008	62.5	40.8	0	10.0	54.2	36.2	1.7	1.0	61.6	39.2	0	23	23.1	19.1	8.8	9.0
18/09/2014	1012 - 1014	56.5	39.4	0.2	8.0	54.2	36.2	1.5	4.0	45.0	34.5	0.1	29	5.4	4.0	15.9	9.0
16/10/2014	1007-1009	6.6	14.3	7.6	8.0	53.1	34.9	2.8	2.0	51.4	37.7	0	19	0.6	0.8	21.2	3.0
10/11/2014	997 - 1003	63.4	41.2	0	5.0	53.8	36.3	2.7	3.0	54.5	37.8	0	17	16.9	11.3	12.8	6.0
09/12/2014	1013-1020	41.7	33.3	1.1	7.0	36.1	30.8	0.8	3	36.2	31.5	0.1	10	0.6	0.7	21.2	1.0

Table 2.10 (continued) Monitoring Results for In-Waste Landfill Gas Monitoring Boreholes in Cell 3 (January-December 2014)

Date	AP (mb)	C33				C34				C35				C36			
		CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO
28/01/2014	977-978	61.9	39.8	0.1	1	61.4	41.7	0.2	3	52.6	38.2	0	1	45.9	36.3	0.2	1
25/02/2014	994	48.9	36	0.1	1	62.9	41.1	0	5	56.4	37.1	0	1	33.8	28.5	0.1	1
12/03/2014	1030-1034	40.8	31.9	0.2	11	62.3	39.5	0.2	34	48.6	34.3	0.4	11	31	29.2	0.4	6
22/04/2014	1010-1012	61.4	40.2	0.1	13.0	62.0	40.5	0	54.0	60.6	38.6	0.2	14.0	61.2	40.0	0.1	14.0
20/05/2014	1005-1008	52.8	36.4	0.1	19.0	59.7	39.2	0	56.0	58.7	37.5	0.1	18.0	55.7	36.1	0	21.0
18/06/2014	1028-1029	33.6	29.4	0.1	10.0	60.9	38.2	0	52.0	45.2	31.2	0.2	17.0	13.1	20.5	0.1	8.0
29/07/2014	1020 - 1039	30.1	28.5	0.2	6.0	61.6	39.2	0	45	42.9	31.8	0.2	6.0	24.2	26.2	0	2.0
13/08/2014	1006 - 1008	62.5	38.7	0	8.0	62.3	39.7	0	40	61.2	38.4	0.1	9.0	64.0	40.1	0	4.0
18/09/2014	1012 - 1019	43.4	34.0	0.2	9.0	55.7	37.9	0	61	44.8	33.9	0.3	12.0	40.7	34.0	0.1	6.0
16/10/2014	1007-1009	21.8	26.9	0.3	5.0	37.4	32.9	0	8	33.8	29.1	0.3	5.0	12.4	2.0	0.4	6
10/11/2014	996 - 1003	58.9	38	0.3	7.0	62.9	39.6	0	31	61.2	41.5	0.2	6.0	61.6	40.7	0	4.0
09/12/2014	1013-1020	26.4	27.8	0.4	4.0	48.5	35.9	0.1	15	25.4	26.8	0.1	5.0	11.7	21.1	1.1	4

Table 2.11 Monitoring Results for In-Waste Landfill Gas Monitoring Boreholes in Cell 4 (January-December 2014)

Date	AP (mb)	LM4/2				LCP4A				C41				C42			
		CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO
28/01/2014	977	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	61.4	41.8	0	1	61.7	41.4	0	2
25/02/2014	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.
02/03/2014	1032	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.
22/04/2014	1009-1012	60.4	42.7	0	69.0	60.9	41.3	0	36.0	62.1	39.8	0	49.0	63.7	38.2	0	41.0
20/05/2014	1006-1009	59.1	41.0	0	63.0	n.m.	n.m.	n.m.	n.m.	59.5	39.0	0	53.0	61.0	37.5	0	46.0
18/06/2014	1028	55.3	38.8	0.2	68.0	55.7	38.0	1.1	26.0	60.7	38.7	0	63.0	61.6	37.6	0	29.0
29/07/2014	1021-1025	60.4	40.5	0	12.0	60.7	40.1	0	19.0	61.9	39.7	0	22.0	62.7	39.3	0	17.0
13/08/2014	1007 - 1008	61.8	41.4	0	13.0	61.0	40.8	0	18.0	61.8	40.1	0	23.0	61.7	38.5	0	15
18/09/2014	1012 - 1013	58.6	39.6	0	21.0	58.3	39.9	0.1	26.0	58.7	38.8	0	34.0	60.2	37.8	0	24.0
16/10/2014	1008-1015	59	40.9	0	14	60.1	41.6	0	11	60.2	40.5	0	23	61.1	38.5	0	9
10/11/2014	1000 - 1002	62.9	42.4	0	10	51.4	36.2	3.1	13	64.2	40.3	0	18	62.6	39.6	0	12
09/12/2014	1013-1014	60.9	40.7	0	12	60.6	40.9	0.1	9	63.3	39.1	0	15	42.8	33.4	0	7

Table 2.11 (continued) Monitoring Results for In-Waste Landfill Gas Monitoring Boreholes in Cell 4 (January-December 2014)

Date	AP (mb)	C43				C44				C45				C46			
		CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO	CH ₄	CO ₂	O ₂	CO
28/01/2014	977	60.9	42.5	0	0	59.3	43.6	0	6	60.9	42.4	0	3	60.8	42.5	0	3
25/02/2014	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.
02/03/2014	1032	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.	n.m.
22/04/2014	1008-1012	61.6	39.6	0	21.0	60.9	40.9	0	38	62.2	40.5	0	34.0	61.9	40.3	0	52.0
20/05/2014	1007-1011	59.9	38.4	0.1	27.0	58.8	39.7	0	49	59.9	38.9	0	47.0	59.6	39.0	0	64.0
18/06/2014	1028	60.8	38.4	0	22.0	59.6	39.7	0	26	60.2	39.1	0	25.0	60.1	39.0	0	44.0
29/07/2014	1021 - 1025	62.5	39.7	0	21	60.6	40.1	0	20	61.3	40.3	0	26	61.3	40.1	0	50
13/08/2014	1007 - 1012	61.8	39.1	0.2	21	60.9	40.0	0	19	61.6	40.1	0	25	61.7	40.0	0	47
18/09/2014	1009 - 1012	59.2	37.8	0	29	58.1	38.9	0	29	59.4	39.0	0	36	n.m.	n.m.	n.m.	n.m.
16/10/2014	1008-1011	64.6	36.4	0	14	61	40.4	0	16	60.8	40.2	0	16	59.3	39.8	0	26
10/11/2014	997 - 1001	63.8	40.1	1.0	15	63.1	40.9	0	15	63.1	41	0	18	62.8	40.7	0	29
09/12/2014	1013-1014	64.3	39.5	0.1	5	54.3	38.1	0	7	63.2	40.5	0.2	8	58.1	38.8	0	14

Notes: AP- Atmospheric Pressure.

CH₄, CO₂ and O₂ in %v/v and CO in ppm

n.m.- not measured as wells were disconnected during the on-going capping works. Additional measurements for C41 in September (58.4% CH₄, 39.3% CO₂, 0% O₂ and 66ppm CO) and C42 in August (62.1% CH₄, 38.8% CO₂, 0% O₂ and 16ppm CO).

3. Review of Hydrogeological, Landfill Gas and Stability Risk Assessments

3.1 Review of Hydrogeological Risk Assessment

Introduction

This section of the report provides an update of the conceptual hydrogeological understanding of Area 3 of Ffridd Rasmus Landfill developed in the 2009 HRA Review (AMEC, 2009) and 2011 LandSim update (AMEC, 2011) through incorporation of data for 2014. The 2011 LandSim update modelled the observed increase in leachate strength (as ammoniacal nitrogen, chloride, zinc and mecoprop) and the decrease in recharge to the sand aquifer (and consequent increase in unsaturated zone thickness) as a result of the engineering of cells within Area 3 with a low permeability liner. Where appropriate, the details in this section are drawn from the 2009 HRA Review and 2011 LandSim update.

Hydrogeological Conceptual Model

The conceptual model for Area 3 of the site developed in the 2009 HRA Review and updated in the 2011 LandSim update is summarised in Table 3.1. Monitoring data for 2014 (summarised in Section 2) have been used to update the conceptual model as discussed below.

Table 3.1 Hydrogeological Conceptual Model for Area 3 of Ffridd Rasmus Landfill (2011 LandSim update)

Source	Potential Pathways	Potential Receptors
Landfill leachate	<p>Leachate leakage through the engineered composite liner into the underlying unsaturated sands.</p> <p>Vertical migration through the unsaturated sand to the underlying water table.</p> <p>Lateral migration within groundwater flow westwards towards the coast.</p>	<p>Groundwater within the sand aquifer below the site.</p> <p>Surface water in the drainage ditches around the site boundary.</p> <p>Morfa Harlech SSSI</p>

Review of Source

The source at the site is landfill leachate, which typically comprises a complex range of contaminants. The contaminants and concentrations modelled in the 2011 LandSim update were based on monitoring data available for Area 3 (Table 3.2). A maximum leachate level of 1.5 m above base consistent with the EP leachate compliance level was modelled in the 2011 LandSim update.

Table 3.2 Comparison of Leachate Composition Modelled in 2011 LandSim Update with Leachate Monitoring Data for 2013

Parameter Modelled	Parameter Range Modelled in 2011 LandSim Update			Parameter Range in January-December 2014		Water Quality Standard (mg/l)	
	Min	Mean	Max	Min	Mean	Max	
Ammoniacal-N (mg/l)	154	968	1250	622	1188	2230	0.39 (DWS)
Chloride (mg/l)	487	1420	1760	718	1374	2340	250 (DWS)

Parameter Modelled	Parameter Range Modelled in 2011 LandSim Update			Parameter Range in January-December 2014		Water Quality Standard (mg/l)	
	Min	Mean	Max	Min	Mean	Max	
Zinc (mg/l)	0.101	0.274	0.565	<0.018	0.080	0.191	5 (DWS)
Cadmium (mg/l)	0.0007	0.00236	0.010	<0.0006	0.0013	0.0028	0.001 (MRV)
Mecoprop (mg/l)	0.0106	0.0313	0.0456	0.0225	0.0354	0.0777	0.00004 (MRV)
Naphthalene (mg/l)	0.005	-	0.05	<0.008	-	<0.02	0.0024 (EQS)
Leachate (m above base)	0.5	1	1.5	0.78	1.10	1.47	-

Notes: Cadmium concentrations are those modelled in the 2009 HRA Review as it was not remodelled in the 2011 LandSim update (concentrations during January 2010 -September 2011 were within the range modelled in the 2009 HRA Review) At the request of the EA, an additional hazardous substance (naphthalene) was selected and modelled in the 2011 LandSim update. DWS- drinking water standard. MRV- minimum reporting value. EQS- environment quality standard

Comparison of leachate monitoring data for the period of January to December 2014 with the 2009 HRA and 2011 LandSim update modelled source parameters (Table 3.2) indicates that:

- ▶ Leachate levels during 2014 (0.78 to 1.47 m above base) are within the range modelled in the 2011 LandSim Update (0.5-1.5 m above base);
- ▶ Ammoniacal-nitrogen, chloride and mecoprop concentrations during 2014 (622-2230 mg/l, 718-2340 mg/l and 0.0225-0.0777 mg/l, respectively) exceed the range modelled in the 2011 LandSim update (154-1250 mg/l, 487-1760 mg/l and 0.0106-0.0456 mg/l, respectively);
- ▶ Zinc concentrations during 2014 (0.08-0.191 mg/l) remained within the range modelled in the 2011 LandSim update (0.101-0.565 mg/l). It is noted that concentrations are below the water quality standard;
- ▶ Cadmium concentrations during 2014 (<0.0006-0.0028 mg/l) remained within the range modelled in the 2009 HRA Review (0.0007-0.010 mg/l);
- ▶ Naphthalene (carbon band C11.7) was modelled in the 2011 LandSim update as representative of the carbon band C10-C16. Naphthalene and hydrocarbon band C10-C16 leachate concentrations during 2014 (<0.008-<0.02 mg/l and 0.334-0.513 mg/l, respectively) were below the concentrations modelled/measured in 2011 (0.005-0.05 mg/l and 0.353-1.55 mg/l, respectively).

It is concluded that the 2014 leachate quality and level monitoring data were consistent with the 2009 HRA and 2011 LandSim update assumptions except for chloride, ammoniacal-nitrogen and mecoprop concentrations which were higher than the modelled concentrations. This could be related to the capping of the site which has reduced infiltration into the waste and associated dilution. The risks to groundwater posed by the increase in leachate strength during 2014 have not been reassessed but would be taken into account in the next six yearly review of the site's HRA to be undertaken in 2015.

Review of Pathways

There were no alterations to the operation, construction or management of the site proposed in the 2009 HRA Review. A lining system comprising 0.5 m bentonite enhanced soil (BES), 2 mm HDPE geomembrane and a leachate drainage blanket was installed in Cells 1 to 4 as modelled in the 2011 LandSim update. The potential pathways for any contaminants from the landfill continue to be as identified in the 2011 LandSim update:

- ▶ Leachate leakage through the engineered composite liner into the underlying unsaturated sands;
- ▶ Vertical migration through the unsaturated sand to the underlying water table; and
- ▶ Lateral migration within the sand aquifer in a westward direction towards the coast.

The sand left in place once extraction is complete represents an unsaturated zone beneath the landfill that provides attenuation of any contaminant leakage. The thickness of the unsaturated zone modelled in the 2011 LandSim model update was 0.6 to 2.2 m based on groundwater levels in the vicinity of the site for the period January 2010 to September 2011 and landfill base levels. The unsaturated zone thickness for 2014 is calculated as 0.1 to 2.4 m using 2014 groundwater level data in the vicinity of Area 3 (3.74 to 6.09 m AOD) and the lowest elevations of the base of the liner in Cell 1 (6.36 m AOD), Cell 2 (6.18 m AOD), Cell 3 (6.2 m AOD) and Cell 4 (5.7 m AOD). This updated unsaturated zone thickness is slightly lower than that modelled in the 2011 LandSim update.

On this basis, it is concluded that the pathways modelled in the 2011 LandSim update remain valid.

Review of Receptors

The key potential receptors identified in the 2009 HRA Review and 2011 LandSim update comprise the following:

- ▶ Groundwater within the sand aquifer beneath the site;
- ▶ Surface water in the drainage ditches around the site boundary; and
- ▶ The Morfa Harlech SSSI which lies to the west, downgradient of the site.

No additional receptors have been identified during 2014 and therefore the receptors considered in the 2011 LandSim update remain valid. A list of water abstractions located in the proximity of the site will be collected in the next six yearly review of the site's HRA to be undertaken in 2015.

Conclusions

The site conceptual model developed in the 2009 HRA Review and reviewed in the 2011 LandSim update was updated using monitoring data for 2014. Review of the modelled source, pathways and receptors indicates that:

- ▶ Source: leachate levels for 2014 have not exceeded the maximum leachate level (=EP compliance level) modelled in the 2011 LandSim update; leachate strength continued to increase during 2014 and exceeded the concentrations modelled in the 2011 LandSim update for ammoniacal-nitrogen, chloride and mecoprop;
- ▶ Pathways: groundwater monitoring data for 2014 show that the unsaturated zone thickness beneath Area 3 is slightly lower than that modelled in the 2011 LandSim update; and
- ▶ Receptors: No additional receptors have been identified during 2014 and therefore the receptors identified in the 2011 LandSim update remain valid for 2014.

Overall the hydrogeological conceptual model for Area 3 has not changed from the 2011 LandSim update considering monitoring data for 2014, except for an increase in leachate strength (as ammonium, chloride and mecoprop) and a slight decrease in the unsaturated zone thickness. On this basis it is proposed to re-assess the risks to groundwater in the next six yearly review of the site's HRA which will be undertaken in 2015.

3.2 Review of Landfill Gas Risk Assessment

Landfill Gas Generation

Landfill gas is generated during the decomposition of biodegradable waste. The decomposition process of the waste occurs in a number of stages following deposition.

Landfill gas generation from fresh waste commences initially under aerobic conditions (i.e. in the presence of oxygen). Initially, carbon dioxide concentrations increase as a precursor to methane generation, which occurs only under anaerobic conditions. Methane production will continue within the waste for many decades.

The landfill gas mainly comprises methane and carbon dioxide, which are both colourless and odourless. However, the gas can contain hundreds of trace compounds which often give rise to a characteristic smell.

Typical gas production rates are commonly assumed to be approximately 10 m³ of gas per tonne of waste per annum. Gas production rates will vary within the landfill, generally as a function of:

- ▶ The geometry of the landfill;
- ▶ The type of waste and rate of input;
- ▶ The age of the waste;
- ▶ Moisture content, pH, temperature and density of the waste;
- ▶ The nature of the cover to the landfill.

Landfill gas is generally emitted from the waste surface, driven by convection due to increased temperature within the waste mass relative to the surrounding air temperature. The ambient air pressure will affect the rate of emission. Low air pressure often results in higher emissions (as gas is driven from the waste body, where pressure has not equilibrated).

Pressure build up within the waste mass might also cause higher emissions. High gas pressures may develop where low permeability layers confine the gas. In such circumstances, the gas will move to lower pressure areas, and often this may result in lateral movement. If this occurs near the margins of the waste, it can result in high emission rates, or migration through surrounding soils.

Current Situation

Cell 1 and Cell 2

Waste previously deposited in engineered containment Cells 1 and 2 has been capped and a landfill gas collection system (including extraction wells, collector pipework and condensate knockout pots) is in operation. Four landfill gas collection wells (C11, C12, C13 and C14) are available for monitoring in Cell 1 and five wells (C21 to C25) are available in Cell 2.

Cell 3

Six gas wells numbers (C31 to C36) were completed in Cell 3 in October 2012; details are given in Amec Foster Wheeler technical note 28587n737i1. Gas extraction from the wells commenced in March 2013 following capping operations and installation of collection pipework.

Cell 4A

Six gas wells, numbers C41 to C46 were completed in Cell 4A in July 2013. Details of their construction are provided in Amec Foster Wheeler technical note 28587n772i1. Gas extraction from the wells commenced following installation of collection pipework, although this is predominantly for odour control until both cells 4A and 4B are capped (see 'Cell 4B' below for further details).

Cell 4B

Waste operations commenced in Cell 4B on 14 June 2013. Cell 4B was filled with waste to closure on 6 January 2014 and capping of cells 4A and 4B was complete in late March 2014. A total of 7 gas wells were drilled in Cell 4B in early March 2014, details of which are provided in the capping CQA report, ref: 28587rr886i1 dated November 2014. These wells were connected to the gas extraction system in late April 2014.

Landfill Gas Flare

Landfill gas from the closed landfill Area 2 and from the active landfill Area 3 is collected and combusted in a 500 m³/hour high temperature enclosed flare. Annual flare monitoring is undertaken as per Schedule 4 (Table S4.2) in the permit.

Catalyst Environmental undertook the annual monitoring of the emissions from the enclosed flare on 21 February 2014 the report submitted by Catalyst Environmental is presented as Appendix E. All results are within the emission limits specified in the permit.

A trace gas analysis of the raw landfill gas taken at the time of the emission testing is included in Appendix E.

Monitoring

Landfill gas is monitored at a number of locations within and around the perimeter of the landfill. Monitoring of landfill gas is discussed in Section 2.6.

GasSim Model

The GasSim model was last updated in February 2015 for Area 3. The GasSim model was updated with actual waste inputs for 2014 and the output graph is included as Appendix F.

The GasSim model predicts that a maximum of 189.28 m³/hr (at the 95th percentile) landfill gas was produced by the wastes in Cells 1-3, 4A and 4B in Area 3 in 2014 although the model does not include production from waste in the first year of operation.

3.3 Review of Stability Risk Assessment

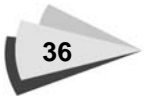
The original Stability Risk Assessment was undertaken in November 2004 as a part of the Permit application for Area 3. The assessment concluded that the general design as submitted in the permit application was stable and could be constructed and operated safely and without risk to the stability and integrity of the lining system.

Basal Lining System

Cells 1 to 4 basal lining systems were installed in accordance with the assessment undertaken in November 2004 and as detailed in subsequent design reports for each cell which were submitted to and commented on by the Environment Agency (now NRW).

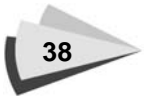
Capping System

The detailed design of the capping system depends on the final waste profile achieved in the cell. As a part of the detailed design phase undertaken for the capping to Cells 1 to 4, a review of the capping stability was undertaken based on the proposed final slope profiles. This review was submitted to the Environment Agency as part of the Design Report submitted in advance of capping works for each cell. These assessments conclude that the restored capping slopes will remain stable during construction and in the long term. A CQA verification report which details geosynthetics interface testing undertaken as part of Cell 4 capping was submitted to NRW.



4. Energy Consumption

At the time of issue of this report, Gwynedd Council has been unable to get an update on the total energy consumed by the site between January and December 2014.



5. Production/Treatment Volumes

5.1 Introduction

This section summarises the volumes produced and treated (if applicable) at the site of landfill leachate, surface water and/or groundwater and landfill gas between January and December 2014.

5.2 Landfill Leachate

The effective management of leachate levels is a key element in the operation of Area 3 to ensure there are no adverse impacts on groundwater.

Monitoring data for Area 3 between January and December 2014 indicates that leachate levels were below the EP compliance level of 1.5 m above base (see Section 2.2). This suggests that the leachate extraction rates were effective and the on-site leachate storage capacity was sufficient to ensure leachate level compliance in Area 3. A total of 7,369.08 tonnes of leachate (1,560.8 tonnes in 2013) was extracted during 2014. Leachate was removed from both a sump in the base of each cell via an upslope riser. The leachate extracted was stored on-site in the leachate collection tank prior to removal off-site by tanker for disposal.

5.3 Surface Water/Groundwater

No dewatering has been carried out in association with landfill construction and operation. On this basis there is no groundwater disposal or treatment at the site.

A new surface water management system was installed at the site in September 2012 comprising new surface water drainage pipework and an interceptor connected to new attenuation lagoon discharging into the Afon Desach. Surface water collected from the Area 3 landfill drains both into the attenuation lagoon and an infiltration basin (soakaway located to the east of the site boundary).

5.4 Landfill Gas

The landfill gas collected from the capped Cells 1 to 4 is combusted within an enclosed high temperature flare. Site records indicate that the flare had minimal (1%) downtime during the year. Average flow rate at the flare during 2014 was 318.19 m³/hour. This equates to combustion of some 2,759,471 m³ of landfill gas during the year, based on 1% flare downtime. Note that the flare combusts landfill gas drawn from Area 3 as well as the older (and larger) Area 2 landfill.



6. Waste Settlement and Remaining Capacity

6.1 Remaining Capacity

The landfill closed to receipt of waste on 6 January 2014 and there is no residual capacity. A total of 549.72 tonnes of waste were received at the site between 1st to 5th January 2014.

6.2 Settlement Behaviour

Cell 4 capping was completed on 2 April 2014. A topographical survey was undertaken in July 2014.



7. References

Amec Foster Wheeler, 2014. Ffridd Rasus Landfill- Environmental Monitoring Report January to March 2014. Report Reference 28587rr869i2.

Amec Foster Wheeler, 2014. Ffridd Rasus Landfill- Environmental Monitoring Report April to June 2014. Report Reference 28587rr890i2.

Amec Foster Wheeler, 2014. Ffridd Rasus Landfill- Environmental Monitoring Report July to September 2014. Report Reference 28587rr905i2.

Amec Foster Wheeler, 2014. Ffridd Rasus Landfill- Environmental Monitoring Report October to December 2014. Report Reference 28587rr928i2.



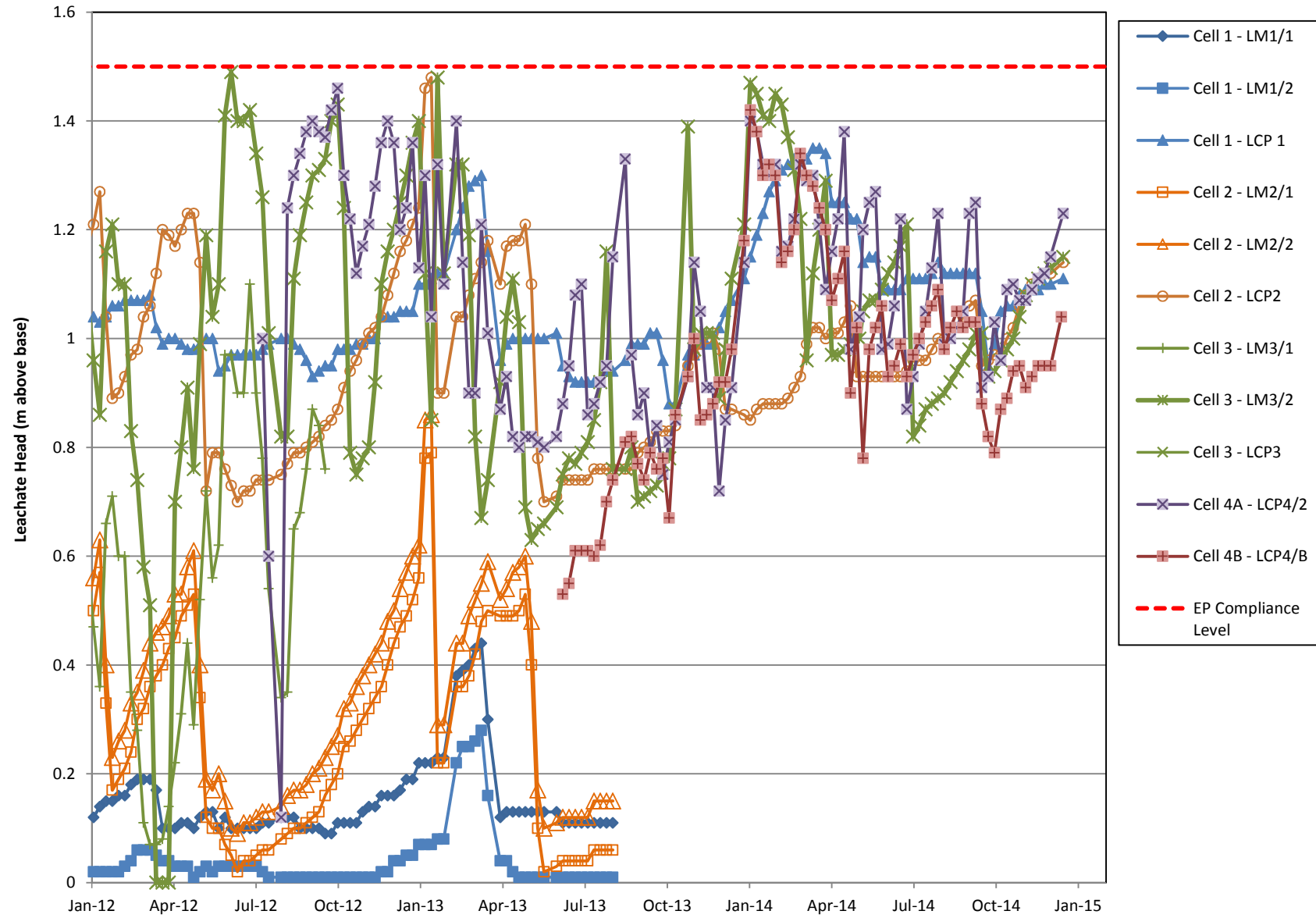


Appendix A

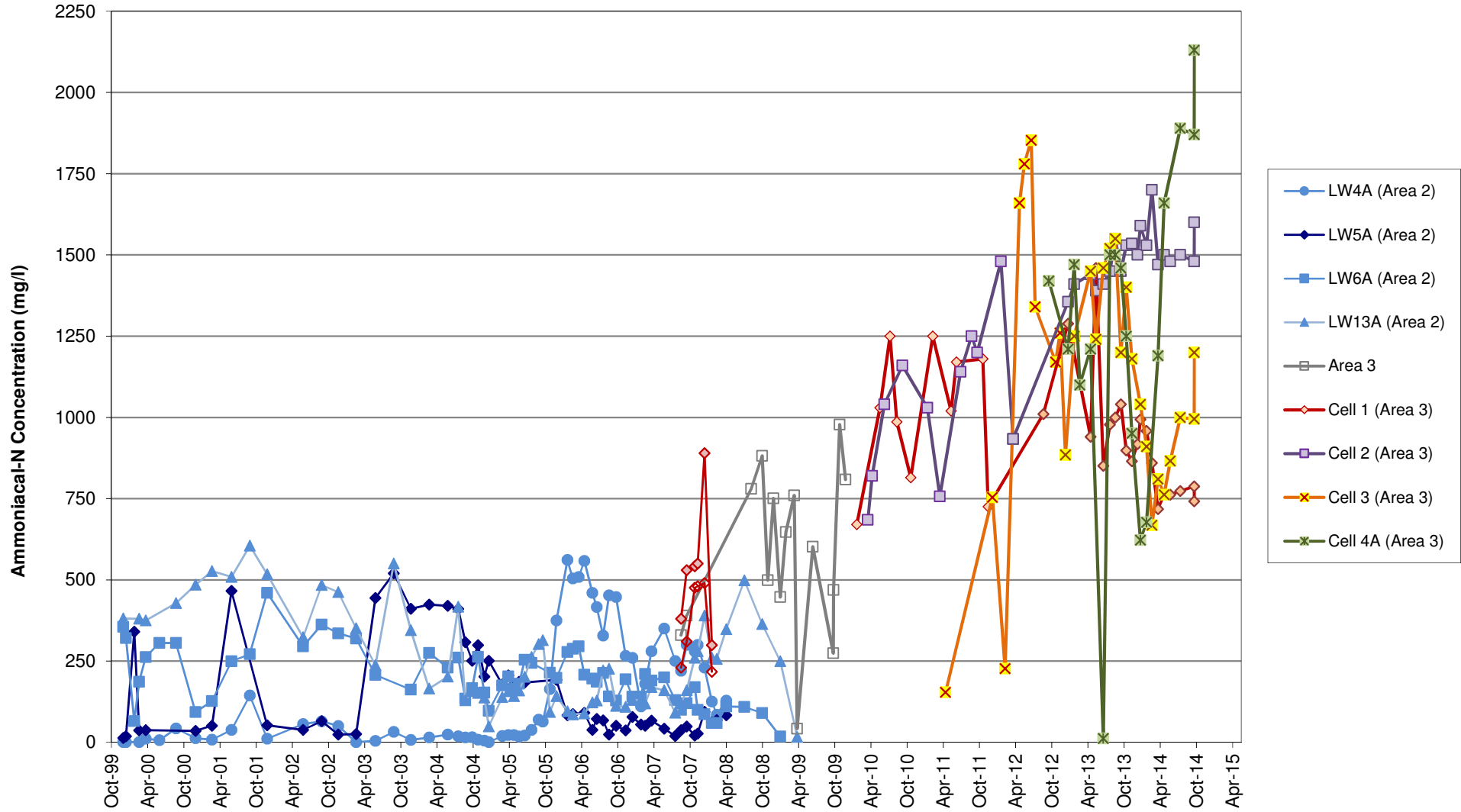
Leachate Levels and Quality Plots



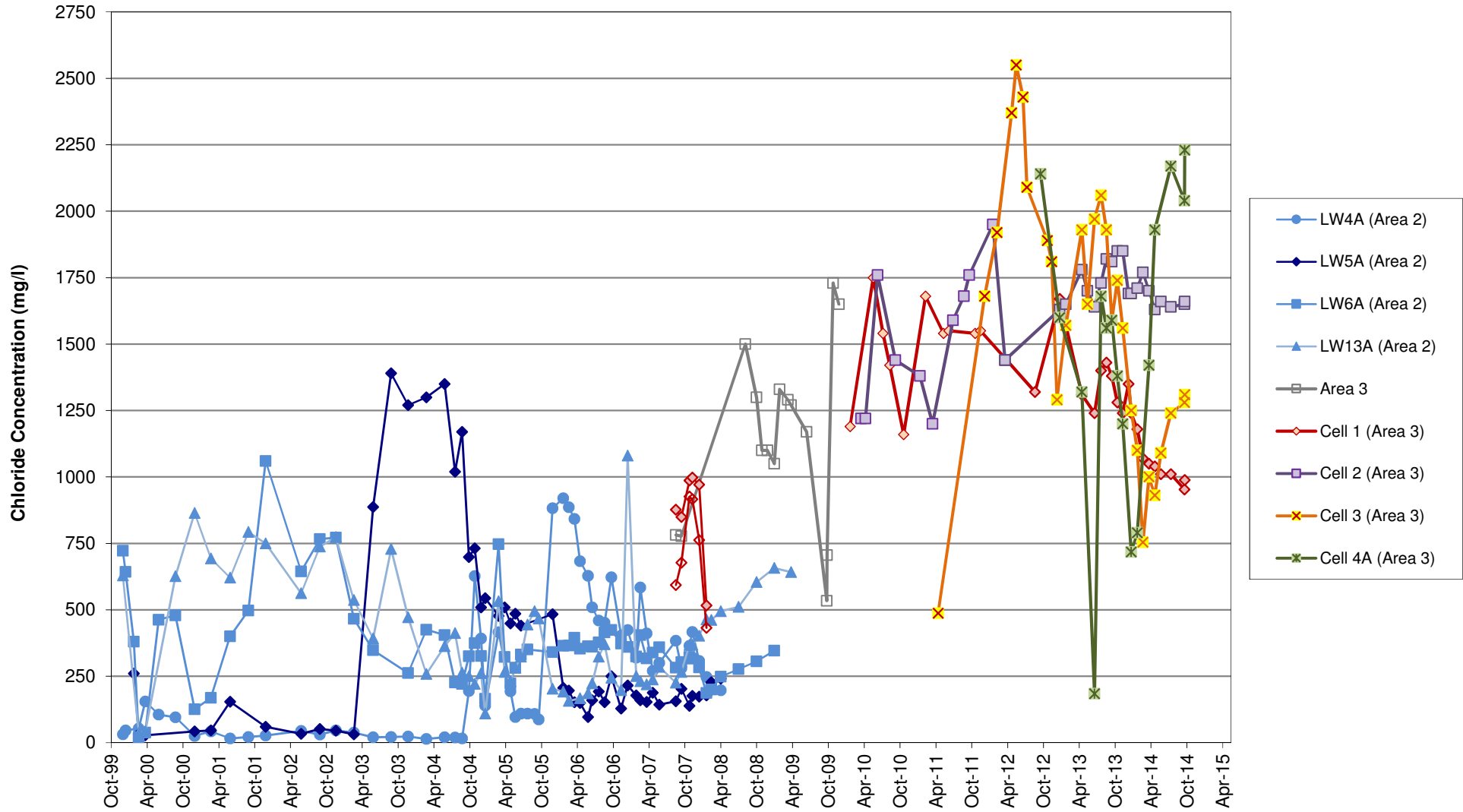
Ffridd Rasmus Landfill - Leachate Levels



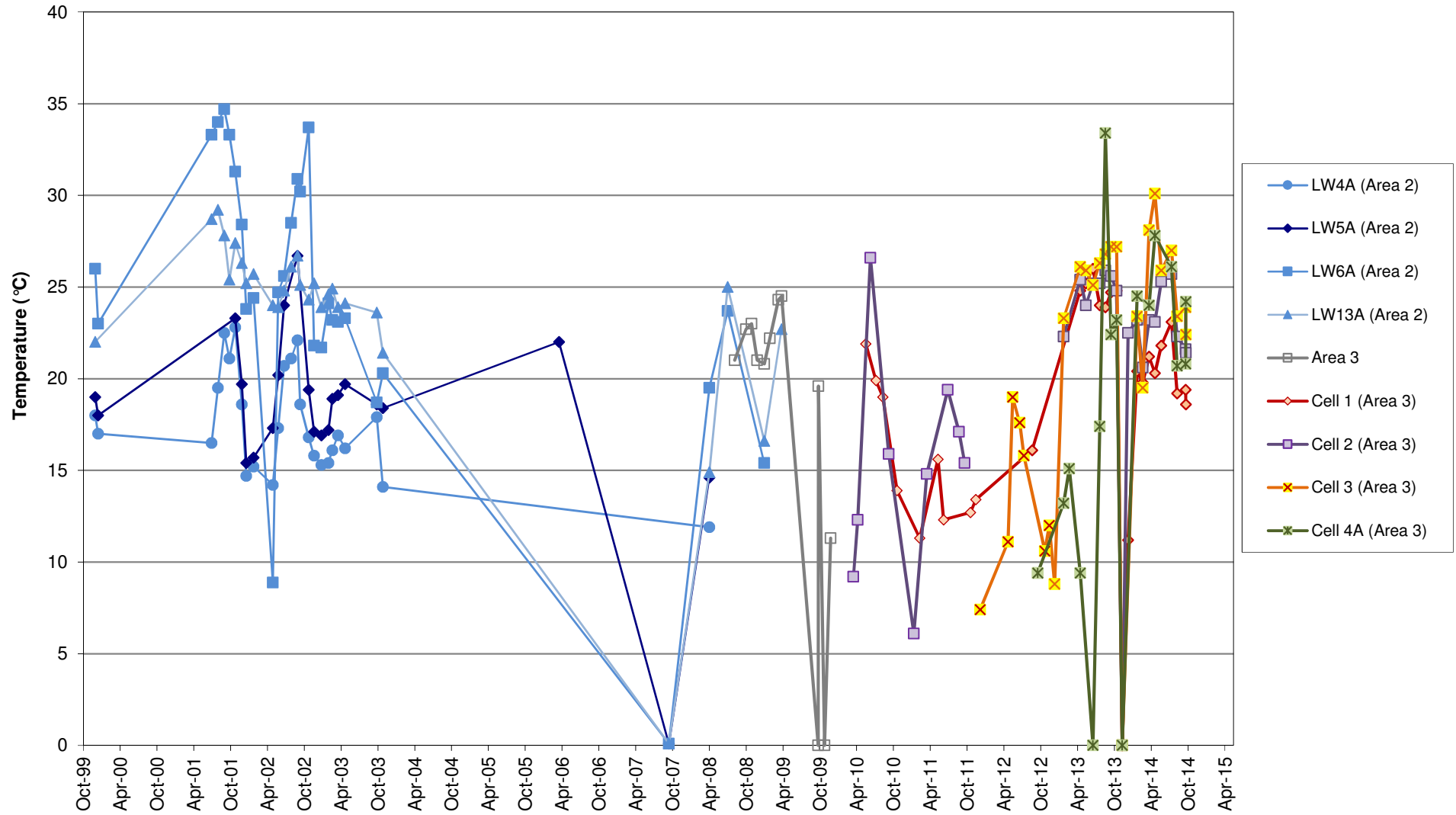
Ffridd Rasmus Landfill - Ammoniacal Nitrogen in Leachate



Ffridd Rasmus Landfill - Chloride in Leachate



Ffridd Rasmus Landfill - Leachate Temperature



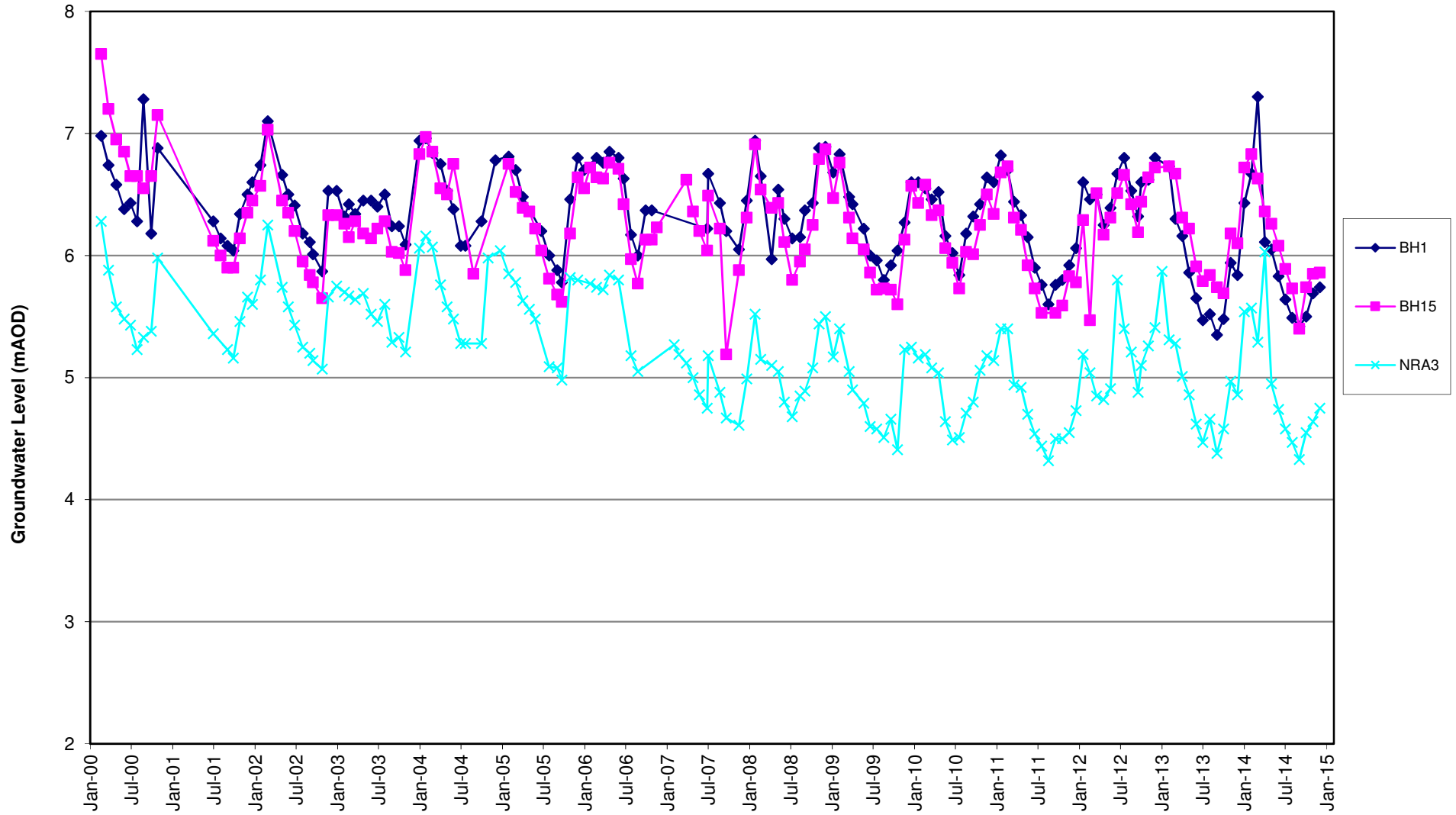


Appendix B

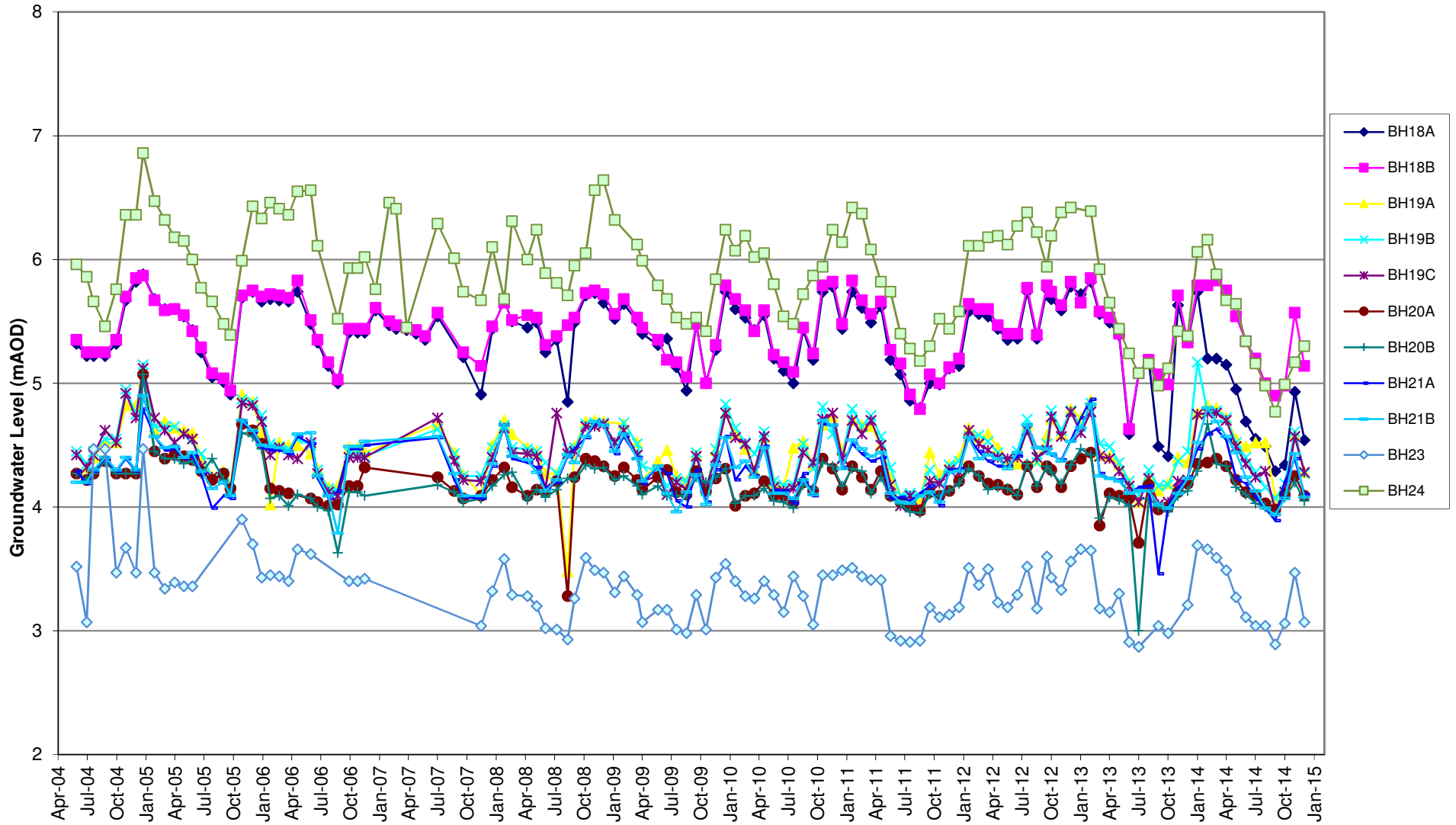
Groundwater Level Plots



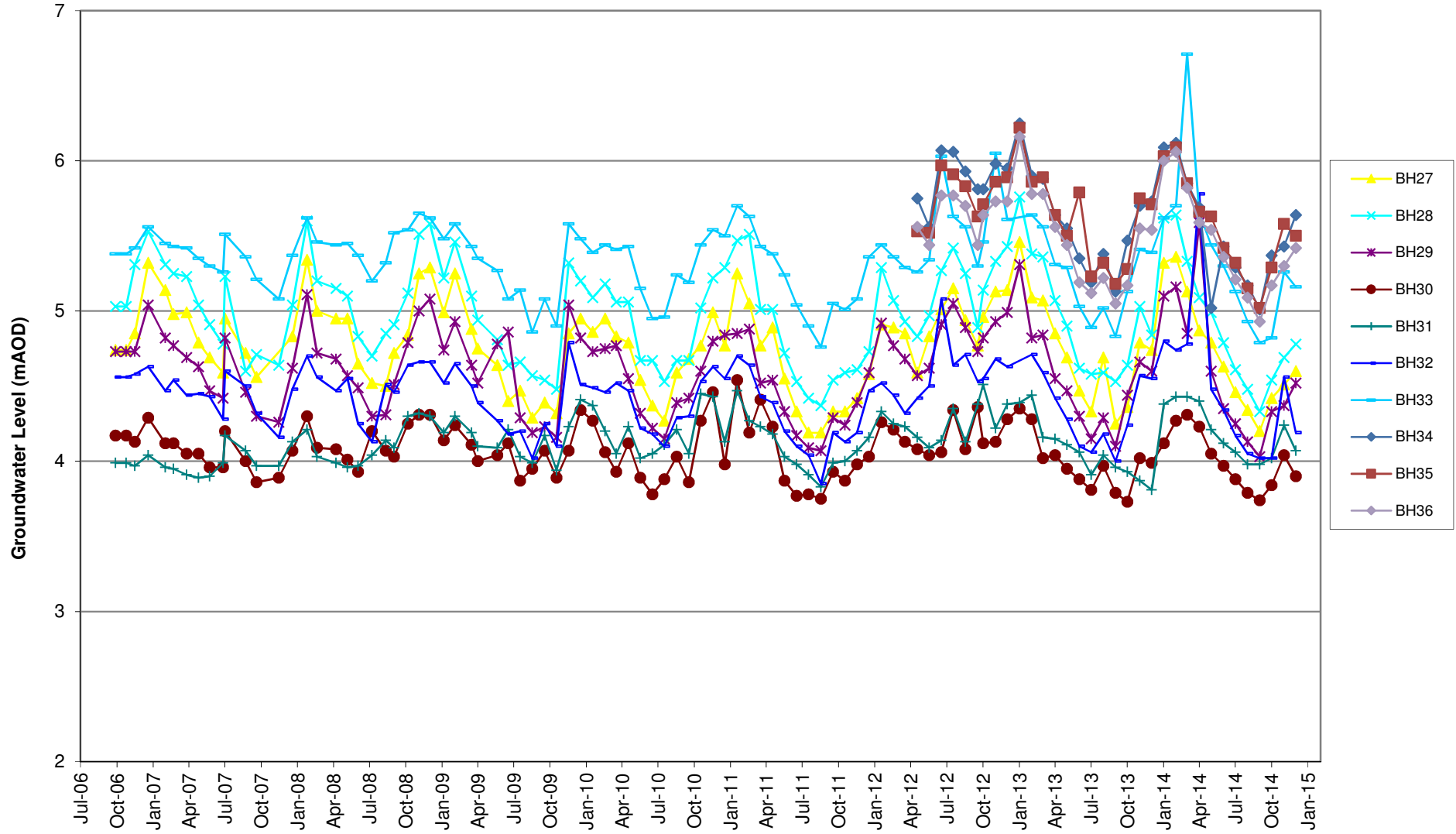
Ffridd Rasmus Landfill - Groundwater Levels (boreholes drilled pre-2004)



Ffridd Rasmus Landfill - Groundwater Levels (boreholes drilled in 2004)



Ffridd Rasmus- Groundwater Levels (boreholes drilled in 2006 and 2012)



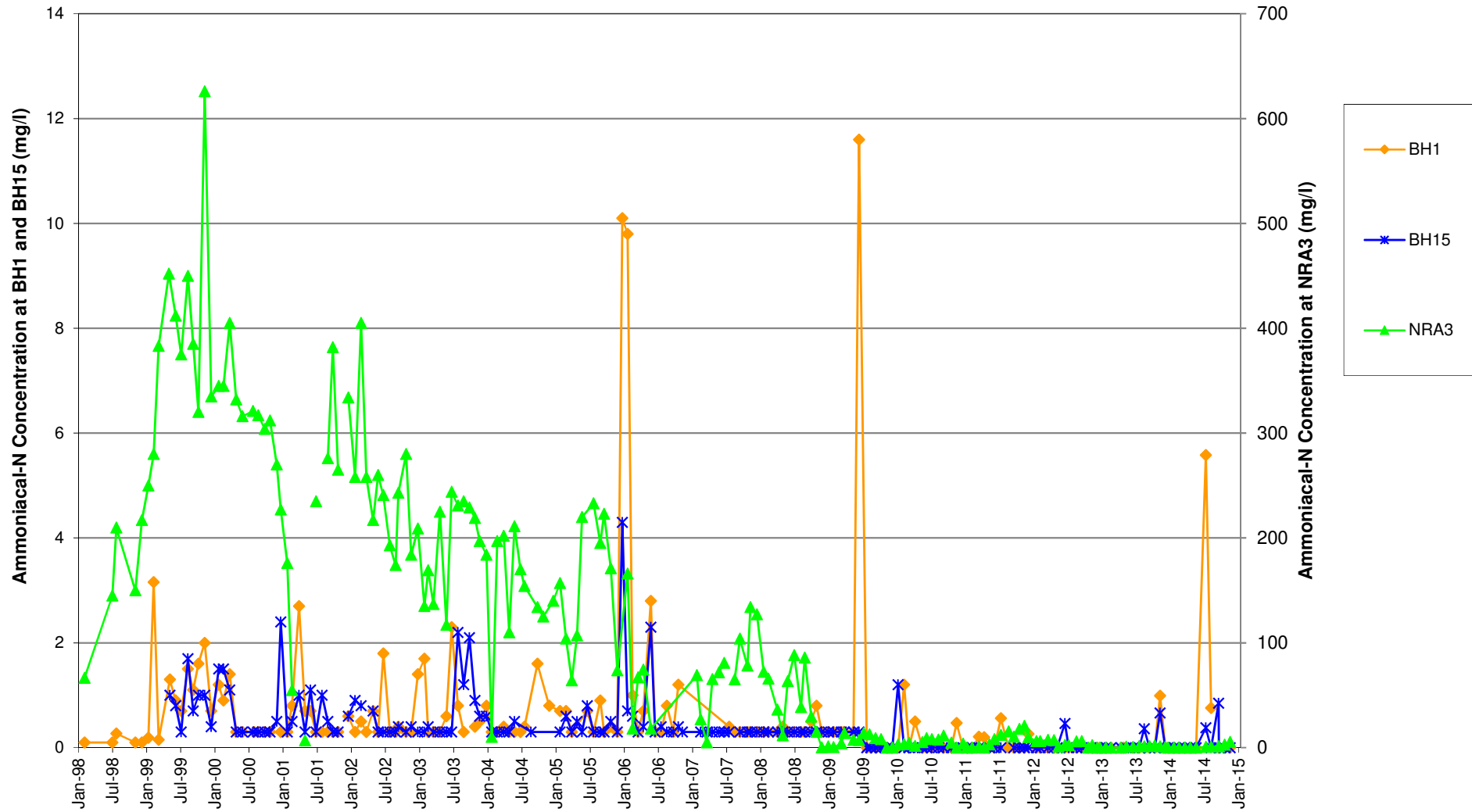


Appendix C

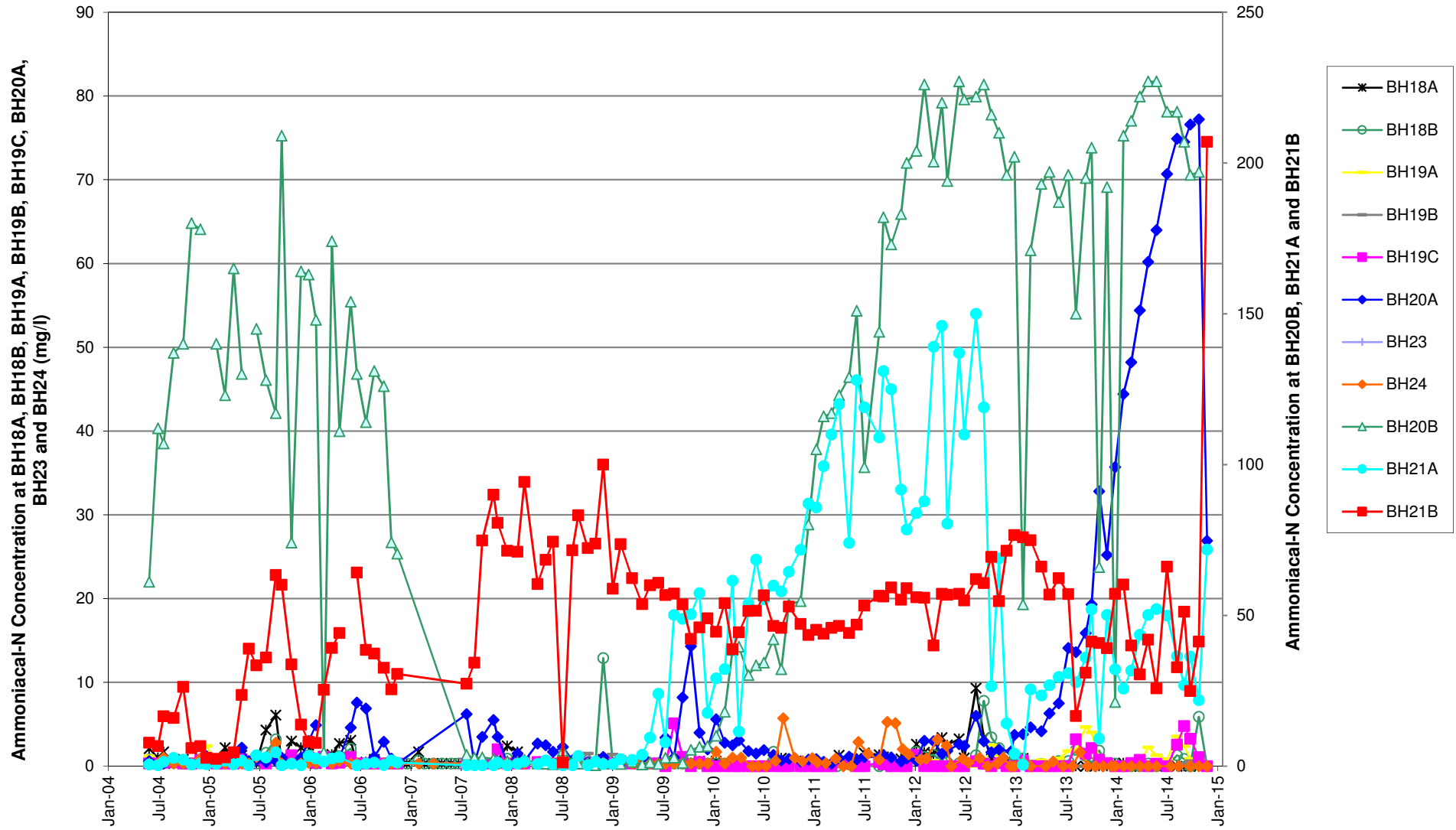
Groundwater Quality Plots



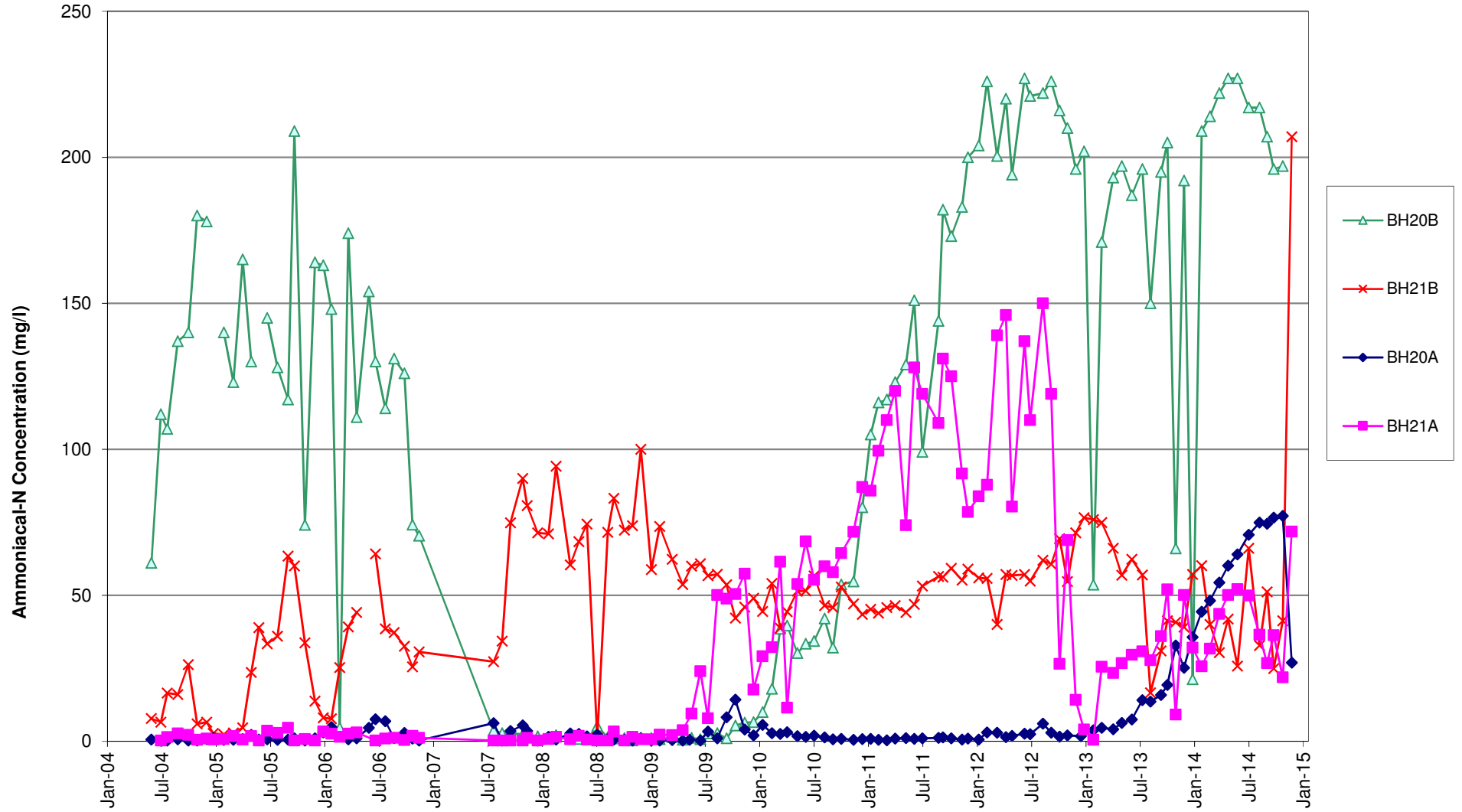
Ffridd Rasmus Landfill - Ammoniacal Nitrogen in Groundwater (Boreholes drilled pre-2004)



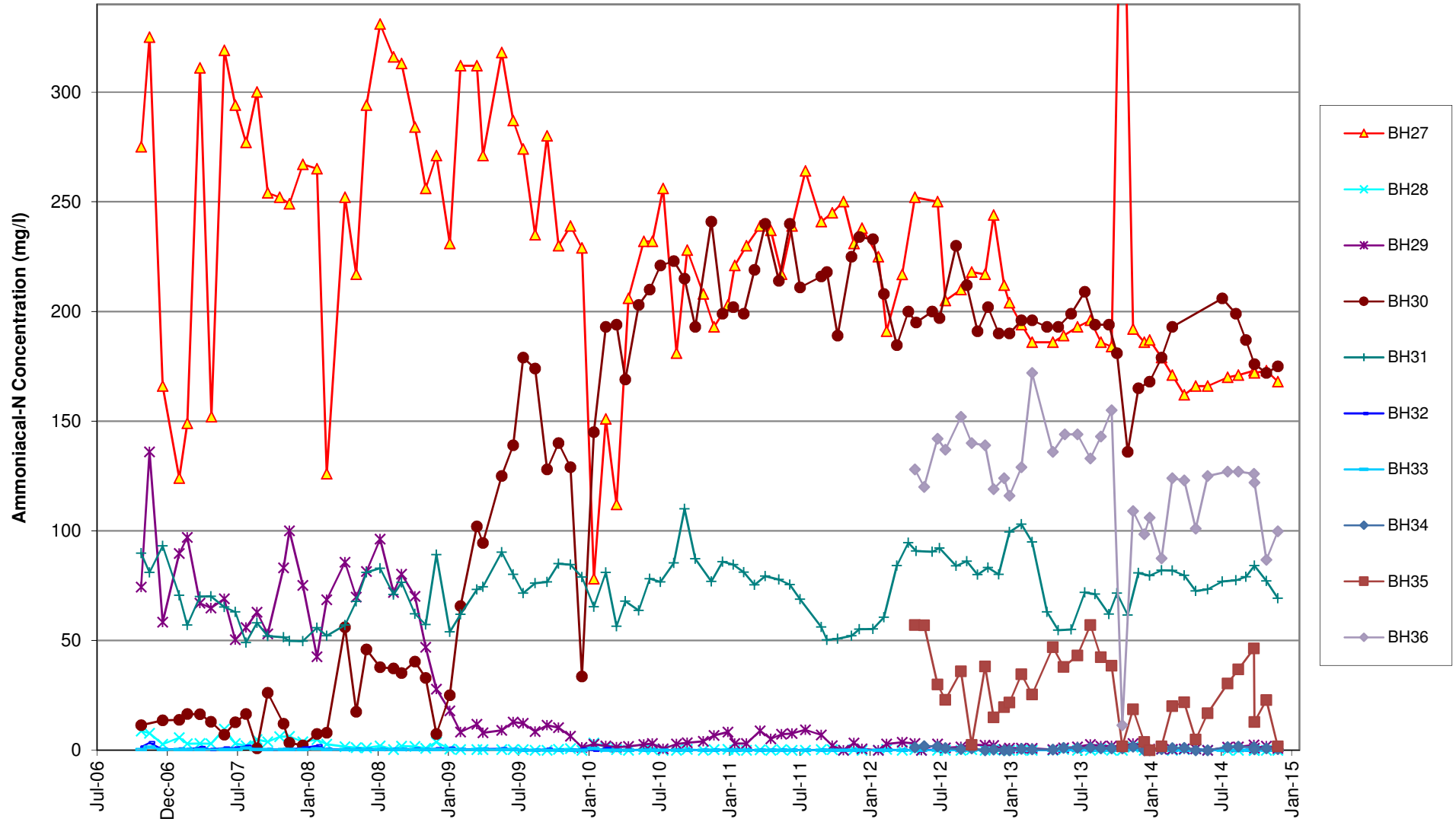
Ffridd Rasmus Landfill - Ammoniacal Nitrogen in Groundwater (boreholes drilled in 2004)



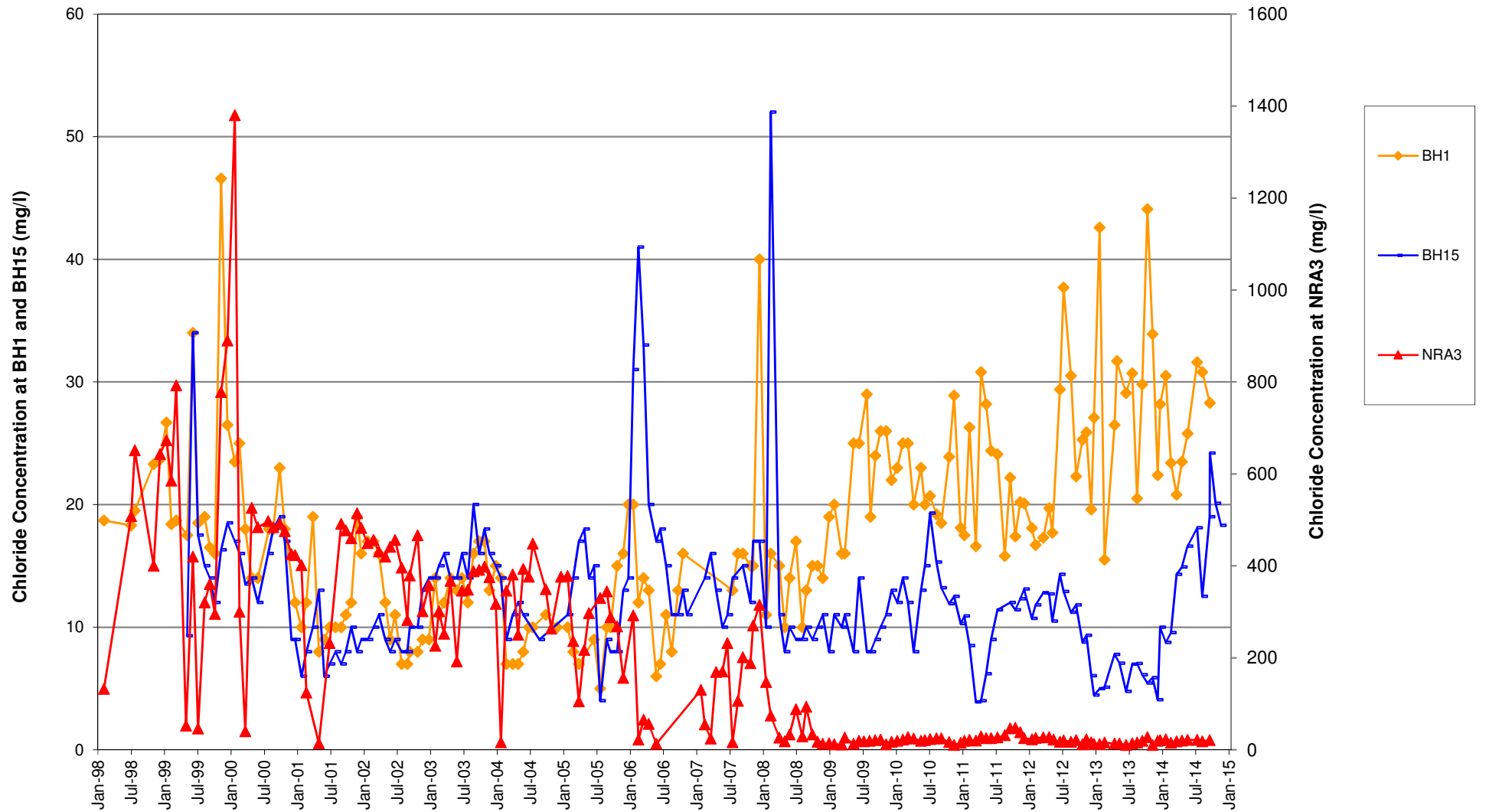
Ffridd Rasmus Landfill - Ammoniacal Nitrogen in Groundwater (boreholes 20A, 20B 21A & 21B)



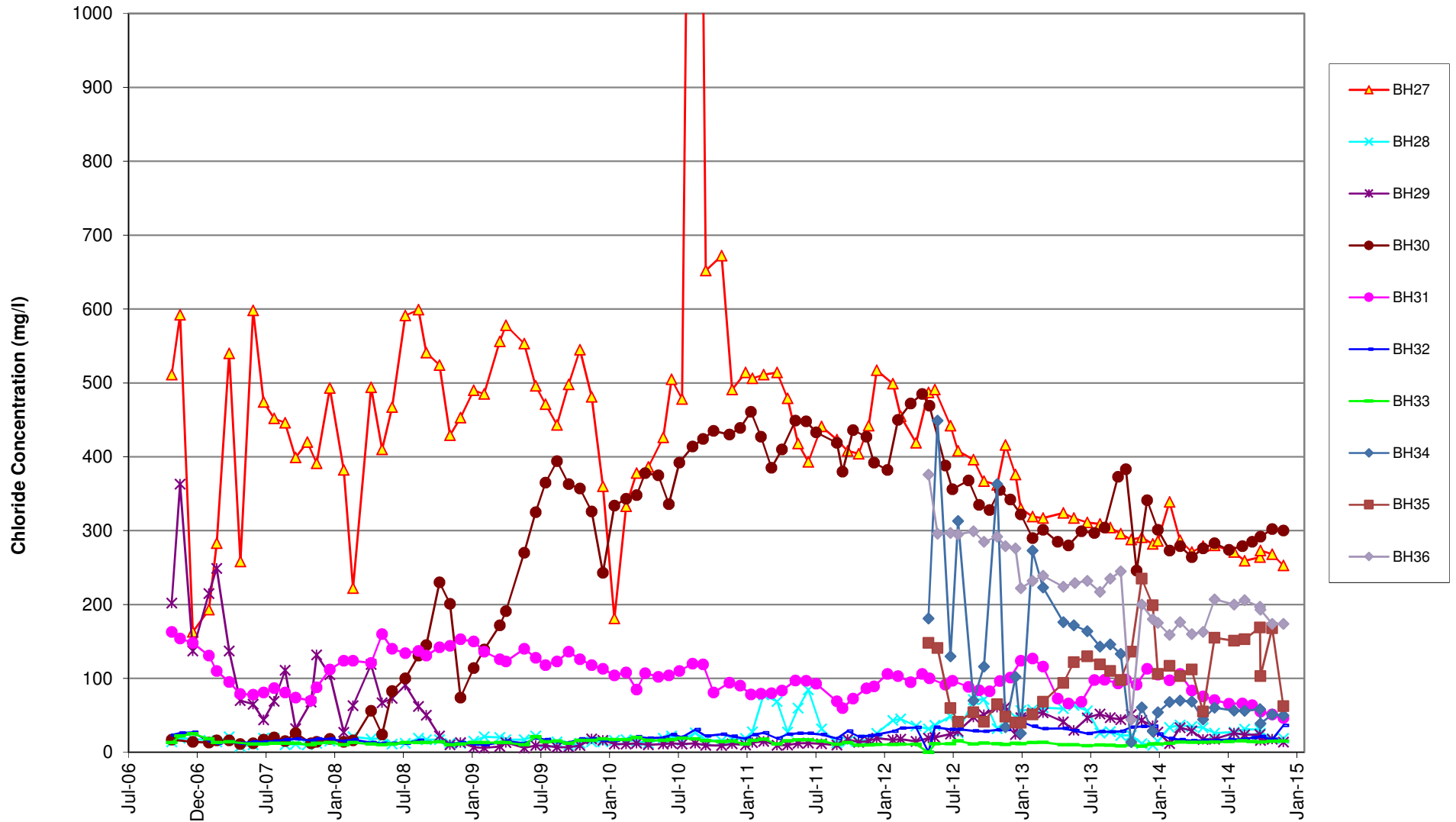
Ffridd Rasmus Landfill - Ammoniacal Nitrogen in groundwater (boreholes drilled in 2006 and 2012)



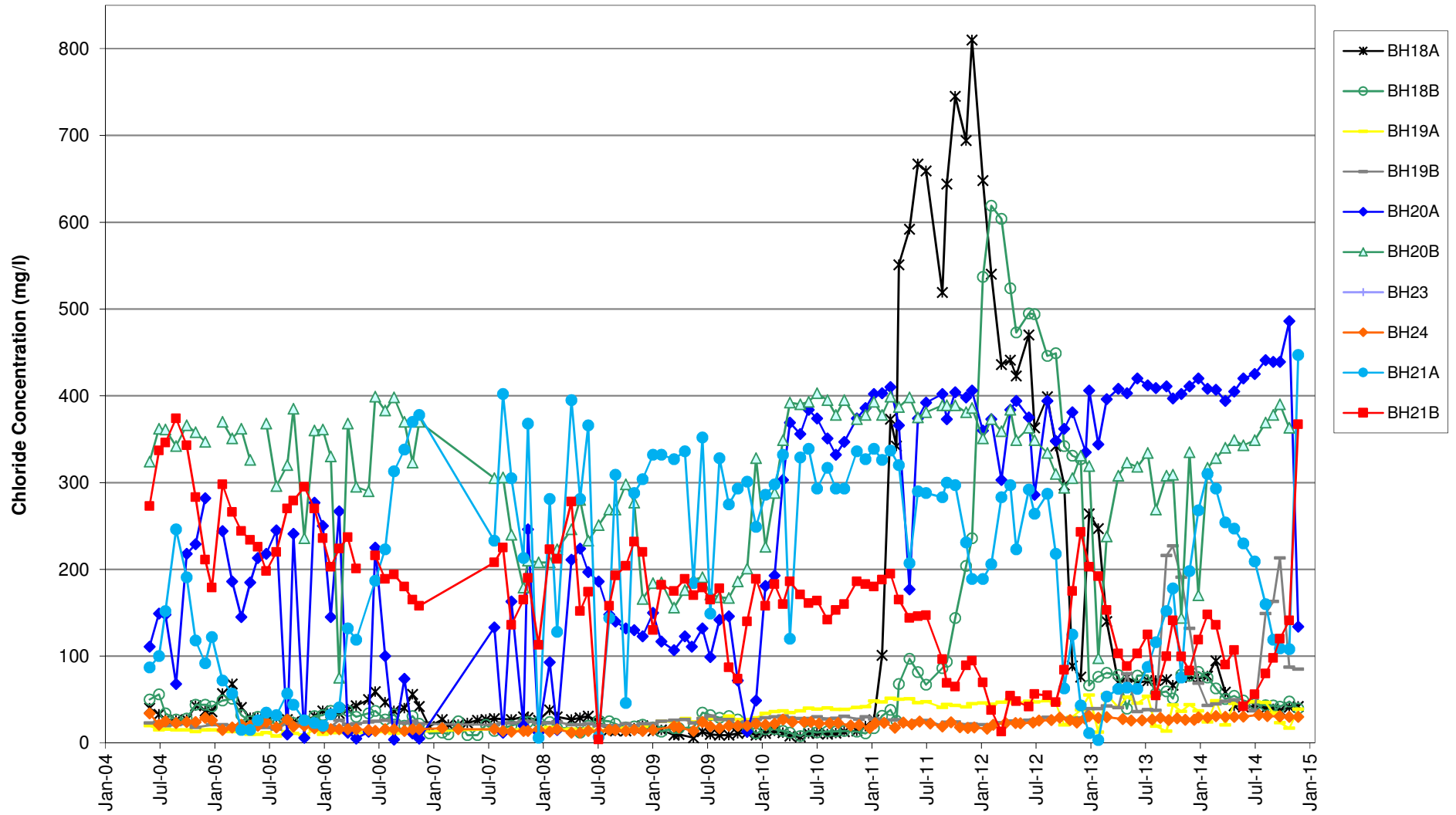
Chloride in Groundwater - boreholes drilled pre 2004



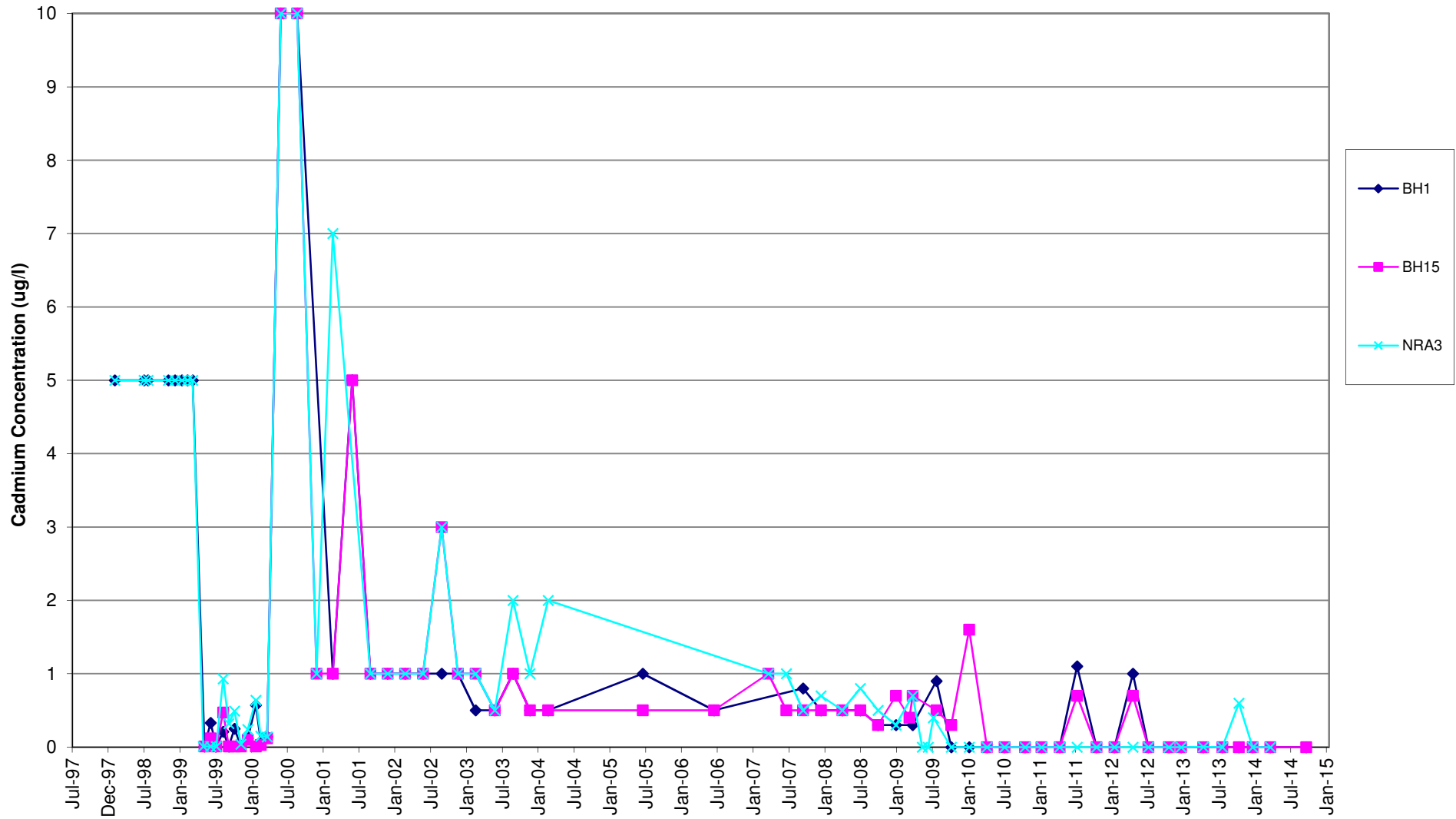
Ffridd Rasmus Landfill - Chloride in Groundwater (boreholes drilled in 2006 and 2012)



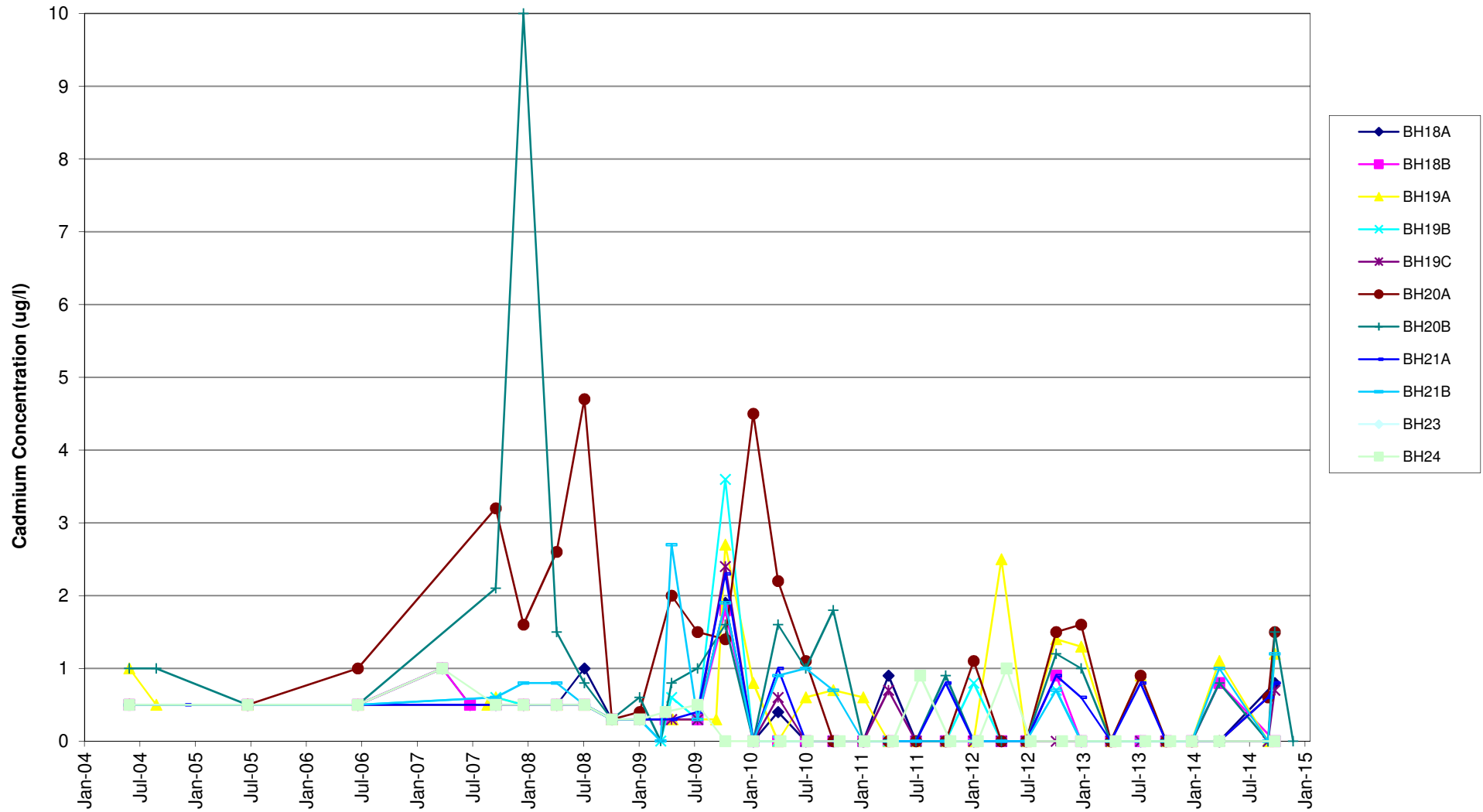
Ffridd Rasmus Landfill - Chloride in Groundwater (boreholes drilled in 2004)



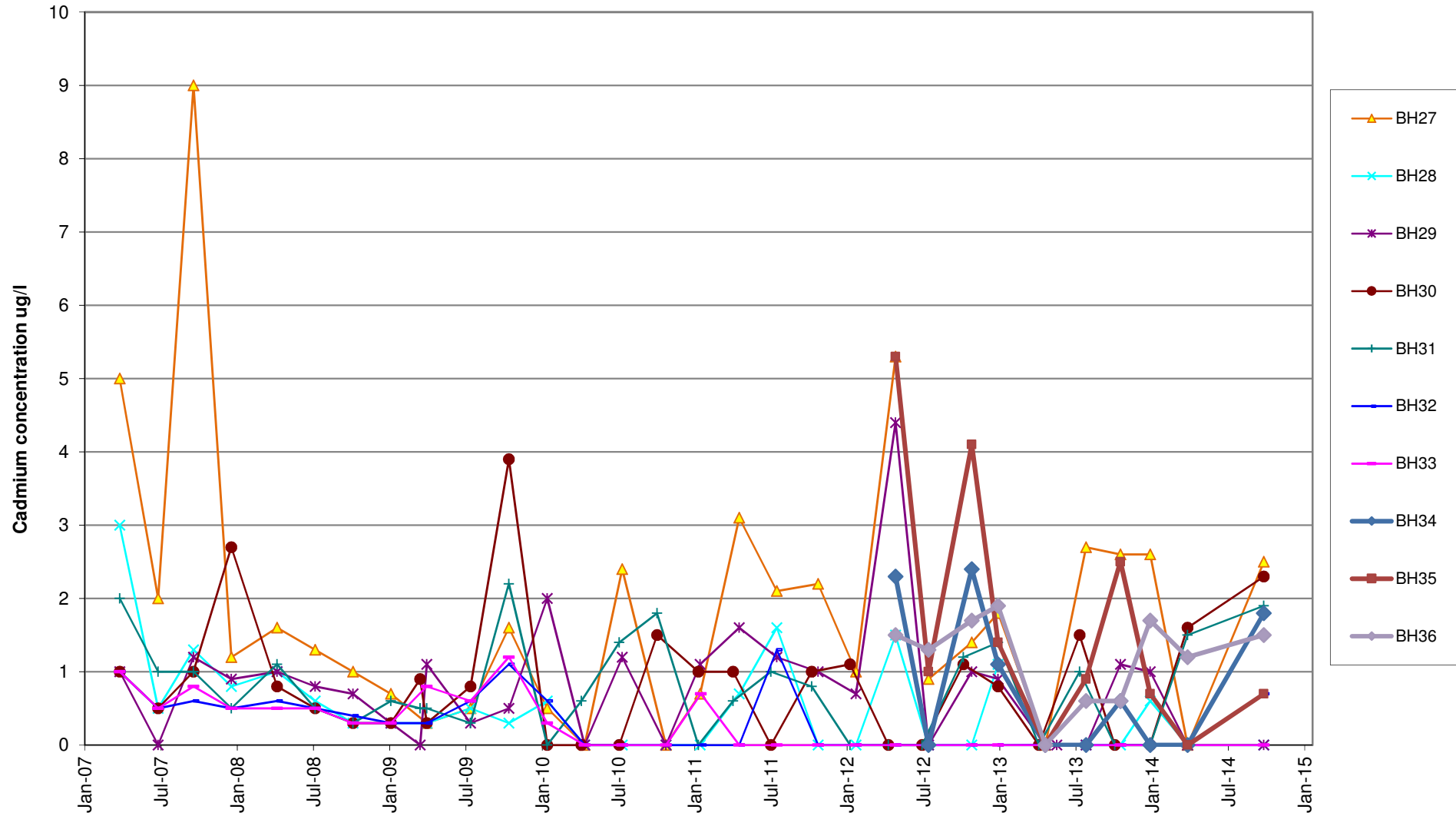
Ffridd Rasmus Landfill - Cadmium in Groundwater (boreholes drilled pre 2004)



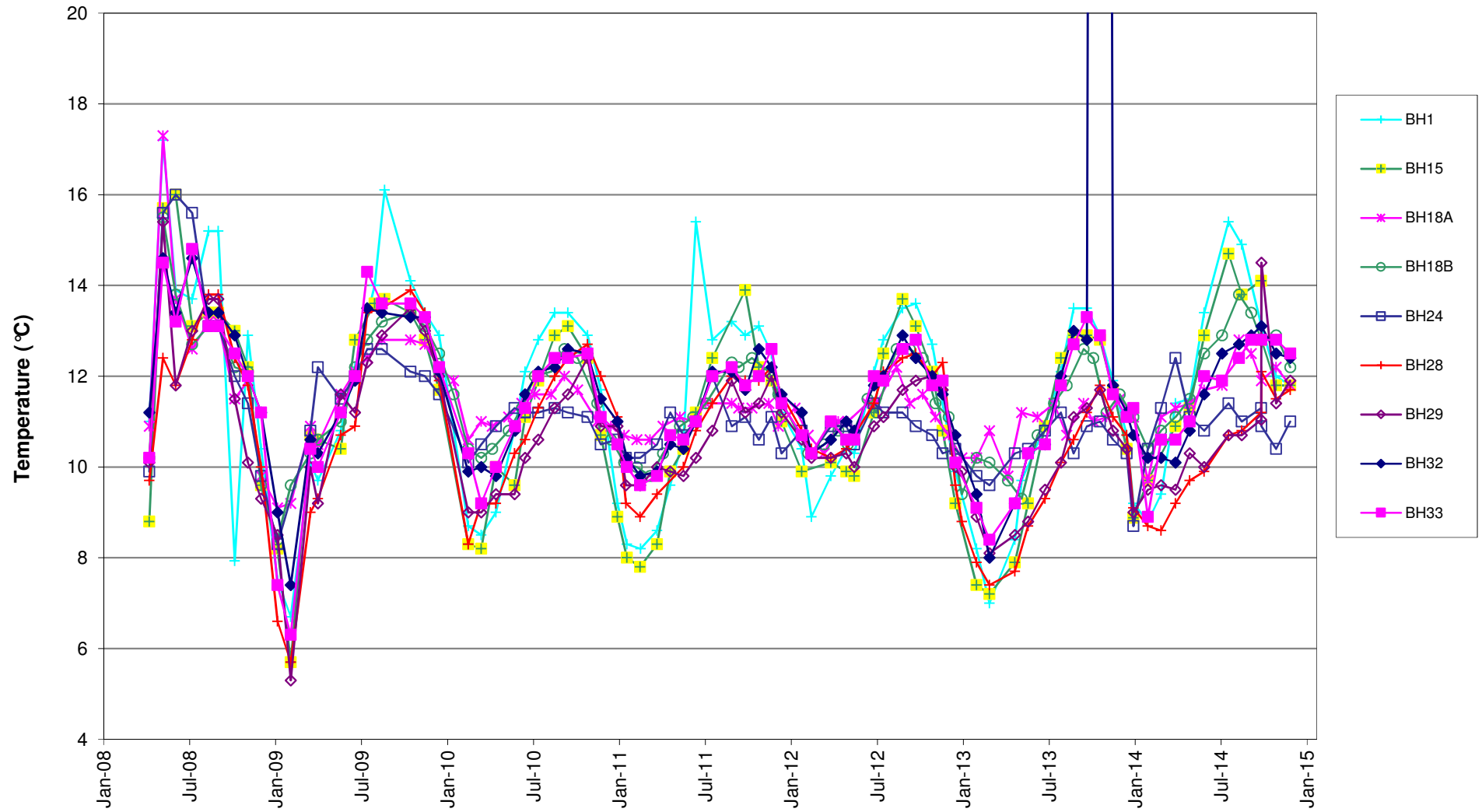
Ffridd Rasmus Landfill - Cadmium in Groundwater (boreholes drilled in 2004)



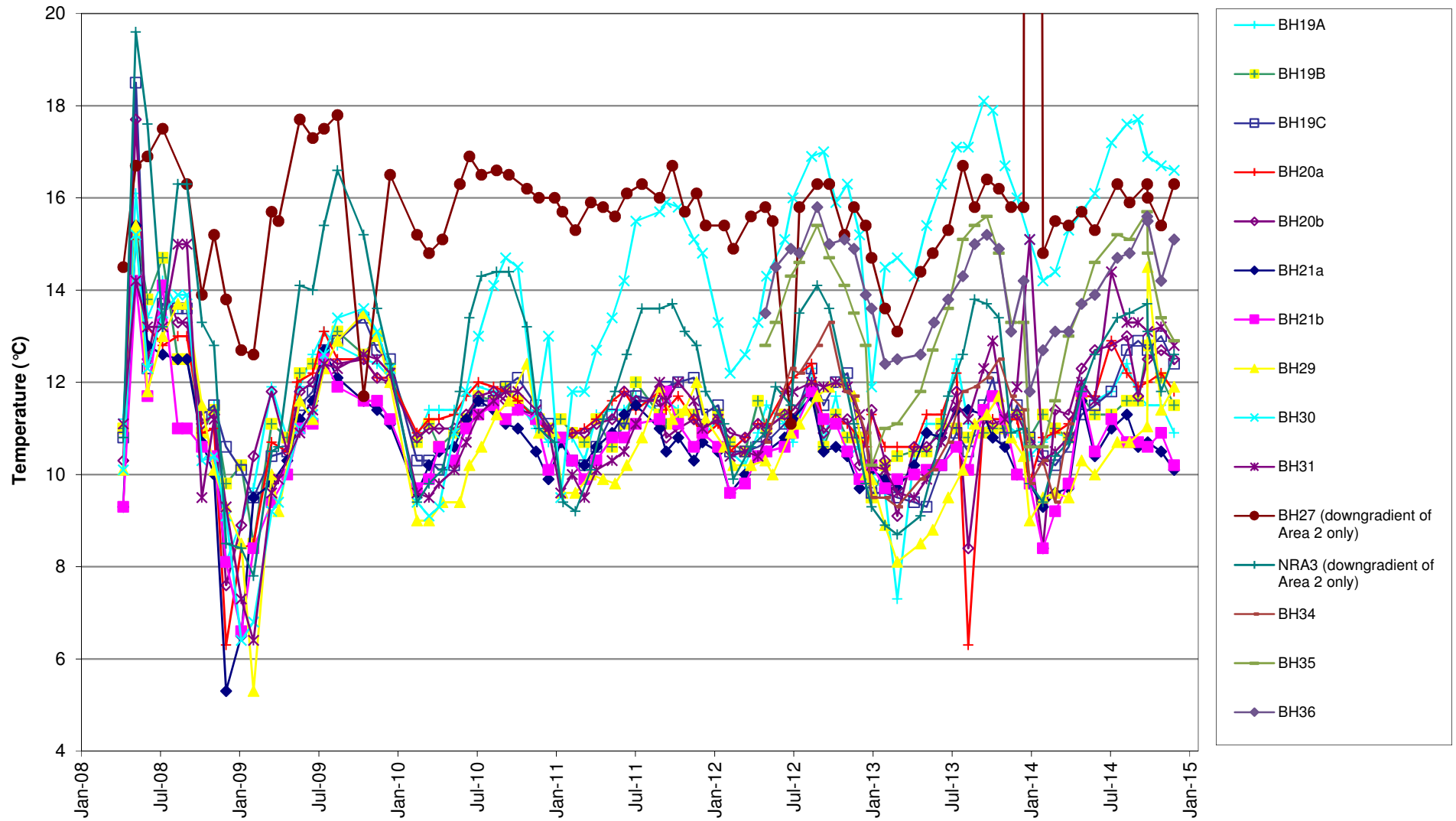
Ffridd Rasmus Landfill - Cadmium in Groundwater (boreholes drilled in 2006)



Ffridd Rasmus Landfill - Groundwater Temperature (Upgradient/Lateral to Groundwater Flow Boreholes)



Ffridd Rasmus Landfill - Groundwater Temperature (Downgradient Boreholes)



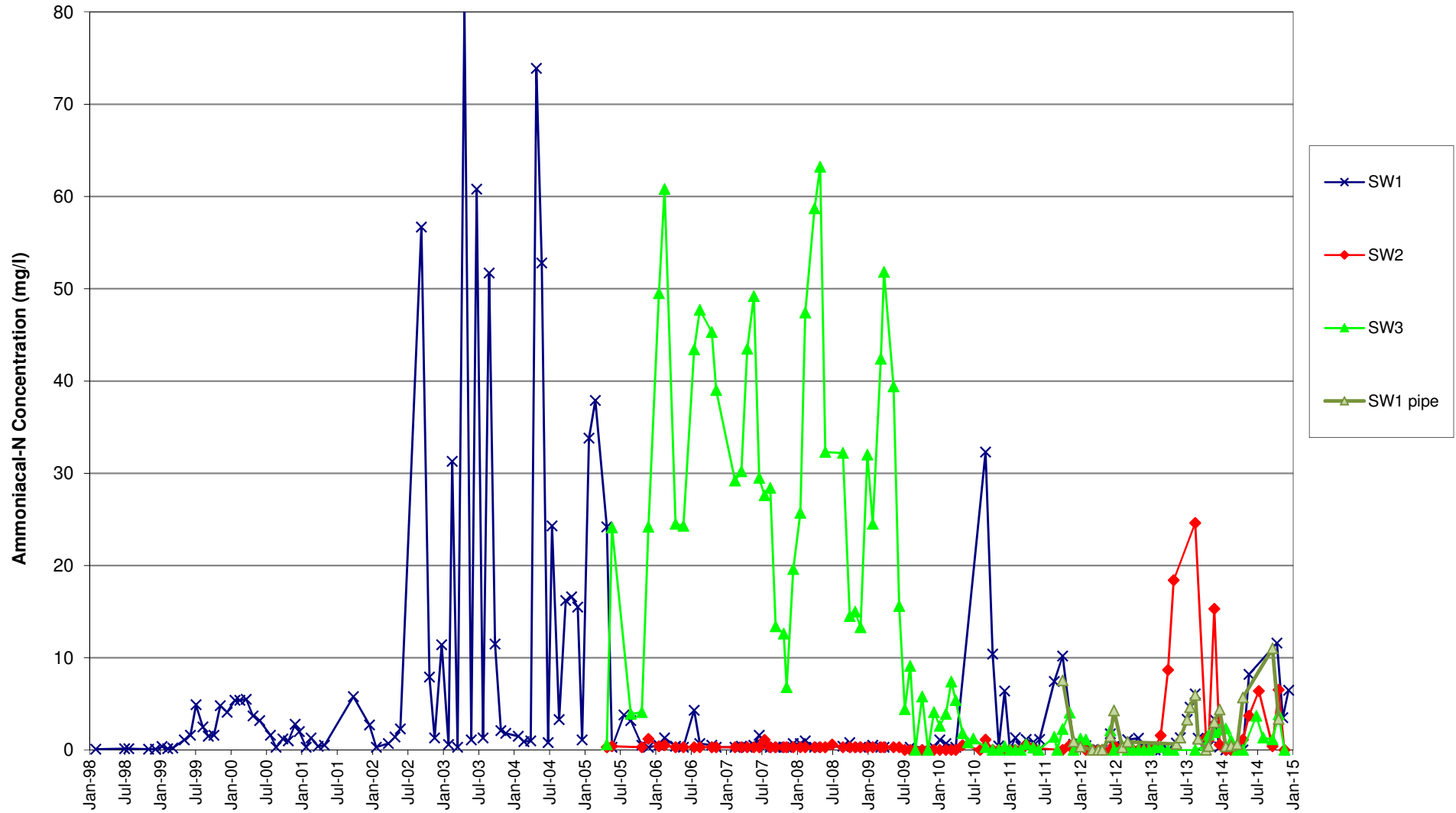


Appendix D

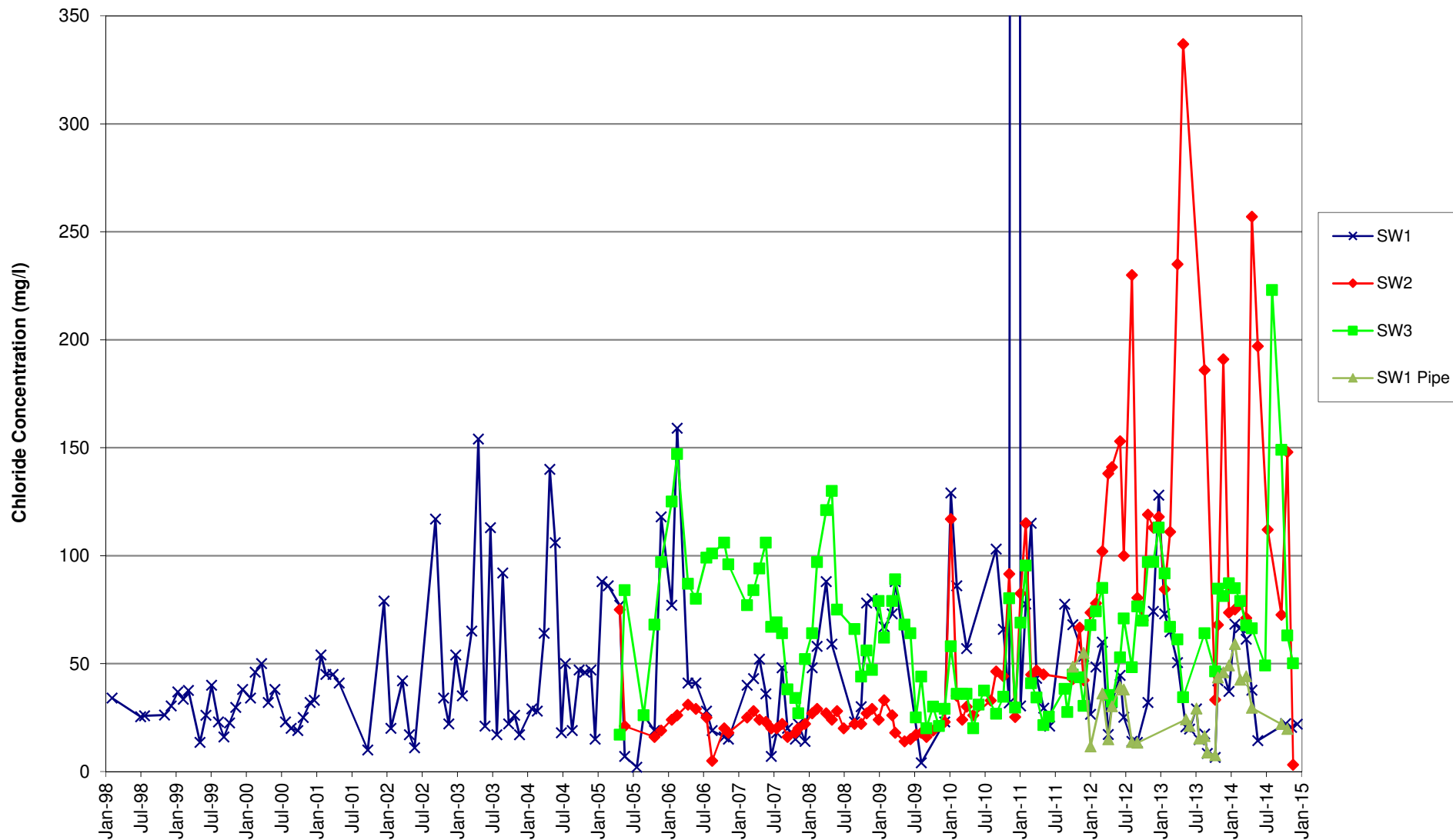
Surface Water Quality Plots



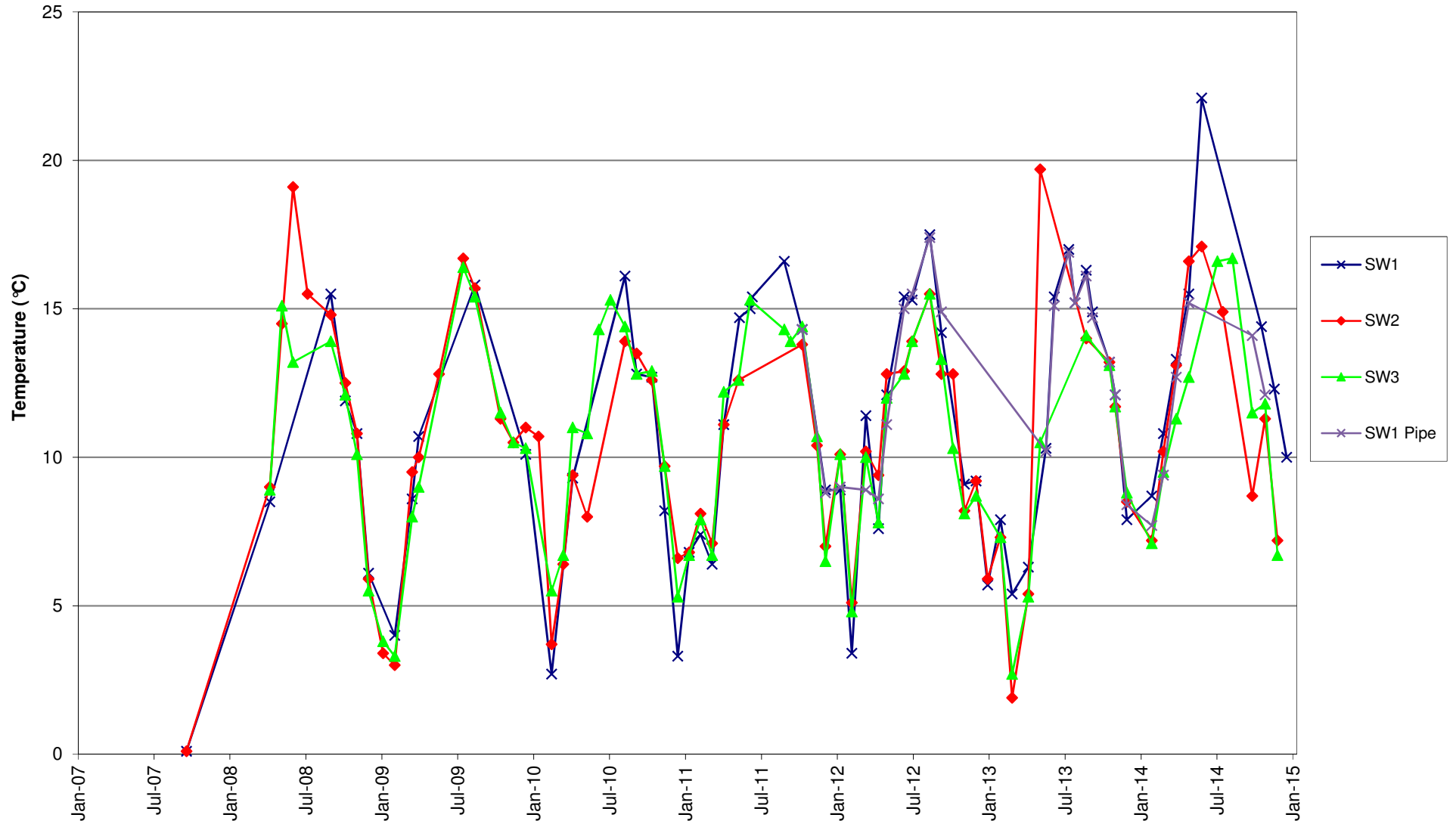
Ffridd Rasmus Landfill - Ammoniacal-Nitrogen in Surface Water



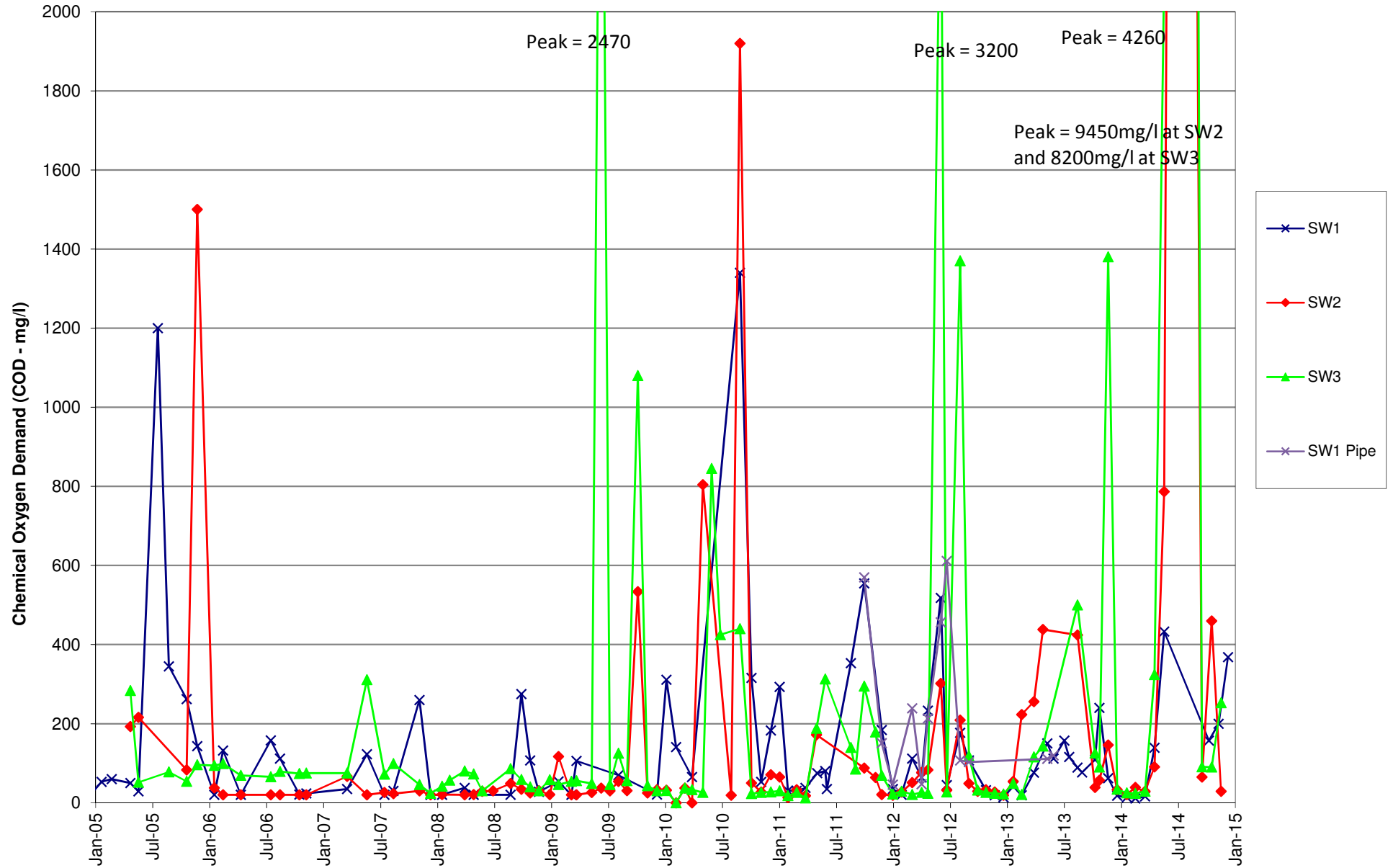
Ffridd Rasmus Landfill - Chloride in Surface Water



Ffridd Rasmus Landfill - Surface Water Temperature



Ffridd Rasmus Landfill - Recent Surface Water COD





Appendix E

Flare Emissions Test Report





Unit C6, Emery Court, The Embankment Business Park, Heaton Mersey, Stockport, SK4 3GL
 T: 0800 328 1821

E: toby.campbell@cat-env.com

Your Catalyst Contact: Toby Campbell (07825 130 074)

Stack Emissions Testing Report Commissioned by
 Gwynedd Council

Installation Name & Address

Gwynedd Council
 Ffidd Rasmus Landfill Site
 Harlech
 LL46 2UW

PPC Permit: GP333OBY, Variation Notice: QP3134LY

Stack Reference

Ffidd Rasmus Flare Stack

Dates of the Monitoring Campaign

21st February 2014

Job Reference Number


CAT-1777

Report Written by
Alex Powell Team Leader MCERTS Level 2 MM 10 1082 TE1 TE2 & TE4

Report Approved by
Brian Jacob Team Leader MCERTS Level 2 MM 06 693 TE1 TE2 TE3 TE4

Report Date
24th February 2014

Version
Version 1

Signature of Report Approver


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Executive Summary

(Page 1 of 7)

MONITORING OBJECTIVES

Gwynedd Council, Harlech
Ffidd Rasmus Flare Stack
21st February 2014

Overall Aim of the Monitoring Campaign

Catalyst Environmental Ltd - an Exova Group Company were commissioned by Gwynedd Council to carry out stack emissions testing on the Ffidd Rasmus Flare Stack at Harlech.

The aim of the monitoring campaign was to demonstrate compliance with a set of emission limit values (ELVs) as specified in the Site's Permit.

Special Requirements

There were no special requirements.

Target Parameters

Total VOCs (as Carbon), Oxides of Nitrogen (as NO₂), Carbon Monoxide

Executive Summary

(Page 2 of 7)

MONITORING RESULTS

Gwynedd Council, Harlech

Ffidd Rasus Flare Stack

21st February 2014

where MU = Measurement Uncertainty associated with the Result

Parameter	Concentration			
	Units	Result	MU * +/-	Limit **
Total VOCs (as Carbon)	¹ mg/m ³	0.25	0.10	10
Oxides of Nitrogen (as NO ₂)	¹ mg/m ³	109	32.8	150
Carbon Monoxide	¹ mg/m ³	7.7	1.5	50
Oxygen	% v/v	Dry 7.3	0.16	
Water Vapour	% v/v	16.3	0.67	

¹ Reference Conditions (REF) are: 273K, 101.3kPa, dry gas, 3% oxygen.

* The MU is calculated from values in LFTGN 05 [2010]. i.e. 20% of the Result for CO, 30% of the Result for NO_x & 40% of the Result for TVOCs)

** The result is considered to be an 'Approach to Limit' if it is above the Limit, but below the Limit once the MU is subtracted from it. The Result is considered to be Non-Compliant if, even after subtracting the MU from the Result, the Result is still above the Limit in LFTGN 05 [2010] or the calculated MU (See the Measurement Uncertainty Calculations in Appendix 2 of this Test Report) is above 6% for CO, 10% for NO_x & 15% for TVOCs

Executive Summary

(Page 3 of 7)

MONITORING DATE(S) & TIMES

Gwynedd Council, Harlech
Ffidd Rasus Flare Stack
21st February 2014

Parameter	Units	Concentration	Sampling Date(s)	Sampling Times	Duration mins
Total VOCs (as Carbon)	R1 mg/m ³	0.25	21 02 14	14:30 - 15:30	60
Oxides of Nitrogen (as NO ₂)	R1 mg/m ³	109	21 02 14	14:30 - 15:30	60
Carbon Monoxide	R1 mg/m ³	7.7	21 02 14	14:30 - 15:30	60
Oxygen	R1 % v/v	7.3	21 02 14	14:30 - 15:30	60
Water Vapour	R1 % v/v	16.3	21/02/2014	14:30 - 15:30	60

All results are expressed at the respective reference conditions.

Executive Summary

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PROCESS DETAILS

Gwynedd Council, Harlech
 Ffidd Rasus Flare Stack
 21st February 2014

Standard Operating Conditions

Parameter	Value
Process Status	Normal Operation
Capacity (of 100%) and Tonnes / Hour	~ 100 m ³ /hr
Continuous or Batch Process	Continuous
Feedstock (if applicable)	N/A
Abatement System	N/A
Abatement System Running Status	N/A
Fuel	Landfill Gas
Plume Appearance	Heat Haze Visible

Site Specific Operating Conditions

Parameter	Status
Flare Temperature during test	1006 Degrees Celcius

Executive Summary

(Page 5 of 7)

MONITORING & ANALYTICAL METHODS

Gwynedd Council, Harlech

Ffidd Rasmus Flare Stack

21st February 2014

Parameter	Monitoring				Analysis				MCERTS Testing	LOD (Average)
	Standard	Technical Procedure	UKAS Testing	Testing Lab	Analytical Procedure	Analytical Technique	UKAS Analysis	Analysis Lab		
Water Vapour	BS EN 14790	CAT-TP-05	Yes	CAT	CAT-TP-05	Gravimetric	Yes	CAT	Yes	0.1 % v/v
Total VOCs (as Carbon)	BS EN 12619:2013	CAT-TP-20	Yes	CAT	Flame Ionisation Detection by Sick 3006 FID				Yes	0.16 mg/m ³
Oxides of Nitrogen (as NO ₂)	BS EN 14792	CAT-TP-21	Yes	CAT	Chemiluminescence by Horiba PG-250				Yes	0.21 mg/m ³
Carbon Monoxide	BS EN 15058	CAT-TP-21	Yes	CAT	NDIR by Horiba PG-250				Yes	0.62 mg/m ³
Oxygen	BS EN 14789	CAT-TP-21	Yes	CAT	Dry Zirconia Cell by Horiba PG-250				Yes	0.01 %

ANALYSIS LABORATORIES

(with short name reference as appears in the table above)

Catalyst Environmental Ltd (CAT)	UKAS Accreditation Number: 4279
----------------------------------	---------------------------------

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
All Parameters	All Runs	There are no deviations associated with the sampling employed.

Executive Summary

(Page 6 of 7)

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	1.18
Width	m	-
Area	m ²	1.09
Port Depth	cm	31
Orientation of Duct	-	Vertical
Sample Port Size	-	5" Flange

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	Temporary
Inside / Outside	Outside

Platform Details

EA Technical Guidance Note M1 / BS EN 15259 Platform Requirements	Value
Sufficient working area to manipulate probe and operate the measuring instruments	Yes
Platform has 2 levels of handrails (approx. 0.5m & 1.0m high)	Yes
Platform has vertical base boards (approx. 0.25m high)	Yes
Platform has chains / self closing gates at top of ladders	Yes
There are no obstructions present which hamper insertion of sampling equipment	Yes
Safe Access Available	Yes
Easy Access Available	Yes

Sampling Location / Platform Improvement Recommendations

The sampling location meets all the requirements specified in EA Guidance Note M1 and BS EN 15259, and therefore there are no improvement recommendations.

BS EN 15259 Homogeneity Test Requirements

There is no requirement to perform a BS EN 15259 Homogeneity Test on this Stack.

Executive Summary
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PLANT PHOTOS

Photo 1



Photo 2



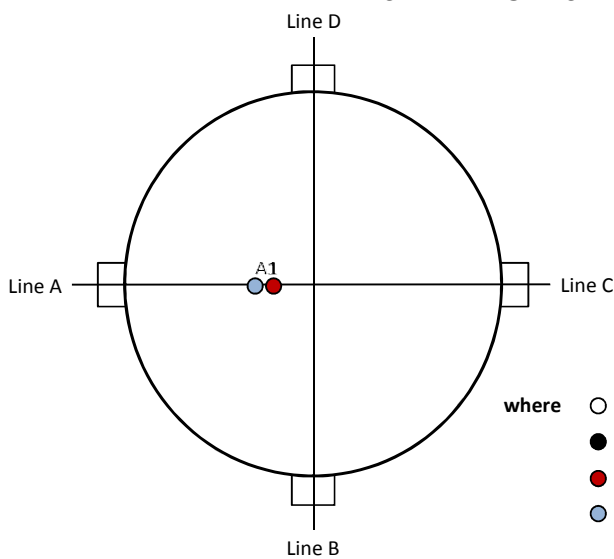
Photo 3



Photo 4



SAMPLE POINTS



- where
- = isokinetic point sampled at
 - = isokinetic point not sampled at
 - = combustion gases sample point
 - = non-isokinetic sample point

APPENDICES

APPENDIX CONTENTS

APPENDIX 1 - Stack Emissions Monitoring Personnel, List of Equipment & Methods and Technical Procedures Used

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	Alex Powell	MCERTS Level 2	MM 10 1082	TE1 TE2 & TE4
Trainee	Gareth Jones	MCERTS Trainee	MM 13 1241	None

LIST OF EQUIPMENT

Extractive Sampling		Instrumental Analysers		Miscellaneous Items	
Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.
Control Box DGM	-	Horiba PG-250	CAT 9.9	Digital Manometer (1)	-
Box Thermocouples	-	Servomex 4900	-	Digital Manometer (2)	-
Umbilical	-	Eco Physics CLD 822Mh	-	Digital Temperature Meter	CAT 3.25
Oven Box	-	Testo 350 XL	-	Stopwatch	CAT 14.53
Probe	-	Servomex 5200MP	-	Barometer	CAT 13.26
S-Pitot (1)	-	JCT JCC P1 Cooler	CAT 4.135	Stack Thermocouple (1)	CAT 4.474
S-Pitot (2)	-	FT-IR	-	Stack Thermocouple (2)	-
L-Pitot	-	FT-IR Sampling System	-	1m Heated Line (1)	-
500g Check Weight	CAT 17.23	Bernath 3006 FID	CAT 8.16	1m Heated Line (2)	-
1Kg Check Weight	CAT 17.23	Heated Head Filter	CAT 12.92	1m Heated Line (3)	-
Last Impinger Arm	-	Mass Flow Controller (1)	CAT 6.3	5m Heated Line (1)	-
Callipers	-	Mass Flow Controller (2)	CAT 6.4	15m Heated Line (1)	-
Tubes Kit Thermocouple	-	Mass View (1)	CAT 25.40	15m Heated Line (2)	-
Laboratory Balance	CAT 1.18 / 1.18a	Mass View (2)	CAT 25.41	20m Heated Line (1)	CAT 20.29
Tape Measure	CAT 16.32	Easylogger EN-EL-12 Bit	CAT 11.44	Dual Channel Heater Controller	-

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
Water Vapour	BS EN 14790	CAT-TP-05
Total VOCs (as Carbon)	BS EN 12619:2013	CAT-TP-20
Oxides of Nitrogen (as NO ₂)	BS EN 14792	CAT-TP-21
Carbon Monoxide	BS EN 15058	CAT-TP-21
Oxygen	BS EN 14789	CAT-TP-21

WATER VAPOUR: RESULTS SUMMARY

Gwynedd Council, Harlech
Ffidd Rasmus Flare Stack

Sample Runs

Parameter	Units	Run 1	Mean
Concentration	% v/v	16.3	16.3
Uncertainty	±% v/v	0.67	0.67

General Sampling Information

Parameter	Value
Standard	BS EN 14790
Technical Procedure	CAT-TP-05

WATER VAPOUR: SAMPLING DETAILS

Sample Runs

Parameter	Units	Run 1
Sampling Times	-	14:30 - 15:30
Sampling Dates	-	21/02/2014
Sampling Device	-	MFC / MV
Duration	mins	60
Volume Sampled (STP, Dry)	m ³	0.1880
Volume Sampled (STP, Wet)	m ³	0.2247
Sample Flow Rate	l/min	3.05
Liquid Trap Start Mass	g	3992.9
Liquid Trap End Mass	g	4015.1
Silica Trap Start Mass	g	1327.1
Silica Trap End Mass	g	1334.3
Total Mass Of Water Vapour	g	29.4
Calculated Water Vapour	% v/v	16.30

Where: MFC stands for Mass Flow Controller, MV stands for Mass View Flowmeter

WATER VAPOUR: QUALITY ASSURANCE

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	3.1	
Pre-Sampling Leak Rate	l/min	0.00	
Post-Sampling Leak Rate	l/min	0.00	
Allowable Leak Rate	l/min	0.06	
Leak Test Acceptable	-	Yes	

Water Droplets	Units	Run 1	
Are Water Droplets Present	-	No	

Measurement Uncertainty	Units	Run 1	
Measurement Uncertainty (MU)	%	4.1	
Allowable MU	%	20.0	
MU Acceptable	%	Yes	

Silica Gel	Units	Run 1	
Less than 50% Faded	%	Yes	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

Method Deviations

Nature of Deviation	Run Number	
	(x = deviation applies to the associated run)	1
There are no deviations associated with the sampling employed.	x	

WATER VAPOUR: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (STP)	V _m	0.188		uV _m	m ³	0.0038	
Repeatability of Weighing	R _w	29.40		uR _w	g	0.12	
Reading of Balance	R _b	29.40		uR _b	g	0.15	
Leak	L	0.00			%	-	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (STP)	%	2.00		≤2%
Repeatability of Weighing	%	0.41		No Requirement
Reading of Balance	%	0.50		No Requirement
Leak	%	0.00		≤2%

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V _m	m ³	0.1880		86.71	
Repeatability of Weighing	R _w	g	29.40		0.55	
Reading of Balance	R _b	g	29.40		0.55	
Leak	L	% v/v	0.00		1.00	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	% v/v	0.326	
Repeatability of Weighing	% v/v	0.067	
Reading of Balance	% v/v	0.082	
Leak	% v/v	0.000	

Parameter	Units	Run 1	
Combined uncertainty	% v/v	0.34	
Expanded uncertainty (95% confidence)	% v/v	0.67	
Expanded uncertainty (95% confidence), estimated with Method Deviations	% v/v	0.67	
Uncertainty if Water Droplets are present	% v/v	N/A	
Reported Uncertainty	% v/v	0.67	
Expanded uncertainty (95% confidence)	%	4.1	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	4.1	
Uncertainty if Water Droplets are present	%	N/A	
Reported Uncertainty	%	4.1	

TOTAL VOCs (as CARBON): RESULTS SUMMARY

Gwynedd Council, Harlech
Ffidd Rasus Flare Stack

Sample Runs

Parameter	Units	Run 1	Mean
Concentration	mg/m ³	0.25	0.25
Uncertainty	±mg/m ³	0.20	0.20

General Sampling Information

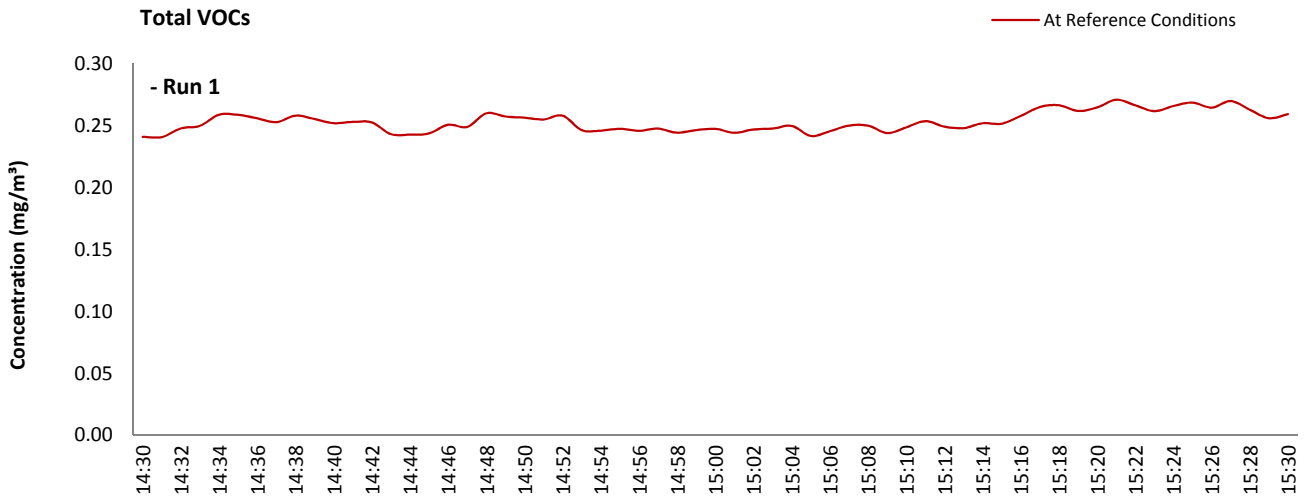
Parameter	Value	
Standard	BS EN 12619:2013	
Technical Procedure	CAT-TP-20	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Reference Number	CYL 1.0083	
Span Gas Expiry Date	16/08/2018	
Span Gas Start Pressure (bar)	140	
Gas Cylinder Concentration (ppm)	80.1	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Synthetic Air (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 3% oxygen.

TOTAL VOCs (as CARBON): DATA TREND

Graphical Trend of Data



TOTAL VOCs (as CARBON): SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1	
Sampling Times	-	14:30 - 15:30	
Sampling Dates	-	21 02 14	
Instrument Range	ppm	100	
Span Gas Value	ppm	80.1	

Quality Assurance

	Zero Drift	Units	Run 1	
CAL 1	Zero Down Sampling Line (Pre)	ppm	0.30	
	Zero Down Sampling Line (Post)	ppm	-1.00	
	Zero Drift	ppm	-1.30	
	Allowable Zero Drift	± ppm	4.01	
	Zero Drift Acceptable	-	Yes	
	Span Drift	Units	Run 1	
CAL 1	Span Down Sampling Line (Pre)	ppm	78.70	
	Span Down Sampling Line (Post)	ppm	79.00	
	Span Drift	ppm	0.30	
	Allowable Span Drift	± ppm	4.01	
	Span Drift Acceptable	-	Yes	
	Test Conditions	Units	Run 1	
	Run Ambient Temperature Range	°C	4 - 9	

Method Deviations

Nature of Deviation	Run Number	
	(x = deviation applies to the associated run)	1
There are no deviations associated with the sampling employed.	x	

TOTAL VOCs (as CARBON): MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			
	Units	Run 1	Run 2	Run 3
MCERTS Certified Range of Analyser	ppm	9.3		
Operational Range of Analyser	ppm	100.0		
Measured Reading	ppm	0.1		

Measured Quantities	Individual Errors as Standard Uncertainties			
	Units	Run 1	Run 2	Run 3
Nonlinearity	ppm	0.011		
Temperature Dependent Zero Drift	ppm	0.027		
Temperature Dependent Span Drift	ppm	0.027		
Cross-Sensitivity	ppm	0.002		
Leak	ppm	0.00		
Calibration Gas Uncertainty	ppm	0.00		
Mass Flow Controllers (dilution) Uncertainty	ppm	0.00		

Parameter	Units	Run 1	Run 2	Run 3
Combined uncertainty	ppm	0.04		
Expanded uncertainty (95% confidence)	ppm	0.08		
Expanded uncertainty (95% confidence), estimated with Method Deviations	ppm	0.08		
Reported Uncertainty	ppm	0.08		
Expanded uncertainty (95% confidence)	%	78.1		
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	78.1		
Reported Uncertainty	%	78.1		

OXIDES OF NITROGEN (as NO₂): RESULTS SUMMARY

Gwynedd Council, Harlech
Ffidd Rasus Flare Stack

Sample Runs

Parameter	Units	Run 1	Mean
Concentration	mg/m ³	109	109
Uncertainty	±mg/m ³	2.7	2.7

General Sampling Information

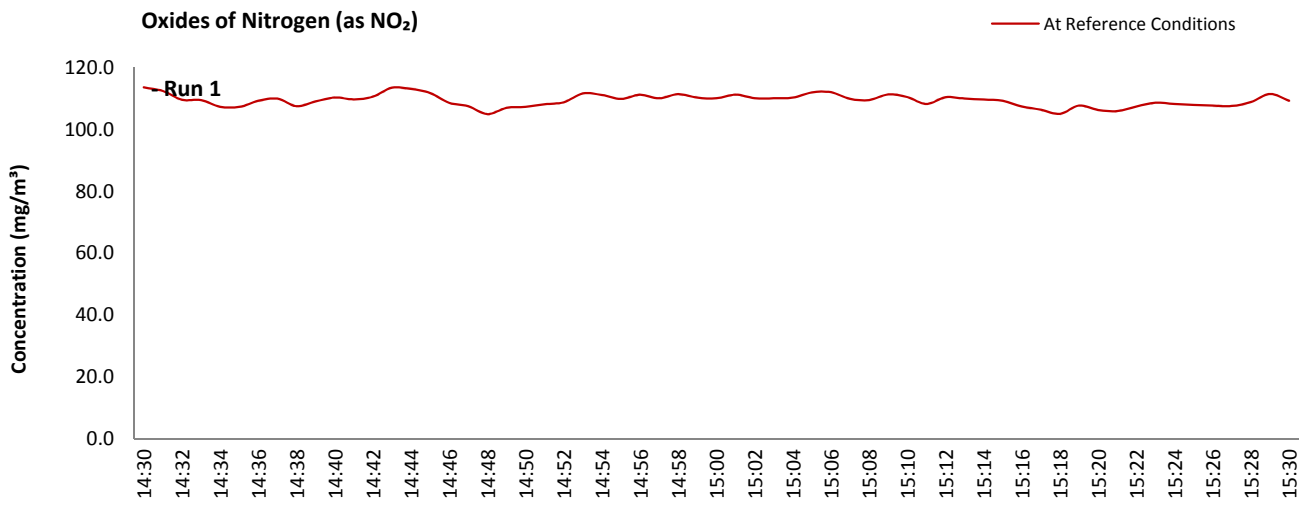
Parameter	Value	
Standard	BS EN 14792	
Technical Procedure	CAT-TP-21	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Date & Result of Last Converter Check	31/10/2013 - 96.4%	
Span Gas Reference Number	CYL 4.0063	
Span Gas Expiry Date	30/04/2016	
Span Gas Start Pressure (bar)	90	
Gas Cylinder Concentration (ppm)	397.3	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 3% oxygen.

OXIDES OF NITROGEN (as NO₂): DATA TREND

Graphical Trend of Data



OXIDES OF NITROGEN (as NO₂): SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1	
Sampling Times	-	14:30 - 15:30	
Sampling Dates	-	21 02 14	
Instrument Range	ppm	250	
Span Gas Value	ppm	73.1	

Quality Assurance

Conditioning Unit Temperature	Units	Run 1	
Average Temperature	°C	1.7	
Allowable Temperature	< °C	4.0	
Temperature Acceptable	-	Yes	

Zero Drift	Units	Run 1	
Zero Down Sampling Line (Pre)	ppm	0.09	
Zero Down Sampling Line (Post)	ppm	0.40	
Zero Drift	ppm	0.31	
Allowable Zero Drift	± ppm	3.65	
Zero Drift Acceptable	-	Yes	

CAL 1

Span Drift	Units	Run 1	
Span Down Sampling Line (Pre)	ppm	74.20	
Span Down Sampling Line (Post)	ppm	72.50	
Span Drift	ppm	-1.70	
Allowable Span Drift	± ppm	3.65	
Span Drift Acceptable	-	Yes	

CAL 1

Test Conditions	Units	Run 1	
Run Ambient Temperature Range	°C	4 - 9	

Method Deviations

Nature of Deviation	Run Number	
	(x = deviation applies to the associated run)	1
There are no deviations associated with the sampling employed.	x	

OXIDES OF NITROGEN (as NO₂): MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value		
	Units	Run 1	
MCERTS Certified Range of Analyser	ppm	60.9	
Operational Range of Analyser	ppm	250.0	
Measured Reading	ppm	40.4	

Measured Quantities	Individual Errors as Standard Uncertainties		
	Units	Run 1	
Nonlinearity	ppm	0.084	
Temperature Dependent Zero Drift	ppm	0.004	
Temperature Dependent Span Drift	ppm	0.063	
Cross-Sensitivity	ppm	0.280	
Leak	ppm	0.00	
Calibration Gas Uncertainty	ppm	0.24	
Mass Flow Controllers (dilution) Uncertainty	ppm	0.33	
NO _x Converter Efficiency	ppm	0.06	

Parameter	Units	Run 1	
Combined uncertainty	ppm	0.51	
Expanded uncertainty (95% confidence)	ppm	1.00	
Expanded uncertainty (95% confidence), estimated with Method Deviations	ppm	1.00	
Reported Uncertainty	ppm	1.00	
Expanded uncertainty (95% confidence)	%	2.5	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	2.5	
Reported Uncertainty	%	2.5	

CARBON MONOXIDE: RESULTS SUMMARY

Gwynedd Council, Harlech
Ffidd Rasus Flare Stack

Sample Runs

Parameter	Units	Run 1	Mean
Concentration	mg/m ³	7.7	7.7
Uncertainty	±mg/m ³	0.39	0.39

General Sampling Information

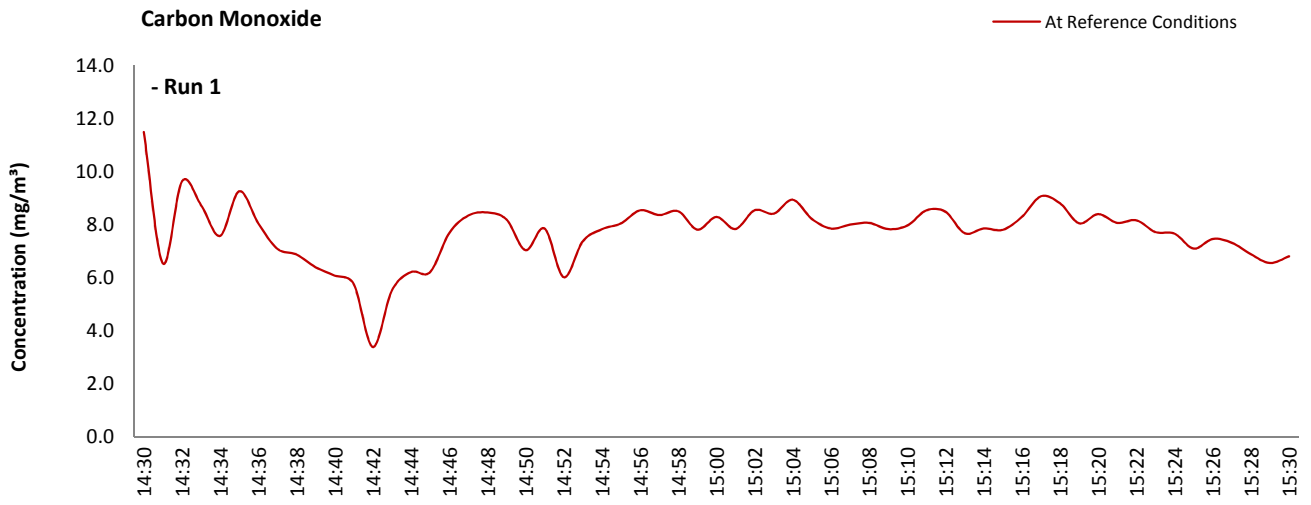
Parameter	Value	
Standard	BS EN 15058	
Technical Procedure	CAT-TP-21	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Reference Number	CYL 2.0046	
Span Gas Expiry Date	30/04/2017	
Span Gas Start Pressure (bar)	60	
Gas Cylinder Concentration (ppm)	397.88	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, dry gas, 3% oxygen.

CARBON MONOXIDE: DATA TREND

Graphical Trend of Data



CARBON MONOXIDE: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1	
Sampling Times	-	14:30 - 15:30	
Sampling Dates	-	21 02 14	
Instrument Range	ppm	100	
Span Gas Value	ppm	40.0	

Quality Assurance

Conditioning Unit Temperature	Units	Run 1	
Average Temperature	°C	1.7	
Allowable Temperature	< °C	4.0	
Temperature Acceptable	-	Yes	

Zero Drift	Units	Run 1	
Zero Down Sampling Line (Pre)	ppm	0.60	
Zero Down Sampling Line (Post)	ppm	0.20	
Zero Drift	ppm	-0.40	
Allowable Zero Drift	± ppm	2.00	
Zero Drift Acceptable	-	Yes	

CAL 1

Span Drift	Units	Run 1	
Span Down Sampling Line (Pre)	ppm	40.70	
Span Down Sampling Line (Post)	ppm	40.40	
Span Drift	ppm	-0.30	
Allowable Span Drift	± ppm	2.00	
Span Drift Acceptable	-	Yes	

CAL 1

Test Conditions	Units	Run 1	
Run Ambient Temperature Range	°C	4 - 9	

Method Deviations

Nature of Deviation	Run Number
(x = deviation applies to the associated run)	1
There are no deviations associated with the sampling employed.	x

CARBON MONOXIDE: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value		
	Units	Run 1	
MCERTS Certified Range of Analyser	ppm	76.0	
Operational Range of Analyser	ppm	100.0	
Measured Reading	ppm	4.7	

Measured Quantities	Individual Errors as Standard Uncertainties		
	Units	Run 1	
Nonlinearity	ppm	0.075	
Temperature Dependent Zero Drift	ppm	0.022	
Temperature Dependent Span Drift	ppm	0.022	
Cross-Sensitivity	ppm	0.078	
Leak	ppm	0.00	
Calibration Gas Uncertainty	ppm	0.03	
Mass Flow Controllers (dilution) Uncertainty	ppm	0.04	

Parameter	Units	Run 1	
Combined uncertainty	ppm	0.12	
Expanded uncertainty (95% confidence)	ppm	0.24	
Expanded uncertainty (95% confidence), estimated with Method Deviations	ppm	0.24	
Reported Uncertainty	ppm	0.24	
Expanded uncertainty (95% confidence)	%	5.1	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	5.1	
Reported Uncertainty	%	5.1	

OXYGEN: RESULTS SUMMARY

Gwynedd Council, Harlech
Ffidd Rasus Flare Stack

Sample Runs

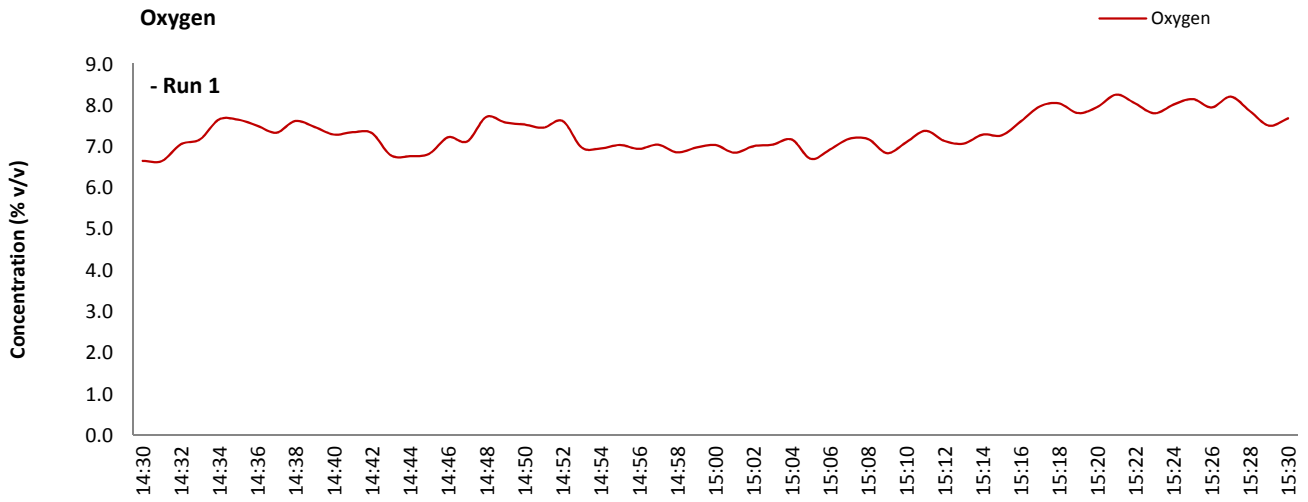
Parameter	Units	Run 1	Mean
Concentration	% v/v	7.3	7.3
Uncertainty	±% v/v	0.16	0.16

General Sampling Information

Parameter	Value	
Standard	BS EN 14789	
Technical Procedure	CAT-TP-21	
Probe Material	Stainless Steel	
Filtration Type / Size	0.1µm Glass Fibre	
Heated Head Filter Used	Yes	
Heated Line Temperature	180°C	
Span Gas Reference Number	CYL 11.0145	
Span Gas Expiry Date	16 10 18	
Span Gas Start Pressure (bar)	160	
Gas Cylinder Concentration (% v/v)	20.87	NOTE: Dilution performed to achieve correct span value
Span Gas Uncertainty (%)	2	
Zero Gas Type	Nitrogen (5 Grade)	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

OXYGEN: DATA TREND

Graphical Trend of Data



OXYGEN: SAMPLING DETAILS & QUALITY ASSURANCE

Sampling Details

Parameter	Units	Run 1	
Sampling Times	-	14:30 - 15:30	
Sampling Dates	-	21 02 14	
Instrument Range	% v/v	25	
Span Gas Value	% v/v	12.00	

Quality Assurance

Conditioning Unit Temperature	Units	Run 1	
Average Temperature	°C	1.7	
Allowable Temperature	< °C	4.0	
Temperature Acceptable	-	Yes	

Zero Drift	Units	Run 1	
Zero Down Sampling Line (Pre)	% v/v	0.07	
Zero Down Sampling Line (Post)	% v/v	0.13	
Zero Drift	% v/v	0.06	
Allowable Zero Drift	± % v/v	0.60	
Zero Drift Acceptable	-	Yes	

CAL 1

Span Drift	Units	Run 1	
Span Down Sampling Line (Pre)	% v/v	11.86	
Span Down Sampling Line (Post)	% v/v	11.72	
Span Drift	% v/v	-0.14	
Allowable Span Drift	± % v/v	0.60	
Span Drift Acceptable	-	Yes	

CAL 1

Test Conditions	Units	Run 1	
Run Ambient Temperature Range	°C	4 - 9	

Method Deviations

Nature of Deviation	Run Number	
	(x = deviation applies to the associated run)	1
There are no deviations associated with the sampling employed.	x	

OXYGEN: MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value		
	Units	Run 1	
Operational Range of Analyser	% v/v	25.0	
Measured Reading	% v/v	7.3	

Measured Quantities	Individual Errors as Standard Uncertainties		
	Units	Run 1	
Nonlinearity	% v/v	0.007	
Temperature Dependent Zero Drift	% v/v	-0.004	
Temperature Dependent Span Drift	% v/v	-0.010	
Cross-Sensitivity	% v/v	0.025	
Leak	% v/v	0.000	
Calibration Gas Uncertainty	% v/v	0.043	
Mass Flow Controllers (dilution) Uncertainty	% v/v	0.060	

Parameter	Units	Run 1	
Combined uncertainty	% v/v	0.08	
Expanded uncertainty (95% confidence)	% v/v	0.16	
Expanded uncertainty (95% confidence), estimated with Method Deviations	% v/v	0.16	
Reported Uncertainty	% v/v	0.16	
Expanded uncertainty (95% confidence)	%	2.1	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	2.1	
Reported Uncertainty	%	2.1	



EXOVO
CATALYST



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Your Catalyst Contact: Toby Campbell (07825 130 074)

Stack Emissions Testing Report Commissioned by
Gwynedd Council

Installation Name & Address

Gwynedd Council

Ffidd Rasmus Landfill Site

Harlech

LL46 2UW

PPC Permit: GP3330BY, Variation: QP3134LY

Stack Reference

Raw Landfill Gas Supply

Dates of the Monitoring Campaign

16th April 2014

Job Reference Number

CAT-1834

Report Written by

Alex Powell

Team Leader

MCERTS Level 2

MM 10 1082

TE1 TE2 TE4

Report Approved by

James Eldridge

Deputy Regional Manager

MCERTS Level 2

MM 05 641

TE1 TE2 TE3 TE4

Report Date

9th May 2014

Version

Version 1

Signature of Report Approver

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MONITORING OBJECTIVES

Gwynedd Council, Ffidd Rasmus Landfill Site
Raw Landfill Gas Supply
16th April 2014

Overall Aim of the Monitoring Campaign

Catalyst Environmental Ltd - an Exova Group Company were commissioned by Gwynedd Council to carry out stack emissions testing on the Raw Landfill Gas Supply at Ffidd Rasmus Landfill Site.

The aim of the monitoring campaign was to perform testing, as requested by the customer, for a number of prescribed pollutants. There are no emission limits set for any of the pollutants at this time.

Special Requirements

There were no special requirements.

Target Parameters

Methanal, Ethanal, Arsenic, 1,1-Dichloroethane, 1,2-Dichloroethane, 1,1-Dichloroethene, 1,2-Dichloroethene, 1,3-Butadiene, 1-butanethiol, 1-pentene, 1-propanethiol, 2-butoxyethanol, Benzene, Butyric Acid, Carbon Disulphide, Chloroethane, Vinyl Chloride, Dimethyl Disulphide, Dimethyl Sulphide, Ethanethiol, Ethyl Butyrate, Furan (1,4-epoxy-1,3-butadiene), Methanethiol, Styrene, Tetrachloromethane, Toluene, Trichloroethene, Dichloromethane, Oxygen, Nitrogen, Carbon Dioxide, Methane, Hydrogen Sulphide

MONITORING RESULTS

Gwynedd Council, Ffidd Rasmus Landfill Site
Raw Landfill Gas Supply
16th April 2014

where MU = Measurement Uncertainty associated with the Result

Parameter	Concentration			
	Units	Result	MU +/-	Limit
Methanal	¹ mg/m ³	0.12	0.03	-
Ethanal	¹ mg/m ³	0.10	0.02	-
Arsenic	¹ mg/m ³	0.002	0.0004	-
1,1-Dichloroethane	¹ mg/m ³	0.13	0.03	-
1,2-Dichloroethane	¹ mg/m ³	0.16	0.04	-
1,1-Dichloroethene	¹ mg/m ³	< 0.12	0.03	-
1,2-Dichloroethene	¹ mg/m ³	0.35	0.08	-
1,3-Butadiene	¹ mg/m ³	< 1.30	0.31	-
1-butanethiol	¹ mg/m ³	< 0.09	0.02	-
1-pentene	¹ mg/m ³	0.47	0.11	-
1-propanethiol	¹ mg/m ³	< 0.17	0.04	-
2-butoxyethanol	¹ mg/m ³	0.14	0.03	-
Benzene	¹ mg/m ³	1.39	0.33	-
Butyric Acid	¹ mg/m ³	0.69	0.17	-
Carbon Disulphide	¹ mg/m ³	3.48	0.84	-
Chloroethane	¹ mg/m ³	0.26	0.06	-
Vinyl Chloride	¹ mg/m ³	< 0.20	0.05	-
Dimethyl Disulphide	¹ mg/m ³	< 0.02	0.005	-
Dimethyl Sulphide	¹ mg/m ³	0.17	0.04	-
Ethanethiol	¹ mg/m ³	< 0.52	0.12	-
Ethyl Butyrate	¹ mg/m ³	1.13	0.27	-
Furan (1,4-epoxy-1,3-butadiene)	¹ mg/m ³	0.14	0.03	-
Methanethiol	¹ mg/m ³	< 1.73	0.41	-
Styrene	¹ mg/m ³	0.64	0.15	-
Tetrachloromethane	¹ mg/m ³	< 0.14	0.03	-
Toluene	¹ mg/m ³	10.4	2.49	-
Trichloroethene	¹ mg/m ³	0.17	0.04	-
Dichloromethane	¹ mg/m ³	0.31	0.08	-
Oxygen	¹ % v/v	0.60	0.30	-
Nitrogen	¹ % v/v	12.2	0.80	-
Carbon Dioxide	¹ % v/v	31.1	0.80	-
Methane	¹ % v/v	56.1	0.80	-
Hydrogen Sulphide	¹ mg/m ³	214	15.2	-

¹ Reference Conditions (REF) are: 273K, 101.3kPa, without correction for water vapour content.

MONITORING DATE(S) & TIMES

Gwynedd Council, Ffidd Rasmus Landfill Site

Raw Landfill Gas Supply

16th April 2014

Parameter	Units	Concentration	Sampling Date(s)	Sampling Times	Duration mins
Methanal	R1 mg/m ³	0.12	16/04/2014	10:14 - 10:24	10
Ethanal	R1 mg/m ³	0.10	16/04/2014	10:14 - 10:24	10
Arsenic	R1 mg/m ³	0.002	16/04/2014	10:36 - 11:01	25
1,1-Dichloroethane	R1 mg/m ³	0.13	16/04/2014	11:32 - 11:36	4
1,2-Dichloroethane	R1 mg/m ³	0.16	16/04/2014	11:32 - 11:36	4
1,1-Dichloroethene	R1 mg/m ³	< 0.12	16/04/2014	11:32 - 11:36	4
1,2-Dichloroethene	R1 mg/m ³	0.35	16/04/2014	11:32 - 11:36	4
1,3-Butadiene	R1 mg/m ³	< 1.30	16/04/2014	11:32 - 11:36	4
1-butanethiol	R1 mg/m ³	< 0.09	16/04/2014	11:32 - 11:36	4
1-pentene	R1 mg/m ³	0.47	16/04/2014	11:32 - 11:36	4
1-propanethiol	R1 mg/m ³	< 0.17	16/04/2014	11:32 - 11:36	4
2-butoxyethanol	R1 mg/m ³	0.14	16/04/2014	11:32 - 11:36	4
Benzene	R1 mg/m ³	1.39	16/04/2014	11:32 - 11:36	4
Butyric Acid	R1 mg/m ³	0.69	16/04/2014	11:32 - 11:36	4
Carbon Disulphide	R1 mg/m ³	3.48	16/04/2014	11:32 - 11:36	4
Chloroethane	R1 mg/m ³	0.26	16/04/2014	11:32 - 11:36	4
Vinyl Chloride	R1 mg/m ³	< 0.20	16/04/2014	11:32 - 11:36	4
Dimethyl Disulphide	R1 mg/m ³	< 0.02	16/04/2014	11:32 - 11:36	4
Dimethyl Sulphide	R1 mg/m ³	0.17	16/04/2014	11:32 - 11:36	4
Ethanethiol	R1 mg/m ³	< 0.52	16/04/2014	11:32 - 11:36	4
Ethyl Butyrate	R1 mg/m ³	1.13	16/04/2014	11:32 - 11:36	4
Furan (1,4-epoxy-1,3-butadiene)	R1 mg/m ³	0.14	16/04/2014	11:32 - 11:36	4
Methanethiol	R1 mg/m ³	< 1.73	16/04/2014	11:32 - 11:36	4
Styrene	R1 mg/m ³	0.64	16/04/2014	11:32 - 11:36	4
Tetrachloromethane	R1 mg/m ³	< 0.14	16/04/2014	11:32 - 11:36	4
Toluene	R1 mg/m ³	10.4	16/04/2014	11:32 - 11:36	4
Trichloroethene	R1 mg/m ³	0.17	16/04/2014	11:32 - 11:36	4
Dichloromethane	R1 mg/m ³	0.31	16/04/2014	11:32 - 11:36	4
Oxygen	R1 mg/m ³	0.60	16/04/2014	10:09 - 10:11	2
Nitrogen	R1 mg/m ³	12.2	16/04/2014	10:09 - 10:11	2
Carbon Dioxide	R1 mg/m ³	31.1	16/04/2014	10:09 - 10:11	2
Methane	R1 mg/m ³	56.1	16/04/2014	10:09 - 10:11	2
Hydrogen Sulphide	R1 mg/m ³	214	16/04/2014	10:09 - 10:11	2

All results are expressed at the respective reference conditions.

PROCESS DETAILS

Gwynedd Council, Ffidd Rasmus Landfill Site
Raw Landfill Gas Supply
16th April 2014

Standard Operating Conditions

Parameter	Value
Process Status	Normal Operation
Capacity (of 100%) and Tonnes / Hour	N/A - Raw Gas Feed to Flare Stack
Continuous or Batch Process	Continuous
Feedstock (if applicable)	Landfill Gas
Abatement System	N/A
Abatement System Running Status	N/A
Fuel	N/A
Plume Appearance	N/A

Site Specific Operating Conditions

Parameter	Status
Landfill Gas Composition (As read by site instrumentation)	Methane 55.8% / Oxygen 0.3% / Carbon Dioxide 44.8%

MONITORING & ANALYTICAL METHODS

Gwynedd Council, Ffidd Rasmus Landfill Site

Raw Landfill Gas Supply

16th April 2014

Parameter	Monitoring				Analysis					MCERTS Testing	LOD (Average)
	Standard	Technical Procedure	UKAS Testing	Testing Lab	Analytical Procedure	Analytical Technique	UKAS Analysis	Analysis Lab			
Methanal	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	No	LCN	No	0.063 mg/m ³	
Ethanal	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	No	LCN	No	0.063 mg/m ³	
Arsenic	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	No	LCN	No	0.001 mg/m ³	
1,1-Dichloroethane	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.117 mg/m ³	
1,2-Dichloroethane	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.082 mg/m ³	
1,1-Dichloroethene	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.121 mg/m ³	
1,2-Dichloroethene	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.026 mg/m ³	
1,3-Butadiene	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	1.297 mg/m ³	
1-butanethiol	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.086 mg/m ³	
1-pentene	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.216 mg/m ³	
1-propanethiol	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.173 mg/m ³	
2-butoxyethanol	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.13 mg/m ³	
Benzene	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.043 mg/m ³	
Butyric Acid	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	No	LCN	No	0.692 mg/m ³	
Carbon Disulphide	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.303 mg/m ³	
Chloroethane	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.091 mg/m ³	
Vinyl Chloride	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.199 mg/m ³	
Dimethyl Disulphide	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.022 mg/m ³	
Dimethyl Sulphide	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.134 mg/m ³	
Ethanethiol	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	No	LCN	No	0.519 mg/m ³	
Ethyl Butyrate	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.086 mg/m ³	
Furan (1,4-epoxy-1,3-butadiene)	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.216 mg/m ³	
Methanethiol	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	No	LCN	No	1.73 mg/m ³	
Styrene	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	No	LCN	No	0.086 mg/m ³	
Tetrachloromethane	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.143 mg/m ³	
Toluene	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.086 mg/m ³	
Trichloroethene	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.104 mg/m ³	
Dichloromethane	BS EN 13649	CAT-TP-16	Yes	CAT	C51	GC-MS	Yes	LCN	Yes	0.195 mg/m ³	
Oxygen	In-House	CAT-TP-27	Yes	CAT	C72	GC	Yes	LCN	Yes	0.30 % v/v	
Nitrogen	In-House	CAT-TP-27	Yes	CAT	C72	GC	Yes	LCN	Yes	0.80 % v/v	
Carbon Dioxide	In-House	CAT-TP-27	Yes	CAT	C72	GC	Yes	LCN	Yes	0.80 % v/v	
Methane	In-House	CAT-TP-27	Yes	CAT	C72	GC	Yes	LCN	Yes	0.80 % v/v	
Hydrogen Sulphide	In-House	CAT-TP-27	Yes	CAT	C74	GC	Yes	LCN	Yes	15.2mg/m ³	

ANALYSIS LABORATORIES

(with short name reference as appears in the table above)

Catalyst Environmental Ltd (CAT)	UKAS Accreditation Number: 4279
Lucideon (LCN)	UKAS Accreditation Number: 0013

SUMMARY OF SAMPLING DEVIATIONS

Parameter	Run	Deviation
Methanal / Carbon Disulphide	1	The absorption efficiency was less than the required 95%. [70 - 90%]

SUITABILITY OF SAMPLING LOCATION

Duct Characteristics

Parameter	Units	Value
Type	-	Circular
Depth	m	0.10
Width	m	-
Area	m ²	0.01
Port Depth	cm	12
Orientation of Duct	-	Horizontal
Sample Port Size	-	6mm Tap

Location of Sampling Platform

General Platform Information	Value
Permanent / Temporary Platform	On Ground
Inside / Outside	Inside

Platform Details

EA Technical Guidance Note M1 / BS EN 15259 Platform Requirements	Value
Sufficient working area to manipulate probe and operate the measuring instruments	Yes
Platform has 2 levels of handrails (approx. 0.5m & 1.0m high)	N/A
Platform has vertical base boards (approx. 0.25m high)	N/A
Platform has chains / self closing gates at top of ladders	N/A
There are no obstructions present which hamper insertion of sampling equipment	Yes
Safe Access Available	Yes
Easy Access Available	Yes

Sampling Location / Platform Improvement Recommendations

The sampling location meets all the requirements specified in EA Guidance Note M1 and BS EN 15259, and therefore there are no improvement recommendations.

BS EN 15259 Homogeneity Test Requirements

There is no requirement to perform a BS EN 15259 Homogeneity Test on this Stack.

PLANT PHOTOS

Photo 1



Photo 2



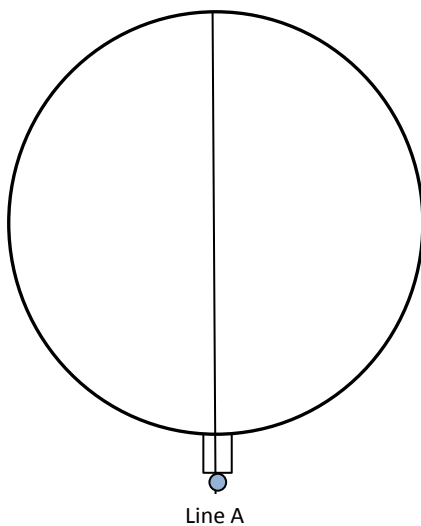
Photo 3



Photo 4



SAMPLE POINTS



Line A

- where
- = isokinetic point sampled at
 - = isokinetic point not sampled at
 - = combustion gases sample point
 - = non-isokinetic sample point

APPENDIX CONTENTS

APPENDIX 1 - Stack Emissions Monitoring Personnel, List of Equipment & Methods and Technical Procedures Used

APPENDIX 2 - Summaries, Calculations, Raw Data and Charts

STACK EMISSIONS MONITORING PERSONNEL

Position	Name	MCERTS Accreditation	MCERTS Number	Technical Endorsements
Team Leader	James Eldridge	MCERTS Level 2	MM 05 641	TE1 TE2 TE3 TE4

LIST OF EQUIPMENT

Extractive Sampling		Instrumental Analysers		Miscellaneous Items	
Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.	Equipment Type	Equipment I.D.
Control Box DGM	-	Horiba PG-250	-	Digital Manometer (1)	-
Box Thermocouples	-	Servomex 4900	-	Digital Manometer (2)	-
Umbilical	-	Eco Physics CLD 822Mh	-	Digital Temperature Meter	-
Oven Box	-	Testo 350 XL	-	Stopwatch	CAT 14.17
Probe	-	Servomex 5200MP	-	Barometer	CAT 13.6
S-Pitot (1)	-	JCT JCC P1 Cooler	-	Stack Thermocouple (1)	-
S-Pitot (2)	-	FT-IR	-	Stack Thermocouple (2)	-
L-Pitot	-	FT-IR Sampling System	-	1m Heated Line (1)	-
500g Check Weight	-	Bernath 3006 FID	-	1m Heated Line (2)	-
1Kg Check Weight	-	Heated Head Filter	-	1m Heated Line (3)	-
Last Impinger Arm	-	Mass Flow Controller (1)	-	5m Heated Line (1)	-
Callipers	-	Mass Flow Controller (2)	-	15m Heated Line (1)	-
Tubes Kit Thermocouple	CAT 4.51	Mass View (1)	CAT 25.16	15m Heated Line (2)	-
Laboratory Balance	CAT 1.18 / 1.18a	Mass View (2)	-	20m Heated Line (1)	-
Tape Measure	CAT 16.91	Easylogger EN-EL-12 Bit	-	Dual Channel Heater Controller	-

METHODS & TECHNICAL PROCEDURES USED

Parameter	Standard	Technical Procedure
All Tube Samples	BS EN 13649	CAT-TP-16
Oxygen	In House	CAT-TP-27
Nitrogen	In House	CAT-TP-27
Carbon Dioxide	In House	CAT-TP-27
Methane	In House	CAT-TP-27
Hydrogen Sulphide	In House	CAT-TP-27

METHANAL / ETHANAL : RESULTS SUMMARY

Gwynedd Council, Ffidd Rasmus Landfill Site
Raw Landfill Gas Supply

Sample Runs

Parameter	Units	Run 1	Mean
Methanal	mg/m ³	0.12	0.12
Ethanal	mg/m ³	0.10	0.10

General Sampling Information

Parameter	Value	
Standard	BS EN 13649	
Technical Procedure	CAT-TP-16	
Name of Analytical Laboratory	LCN	
Analytical Laboratory's Procedure	C51	
UKAS Accredited Analysis?	See Executive Summary	
Date of Sample Analysis	07/05/2014	
Probe Material	Stainless Steel	
Sample Tube Type	DNPH Coated Silica Gel	
Dynamic Dilution Employed	No	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

METHANAL / ETHANAL : SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	10:14 - 10:24
Sampling Dates	-	16/04/2014
Sampling Device	-	MV
Duration	mins	10
N ₂ to Stack Gas Dilution Ratio	: 1	0
Volume Sampled (REF)	m ³	0.0013

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	LOD (Front) µg	LOD (Back) µg	LOD (Total) µg	Concentration mg/m ³	Reported Concentration (Blank Reviewed) mg/m ³	Reported LOD mg/m ³	Adsorption Efficiency %
Methanal	0.11	0.05	0.15	0.04	0.04	0.08	0.12	0.12	0.063	70.4
Ethanal	0.09	< 0.04	0.13	0.04	0.04	0.08	0.10	0.10	0.063	100.0

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

METHANAL / ETHANAL : SAMPLING DETAILS

BLANK 1

Parameter	Units	Value
Sampling Dates	-	Annual Blank - 12/02/2014
Sampling Device	-	MV
Average Volume Sampled (REF)	m ³	0.0013

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	Concentration mg/m ³
Methanal	< 0.03	< 0.03	0.06	< 0.047
Ethanal	< 0.03	< 0.03	0.06	< 0.047

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

METHANAL / ETHANAL : QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	0.100	
Pre-Sampling Leak Rate	l/min	0.000	
Post-Sampling Leak Rate	l/min	0.000	
Allowable Leak Rate	l/min	0.002	
Leak Test Acceptable	-	Yes	

Adsorption Efficiency	Units	Run 1	
Methanal	%	70.4	
Ethanal	%	100.0	
Allowable Adsorption Efficiency	%	95	
Adsorption Efficiency Acceptable	-	No	

Temperature at Sample Tubes	Units	Run 1	
Temperature	°C	11	
Allowable Temperature	°C	40	
Temperature Acceptable	-	Yes	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

METHANAL / ETHANAL : QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	0.100	
Sampling Leak Rate	l/min	0.000	
Allowable Leak Rate	l/min	0.002	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	Allowed	
Allowable for Methanal	mg/m ³	0.05	N/A	
Allowable for Ethanal	mg/m ³	0.05	N/A	

Method Deviations

Nature of Deviation	Run Number
(x = deviation applies to the associated run)	1
The absorption efficiency was less than the required 95%. [70 - 90%]	x

METHANAL / ETHANAL : MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (STP)	V _m	0.0013		uV _m	m ³	0.0	
Leak	L	0.000		uL	%	-	
Laboratory Result	L _r	10.00		uL _r	%	-	
Oxygen Content	O _{2,m}	N/A		uO _{2,m}	% v/v	N/A	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (STP)	%	2.00		≤2%
Leak	%	0.00		≤2%
Laboratory Result	%	10.00		No Requirement
Oxygen Content	%	N/A		≤5%

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V _m	m ³	0.0013		173.61	
Leak	L	mg/m ³	0.000		1.00	
Laboratory Result	L _r	mg/m ³	0.022		1.00	
Factor for O ₂ Correction	O _{2,m}	% v/v	N/A		N/A	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m ³	0.0044	
Leak	mg/m ³	0.0000	
Laboratory Result	mg/m ³	0.0219	
Factor for O ₂ Correction	mg/m ³	N/A	

Parameter	Units	Run 1	
Combined uncertainty	mg/m ³	0.022	
Expanded uncertainty (95% confidence)	mg/m ³	0.044	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	0.052	
Reported Uncertainty	mg/m ³	0.052	
Expanded uncertainty (95% confidence)	%	20.0	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	24.0	
Reported Uncertainty	%	24.0	

NOTE: Uncertainties reported in mg/m³ are based upon the summation of all Speciated VOCs Measured.

ARSENIC : RESULTS SUMMARY

Gwynedd Council, Ffidd Rasmus Landfill Site
Raw Landfill Gas Supply

Sample Runs

Parameter	Units	Run 1	Mean
Arsenic	mg/m ³	0.002	0.002

General Sampling Information

Parameter	Value	
Standard	BS EN 13649	
Technical Procedure	CAT-TP-16	
Name of Analytical Laboratory	LCN	
Analytical Laboratory's Procedure	C51	
UKAS Accredited Analysis?	See Executive Summary	
Date of Sample Analysis	07/05/2014	
Probe Material	Stainless Steel	
Sample Tube Type	Coconut Shell Charcoal	
Dynamic Dilution Employed	No	
Number of Sampling Lines Used	1 / 1	FORMAT: Number Used / Number Required
Number of Sampling Points Used	1 / 1	FORMAT: Number Used / Number Required
Sample Point I.D.'s	A1	

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

ARSENIC : SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	10:36 - 11:01
Sampling Dates	-	16/04/2014
Sampling Device	-	MV
Duration	mins	25
N ₂ to Stack Gas Dilution Ratio	: 1	0
Volume Sampled (REF)	m ³	0.0068

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	LOD (Front) µg	LOD (Back) µg	LOD (Total) µg	Concentration mg/m ³	Reported Concentration (Blank Reviewed) mg/m ³	Reported LOD mg/m ³	Adsorption Efficiency %
Arsenic	0.010	< 0.004	0.014	0.004	0.004	0.008	0.002	0.002	0.001	100.0

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

ARSENIC : SAMPLING DETAILS

BLANK 1

Parameter	Units	Value
Sampling Dates	-	Annual Blank - 12/02/2014
Sampling Device	-	MV
Average Volume Sampled (REF)	m ³	0.0068

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	Concentration mg/m ³
Arsenic	< 0.01	< 0.01	0.01	< 0.001

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

ARSENIC : QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	0.200	
Pre-Sampling Leak Rate	l/min	0.000	
Post-Sampling Leak Rate	l/min	0.000	
Allowable Leak Rate	l/min	0.004	
Leak Test Acceptable	-	Yes	

Adsorption Efficiency	Units	Run 1	
Arsenic	%	100.0	
Allowable Adsorption Efficiency	%	95	
Adsorption Efficiency Acceptable	-	Yes	

Temperature at Sample Tubes	Units	Run 1	
Temperature	°C	21	
Allowable Temperature	°C	40	
Temperature Acceptable	-	Yes	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

ARSENIC : QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	0.200	
Sampling Leak Rate	l/min	0.000	
Allowable Leak Rate	l/min	0.004	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	Allowed	
Allowable for Arsenic	mg/m ³	0.001	N/A	

Method Deviations

Nature of Deviation	Run Number
(x = deviation applies to the associated run)	1
There are no deviations associated with the sampling employed.	x

ARSENIC : MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (STP)	V _m	0.0067		uV _m	m ³	0.0	
Leak	L	0.000		uL	%	-	
Laboratory Result	L _r	10.00		uL _r	%	-	
Oxygen Content	O _{2,m}	N/A		uO _{2,m}	% v/v	N/A	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (STP)	%	2.00		≤2%
Leak	%	0.00		≤2%
Laboratory Result	%	10.00		No Requirement
Oxygen Content	%	N/A		≤5%

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V _m	m ³	0.0067		0.31	
Leak	L	mg/m ³	0.0000		1.00	
Laboratory Result	L _r	mg/m ³	0.0002		1.00	
Factor for O ₂ Correction	O _{2,m}	% v/v	N/A		N/A	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m ³	0.00004	
Leak	mg/m ³	0.0000	
Laboratory Result	mg/m ³	0.0002	
Factor for O ₂ Correction	mg/m ³	N/A	

Parameter	Units	Run 1	
Combined uncertainty	mg/m ³	0.0002	
Expanded uncertainty (95% confidence)	mg/m ³	0.0004	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	0.0004	
Reported Uncertainty	mg/m ³	0.0004	
Expanded uncertainty (95% confidence)	%	20.0	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	20.0	
Reported Uncertainty	%	20.0	

NOTE: Uncertainties reported in mg/m³ are based upon the summation of all Speciated VOCs Measured.

TRACE COMPOUNDS : RESULTS SUMMARY

Gwynedd Council, Ffidd Rasmus Landfill Site
Raw Landfill Gas Supply

Sample Runs

Parameter	Units	Run 1	Mean
1,1-Dichloroethane	mg/m ³	0.13	0.13
1,2-Dichloroethane	mg/m ³	0.16	0.16
1,1-Dichloroethene	mg/m ³	< 0.12	< 0.12
1,2-Dichloroethene	mg/m ³	0.35	0.35
1,3-Butadiene	mg/m ³	< 1.30	< 1.30
1-butanethiol	mg/m ³	< 0.09	< 0.09
1-pentene	mg/m ³	0.47	0.47
1-propanethiol	mg/m ³	< 0.17	< 0.17
2-butoxyethanol	mg/m ³	0.14	0.14
Benzene	mg/m ³	1.39	1.39
Butyric Acid	mg/m ³	0.69	0.69
Carbon Disulphide	mg/m ³	3.48	3.48
Chloroethane	mg/m ³	0.26	0.26
Vinyl Chloride	mg/m ³	< 0.20	< 0.20
Dimethyl Disulphide	mg/m ³	< 0.02	< 0.02
Dimethyl Sulphide	mg/m ³	0.17	0.17
Ethanethiol	mg/m ³	< 0.52	< 0.52
Ethyl Butyrate	mg/m ³	1.13	1.13
Furan (1,4-epoxy-1,3-butadiene)	mg/m ³	0.14	0.14
Methanethiol	mg/m ³	< 1.73	< 1.73
Styrene	mg/m ³	0.64	0.64
Tetrachloromethane	mg/m ³	< 0.14	< 0.14
Toluene	mg/m ³	10.4	10.4
Trichloroethene	mg/m ³	0.17	0.17
Dichloromethane	mg/m ³	0.31	0.31

General Sampling Information

Parameter	Value
Standard	BS EN 13649
Technical Procedure	CAT-TP-16
Name of Analytical Laboratory	LCN
Analytical Laboratory's Procedure	In House
UKAS Accredited Analysis?	See Executive Summary
Date of Sample Analysis	08/05/2014
Probe Material	Stainless Steel
Sample Tube Type	ATD Tube
Dynamic Dilution Employed	No
Number of Sampling Lines Used	1 / 1
Number of Sampling Points Used	1 / 1
Sample Point I.D.'s	A1

FORMAT: Number Used / Number Required

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TRACE COMPOUNDS : SAMPLING DETAILS

RUN 1

Parameter	Units	Value
Sampling Times	-	11:32 - 11:36
Sampling Dates	-	16/04/2014
Sampling Device	-	MV
Duration	mins	4
N ₂ to Stack Gas Dilution Ratio	: 1	0
Volume Sampled (REF)	m ³	0.0005

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	LOD (Front) µg	LOD (Back) µg	LOD (Total) µg	Concentration mg/m ³	Reported Concentration (Blank Reviewed) mg/m ³	Reported LOD mg/m ³	Adsorption Efficiency %
1,1-Dichloroethane	0.03	< 0.03	0.06	0.03	0.03	0.05	0.128	0.128	0.117	100.0
1,2-Dichloroethane	0.06	< 0.02	0.07	0.02	0.02	0.04	0.160	0.160	0.082	100.0
1,1-Dichloroethene	< 0.03	< 0.03	0.06	0.03	0.03	0.06	< 0.121	< 0.121	0.121	100.0
1,2-Dichloroethene	0.16	< 0.01	0.16	0.01	0.01	0.01	0.348	0.348	0.026	100.0
1,3-Butadiene	< 0.30	< 0.30	0.60	0.30	0.30	0.60	< 1.297	< 1.297	1.297	100.0
1-butanethiol	< 0.02	< 0.02	0.04	0.02	0.02	0.04	< 0.086	< 0.086	0.086	100.0
1-pentene	0.17	< 0.05	0.22	0.05	0.05	0.10	0.474	0.474	0.216	100.0
1-propanethiol	< 0.04	< 0.04	0.08	0.04	0.04	0.08	< 0.173	< 0.173	0.173	100.0
2-butoxyethanol	0.04	< 0.03	0.07	0.03	0.03	0.06	0.145	0.145	0.130	100.0
Benzene	0.63	< 0.01	0.64	0.01	0.01	0.02	1.388	1.388	0.043	100.0
Butyric Acid	< 0.16	< 0.16	0.32	0.16	0.16	0.32	< 0.692	0.692	0.692	100.0
Carbon Disulphide	1.40	0.21	1.61	0.07	0.07	0.14	3.483	3.483	0.303	86.8
Chloroethane	0.10	< 0.02	0.12	0.02	0.02	0.04	0.259	0.259	0.091	100.0
Vinyl Chloride	< 0.05	< 0.05	0.09	0.05	0.05	0.09	< 0.199	< 0.199	0.199	100.0
Dimethyl Disulphide	< 0.01	< 0.01	0.01	0.01	0.01	0.01	< 0.022	< 0.022	0.022	100.0
Dimethyl Sulphide	0.05	< 0.03	0.08	0.03	0.03	0.06	0.166	0.166	0.134	100.0
Ethanethiol	< 0.12	< 0.12	0.24	0.12	0.12	0.24	< 0.519	< 0.519	0.519	100.0
Ethyl Butyrate	0.50	< 0.02	0.52	0.02	0.02	0.04	1.129	1.129	0.086	100.0
Furan (1,4-epoxy-1,3-butadiene)	0.06	< 0.01	0.06	0.05	0.05	0.10	0.136	0.136	0.216	100.0
Methanethiol	< 0.40	< 0.40	0.80	0.40	0.40	0.80	< 1.730	< 1.730	1.730	100.0
Styrene	0.28	< 0.02	0.30	0.02	0.02	0.04	0.644	0.644	0.086	100.0
Tetrachloromethane	< 0.03	< 0.03	0.07	0.03	0.03	0.07	< 0.143	< 0.143	0.143	100.0
Toluene	4.73	< 0.06	4.79	0.02	0.02	0.04	10.366	10.366	0.086	100.0
Trichloroethene	0.06	< 0.02	0.08	0.02	0.02	0.05	0.173	0.173	0.104	100.0
Dichloromethane	0.10	< 0.05	0.15	0.05	0.05	0.09	0.314	0.314	0.195	100.0

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TRACE COMPOUNDS : SAMPLING DETAILS

BLANK 1

Parameter	Units	Value
Sampling Dates	-	Annual Blank - 12/02/2014
Sampling Device	-	MV
Average Volume Sampled (REF)	m ³	0.0005

Where: MV stands for Mass View (Mass Flow Controller Technology)

Parameter	Lab Result (Front) µg	Lab Result (Back) µg	Lab Result (Total) µg	Concentration mg/m ³
1,1-Dichloroethane	< 0.027		< 0.027	< 0.058
1,2-Dichloroethane	< 0.019		< 0.019	< 0.041
1,1-Dichloroethene	< 0.028		< 0.028	< 0.061
1,2-Dichloroethene	< 0.006		< 0.006	< 0.013
1,3-Butadiene	< 0.300		< 0.300	< 0.649
1-butanethiol	< 0.020		< 0.020	< 0.043
1-pentene	< 0.050		< 0.050	< 0.108
1-propanethiol	< 0.040		< 0.040	< 0.086
2-butoxyethanol	< 0.030		< 0.030	< 0.065
Benzene	< 0.010		< 0.010	< 0.022
Butyric Acid	< 0.160		< 0.160	0.346
Carbon Disulphide	< 0.070		< 0.070	< 0.151
Chloroethane	< 0.021		< 0.021	< 0.045
Vinyl Chloride	< 0.046		< 0.046	< 0.099
Dimethyl Disulphide	< 0.005		< 0.005	< 0.011
Dimethyl Sulphide	< 0.031		< 0.031	< 0.067
Ethanethiol	< 0.120		< 0.120	< 0.259
Ethyl Butyrate	< 0.020		< 0.020	< 0.043
Furan (1,4-epoxy-1,3-butadiene)	< 0.050		< 0.050	< 0.108
Methanethiol	< 0.400		< 0.400	< 0.865
Styrene	< 0.020		< 0.020	< 0.043
Tetrachloromethane	< 0.030		< 0.030	< 0.065
Toluene	< 0.020		< 0.020	< 0.043
Trichloroethene	< 0.024		< 0.024	< 0.052
Dichloromethane	< 0.045		< 0.045	< 0.097

Reference Conditions

Reference Conditions are: 273K, 101.3kPa, without correction for water vapour content.

TRACE COMPOUNDS : QUALITY ASSURANCE

(PAGE 1 OF 2)

Sample Runs

Leak Test Results	Units	Run 1	
Mean Sampling Rate	l/min	0.100	
Pre-Sampling Leak Rate	l/min	0.000	
Post-Sampling Leak Rate	l/min	0.000	
Allowable Leak Rate	l/min	0.002	
Leak Test Acceptable	-	Yes	

Adsorption Efficiency	Units	Run 1	
1,1-Dichloroethane	%	100.0	
1,2-Dichloroethane	%	100.0	
1,1-Dichloroethene	%	100.0	
1,2-Dichloroethene	%	100.0	
1,3-Butadiene	%	100.0	
1-butanethiol	%	100.0	
1-pentene	%	100.0	
1-propanethiol	%	100.0	
2-butoxyethanol	%	100.0	
Benzene	%	100.0	
Butyric Acid	%	100.0	
Carbon Disulphide	%	86.8	
Chloroethane	%	100.0	
Vinyl Chloride	%	100.0	
Dimethyl Disulphide	%	100.0	
Dimethyl Sulphide	%	100.0	
Ethanethiol	%	100.0	
Ethyl Butyrate	%	100.0	
Furan (1,4-epoxy-1,3-butadiene)	%	100.0	
Methanethiol	%	100.0	
Styrene	%	100.0	
Tetrachloromethane	%	100.0	
Toluene	%	100.0	
Trichloroethene	%	100.0	
Dichloromethane	%	100.0	
Allowable Adsorption Efficiency	%	95	
Adsorption Efficiency Acceptable	-	No	

Temperature at Sample Tubes	Units	Run 1	
Temperature	°C	21	
Allowable Temperature	°C	40	
Temperature Acceptable	-	Yes	

Test Conditions	Units	Run 1	
Ambient Temperature Recorded?	-	Yes	

TRACE COMPOUNDS : QUALITY ASSURANCE

(PAGE 2 OF 2)

Blank Runs

Leak Test Results	Units	Blank 1	
Expected Sampling Rate	l/min	0.100	
Sampling Leak Rate	l/min	0.000	
Allowable Leak Rate	l/min	0.002	
Leak Test Acceptable	-	Yes	

Validity of Blank vs ELV	Units	Blank 1	Allowed	
Allowable for 1,1-Dichloroethane	mg/m ³	0.06	N/A	
Allowable for 1,2-Dichloroethane	mg/m ³	0.04	N/A	
Allowable for 1,1-Dichloroethene	mg/m ³	0.06	N/A	
Allowable for 1,2-Dichloroethene	mg/m ³	0.01	N/A	
Allowable for 1,3-Butadiene	mg/m ³	0.65	N/A	
Allowable for 1-butanethiol	mg/m ³	0.04	N/A	
Allowable for 1-pentene	mg/m ³	0.11	N/A	
Allowable for 1-propanethiol	mg/m ³	0.09	N/A	
Allowable for 2-butoxyethanol	mg/m ³	0.06	N/A	
Allowable for Benzene	mg/m ³	0.02	N/A	
Allowable for Butyric Acid	mg/m ³	0.35	N/A	
Allowable for Carbon Disulphide	mg/m ³	0.15	N/A	
Allowable for Chloroethane	mg/m ³	0.05	N/A	
Allowable for Vinyl Chloride	mg/m ³	0.10	N/A	
Allowable for Dimethyl Disulphide	mg/m ³	0.01	N/A	
Allowable for Dimethyl Sulphide	mg/m ³	0.07	N/A	
Allowable for Ethanethiol	mg/m ³	0.26	N/A	
Allowable for Ethyl Butyrate	mg/m ³	0.04	N/A	
Allowable for Furan (1,4-epoxy-1,3-butadiene)	mg/m ³	0.11	N/A	
Allowable for Methanethiol	mg/m ³	0.86	N/A	
Allowable for Styrene	mg/m ³	0.04	N/A	
Allowable for Tetrachloromethane	mg/m ³	0.06	N/A	
Allowable for Toluene	mg/m ³	0.04	N/A	
Allowable for Trichloroethene	mg/m ³	0.05	N/A	
Allowable for Dichloromethane	mg/m ³	0.10	N/A	

Method Deviations

Nature of Deviation	Run Number
(x = deviation applies to the associated run)	1
The absorption efficiency was less than the required 95%. [70 - 90%]	x

TRACE COMPOUNDS : MEASUREMENT UNCERTAINTY CALCULATIONS

Measured Quantities	Value			Standard uncertainty			
	Symbol	Run 1		Symbol	Units	Run 1	
Sampled Volume (STP)	V _m	0.0005		uV _m	m ³	0.0	
Leak	L	0.000		uL	%	-	
Laboratory Result	L _r	10.00		uL _r	%	-	
Oxygen Content	O _{2,m}	N/A		uO _{2,m}	% v/v	N/A	

Measured Quantities	Uncertainty as a Percentage			Requirement of Standard
	Units	Run 1		
Sampled Volume (STP)	%	2.00		≤2%
Leak	%	0.00		≤2%
Laboratory Result	%	10.00		No Requirement
Oxygen Content	%	N/A		≤5%

Measured Quantities	Uncertainty in Measurement Units				Sensitivity Coefficient	
	Symbol	Units	Run 1		Run 1	
Sampled Volume (STP)	V _m	m ³	0.0005		53066	
Leak	L	mg/m ³	0.000		1.00	
Laboratory Result	L _r	mg/m ³	2.430		1.00	
Factor for O ₂ Correction	O _{2,m}	% v/v	N/A		N/A	

Measured Quantities	Uncertainty in Result		
	Units	Run 1	
Sampled Volume (STP)	mg/m ³	0.4859	
Leak	mg/m ³	0.0000	
Laboratory Result	mg/m ³	2.4296	
Factor for O ₂ Correction	mg/m ³	N/A	

Parameter	Units	Run 1	
Combined uncertainty	mg/m ³	2.478	
Expanded uncertainty (95% confidence)	mg/m ³	4.856	
Expanded uncertainty (95% confidence), estimated with Method Deviations	mg/m ³	5.828	
Reported Uncertainty	mg/m ³	5.828	
Expanded uncertainty (95% confidence)	%	20.0	
Expanded uncertainty (95% confidence), estimated with Method Deviations	%	24.0	
Reported Uncertainty	%	24.0	

NOTE: Uncertainties reported in mg/m³ are based upon the summation of all Speciated VOCs Measured.



Appendix F

GasSim Landfill Gas Production Curve

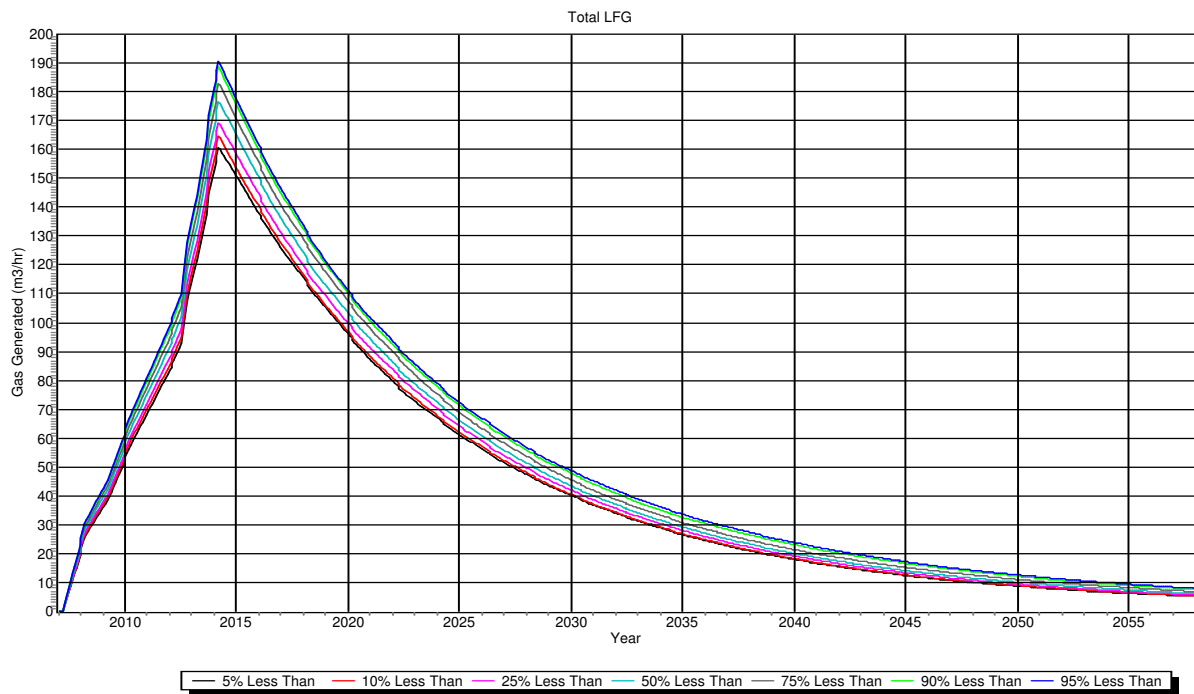


GasSim Version V 2.05

Project Name: Ffridd Rasmus

Project Client: Gwynedd Council

Total: Total Bulk LFG Produced



frridd rasmus 2014 update.gss

13/02/2015 14:54:00

