CEMEX UK Materials Limited
Whitehall Landfill
Permit number: MP3036SS
Variation number: LP3630MR

Annual environmental monitoring report for 2016

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1 Introduction

The PPC permit, issued 17 March 2006, for Whitehall Landfill, Permit Number MP3036SS, specifies under condition 4.1.3 that:

"*The Operator shall submit to the Agency a report on the performance of the Permitted Installation over the previous year, by 31 January each year*"

The Variation notice, issued 22 June 2007, Variation Number LP3630MR amends this under condition 4.2.1 to:

"A report or reports on the performance of the activities over the previous year shall be submitted to the Agency by 31 January (or other date agreed in writing by the Agency) each year. The report(s) shall include as a minimum:

(a) A review of the results of the monitoring and assessment carried out in accordance with this permit against the relevant assumptions, parameters and results in the risk assessments submitted with the Application;

(b) Where the operator's management system encompasses annual improvement targets a summary report of the previous year's progress against such targets.

(c) The annual production/treatment set out in Schedule 5 table S5.2

(d) Details of any contamination or decontamination of the site which has occurred

(e) The topographical surveys required by condition 3.6.3 other than those submitted as part of a CQA validation report

(f) The volumetric difference (reported in cubic metres) between the most recent topographical survey and the previous annual topographical survey i.e. the additional volume of the landfill void that is occupied by waste;

(g) An assessment of the settlement behaviour of the landfill body based on the difference between the most recent topographical survey and previous annual topographical survey for the areas of the landfill which did not receive waste between the surveys;

(h) A calculation of the remaining capacity (reported in cubic metres) derived from the pre-settlement contours and the most recent topographical survey;

(i) The compliance testing undertaken in the period.

This report is presented in compliance with this condition.

In April 2008 the Environmental Permitting Regulations 2008 replaced the PPC Regulations in their entirety, and landfill PPC permits became Environmental Permits; from this point on all references to the site permit in this report are therefore to the Environmental Permit (EP).

2 Site setting and history

The landfill occupies a limestone quarry that was operational from around 1930 until 1976. After cessation of operations the site lay dormant for 20 years. In 1984 a planning application for disposal of inert waste was approved. Following this, in 1996, a Waste Management Licence was granted (by the WRA, the Vale of Glamorgan Borough Council at the time) and landfill operations at the site began.

Waste was first accepted at Whitehall Landfill in November 1998. The site formally operated under Waste Management Licence Number WM130189. Under the WML, the site was licensed to accept solid inert wastes including soils (top soil, sub-soil and overburden), brickwork, stone, concrete, sand (excluding foundry sand), cement, plastics, glass and fired pottery/ceramics. Certain other materials could also be accepted into the landfill provided that together they made up no more than 1% by volume of any one load. These included plaster, wood, wood products and cardboard and paper products.

The principal waste streams arriving at Whitehall Quarry are all of construction and demolition waste, originating from various districts within Wales.

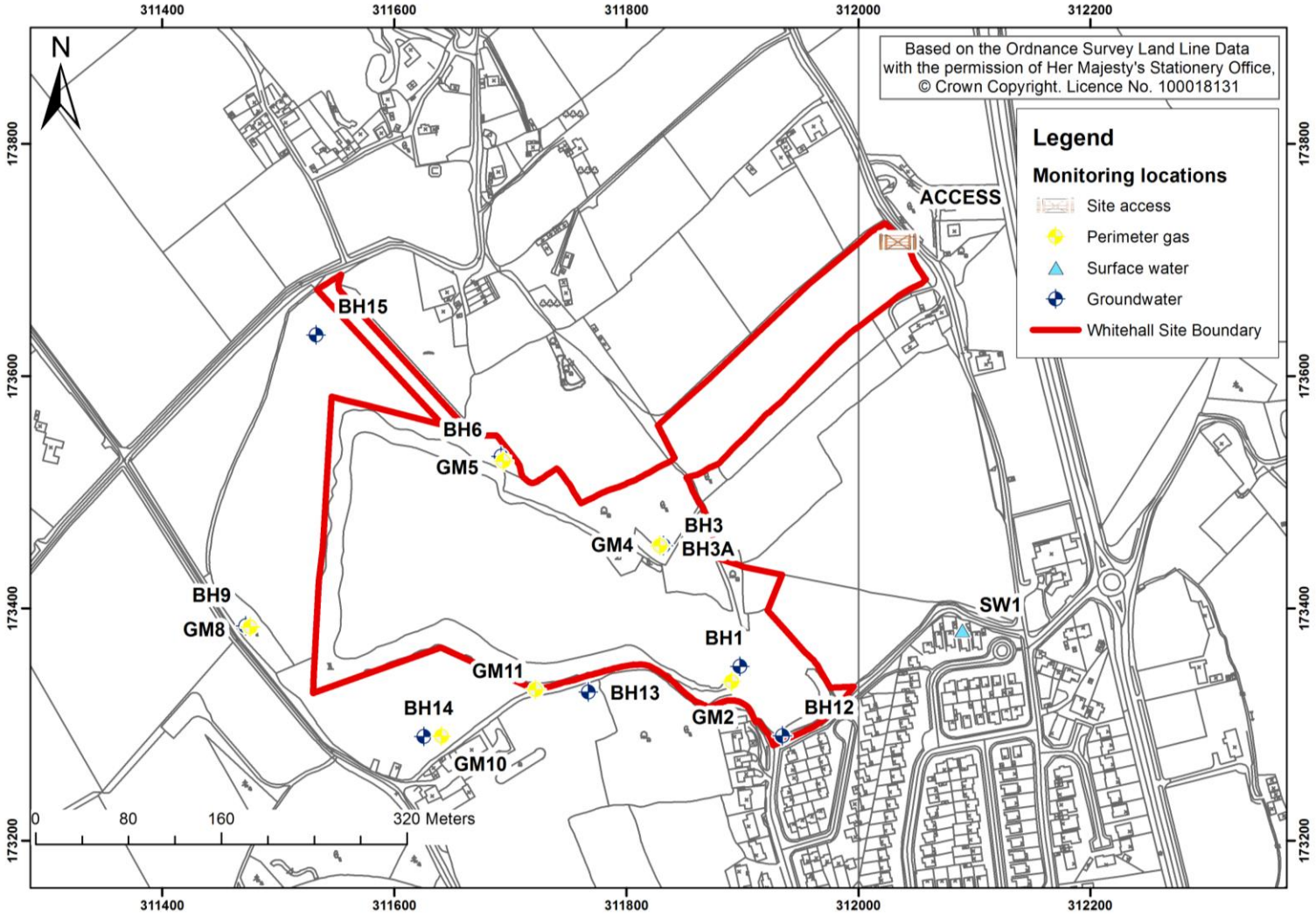
There are three closed landfills situated to the north, up gradient of Whitehall Quarry. The most northerly of these, Greenwood Quarry, located approximately 500 m from Whitehall Quarry (Drawing ESID 2, ESI/Arup (2005)), was licensed to receive inert and semi-inert material (Wildgust, 1998. Lafferty, 1998). Operations ceased in 1988.

Greenwood Old Quarry lies immediately south of this and was licensed to accept solid non-toxic wastes although Wildgust (1998) and Lafferty (1998) suggest that material outside this classification was also accepted.

The most southerly of these sites, Blue Pool, located approximately 130 m from Whitehall Quarry (Drawing ESID 2, ESI (2005)), accepted solid non-toxic wastes and asbestos. Again Wildgust (1998) and Lafferty (1998) suggest other materials were disposed of at this site.

The site covers an area of 5.2 ha and lies in a closed limestone quarry to the northwest of Wenvoe, approximately six miles southwest of Cardiff City Centre, South Glamorgan, at NGR 311700 173450. It is permitted to accept inert waste. The site is surrounded by fields and woodland to the north and woodland to the east (Figure 1). To the west of the site are fields crossed by footpaths and containing a small pond. The southern part of the site is mostly bounded by fields and a track, with woodland towards the eastern part. The south eastern tip of the site is bounded by the houses and gardens along Wallston Road in Wallston which is at the north western edge of Wenvoe.

Figure 1 Site location plan



3 Review of Monitoring Data

Schedule 4 of the site Permit specifies that monitoring of landfill gas and groundwater level and quality is required to assess any potential impact of the landfill on the surrounding environment. The following sections review the data collected from January to the end of the calendar year in December 2016. The locations of the monitoring points are shown on Figure 1.

3.1 Landfill Gas Monitoring

Landfill gas has been monitored for selected parameters in seven perimeter gas monitoring boreholes on an approximate monthly frequency, in accordance with the requirements specified in the variation notice. The location of these boreholes is shown on Figure 1.

Appendix A presents all gas monitoring data collected at these locations during 2016.

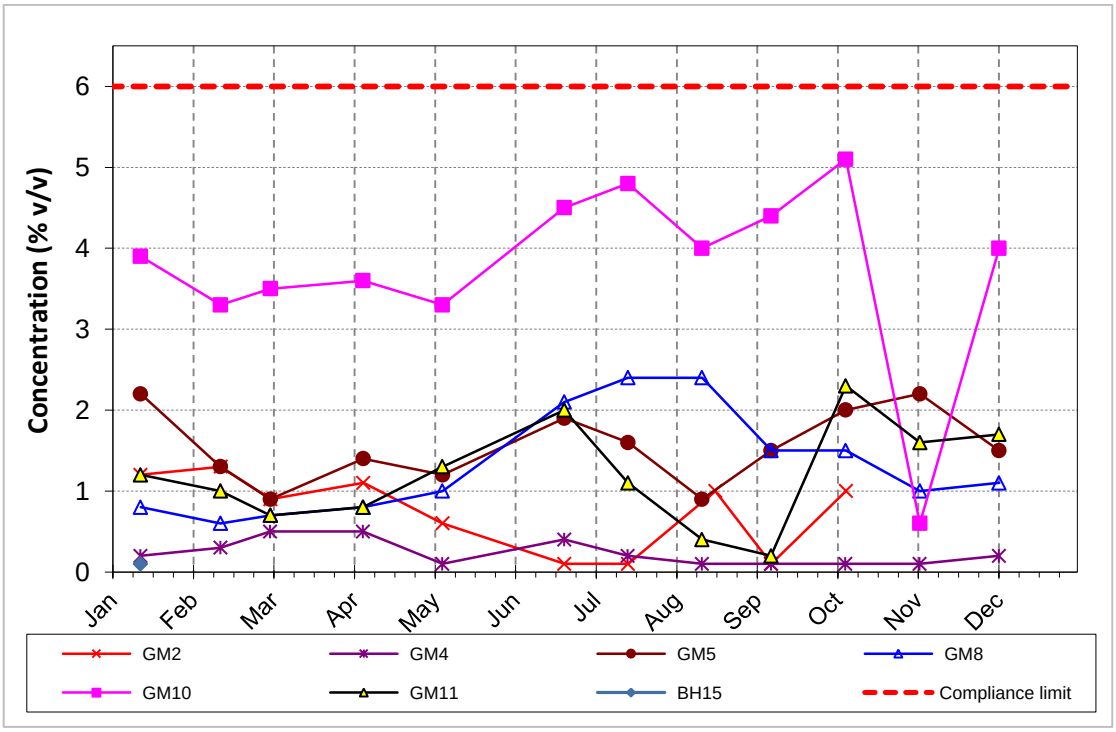
One of the stipulated gas monitoring locations, GM7, was permanently lost in 2007. It has since been replaced by BH15 and gas monitoring has been undertaken at this location (with some interruptions for accessibility issues) since December 2007.

Compliance limits for stable methane and carbon dioxide of 1 % v/v and 6 % v/v respectively have been derived to provide threshold criteria and allow quantitative assessment of any potential harmful emissions from the landfill.

Methane has not been detected at concentrations above the instrumental detection limit (0.1 % v/v) throughout the monitoring period in 2016.

Stable carbon dioxide concentrations between January and December 2016 are compared to the 6% v/v compliance limit at the required gas monitoring locations in Figure 2 below.

Figure 2 Stable carbon dioxide concentrations in 2016



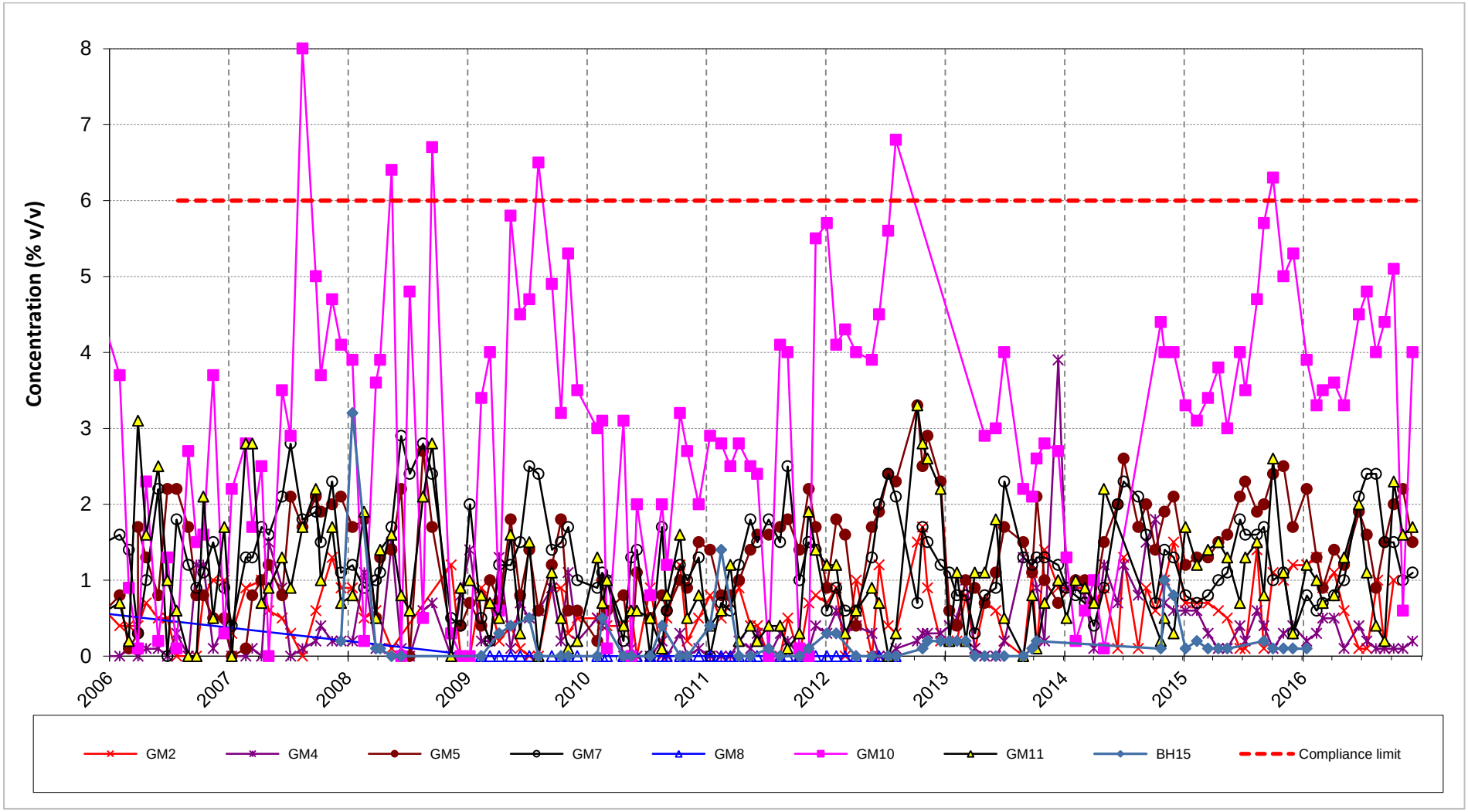
The carbon dioxide compliance limit was not exceeded on any occasion during 2016. The majority of monitoring locations showed concentrations below 3% v/v. Historically carbon dioxide concentrations have always been highest in GM10 and this continued to be the case in 2016, with a maximum reading of 5.1 % v/v.

As with previous years, there are no apparent short term trends in the data and concentrations are variable over the year at all monitoring points. Variations tend to correlate from one borehole to another, and are presumably related to variations in barometric pressure.

BH15 was only monitored for gas in January, when it recorded the lowest gas concentration of any borehole, after which no further readings were taken due to its incorrect removal from the monitoring schedule. This confusion was due to an inconsistency between the monitoring schedule and the permit condition relating to the replacement of GM07. The monitoring schedule has been updated for 2017.

Historical stable carbon dioxide concentrations from early 2006 onwards are presented in Figure 3. The data show that concentrations of carbon dioxide were similar in 2016 to those in 2015 and previous years.

Figure 3 Historical stable carbon dioxide concentrations



3.2 Groundwater Monitoring

Schedule 4 of the Permit requires groundwater quality to be monitored at four down-gradient site perimeter boreholes, BH1, BH12, BH13 and BH14, which have compliance limits set, as well as at five up-gradient boreholes BH3, BH3A, BH6, BH9 and BH15, which do not have any compliance limits, for the parameters listed in Table S4.4 of the permit (and summarised in Table 1). These locations were sampled on a monthly and quarterly frequency for relevant determinands during 2016. The locations of the monitoring boreholes are shown on Figure 1.

Table 1 Groundwater monitoring requirements

Borehole	Parameter	Frequency
BH1, BH3, BH3A, BH6, BH9, BH12, BH13, BH14, BH15	Water level, pH, EC, NH4-N, Cl-, SO4, Alk, TON, TOC, Na, K, Ca, Mg, Fe	Quarterly[1]
	Mn, Cd, Cr, Cu, Ni, Pb, Zn, Naphthalene	Annually

[1] Frequency reduced from monthly to quarterly in mid-2015.

It is noted that Improvement Condition 2 of permit LP3630MR stated that control levels and compliance limits should be derived for certain boreholes. This was completed in 2008 (ESI, 2008). This improvement condition also stated that, once agreed, the groundwater monitoring frequency could be reduced to quarterly. This was implemented at the Site in mid-2015 following discussion and agreement with Natural Resources Wales (NRW). Control levels and compliance limits were also updated for selected locations following the 2016 HRA review (ESI, 2016). These changes were agreed with NRW via letter and email dated 15 July 2016.

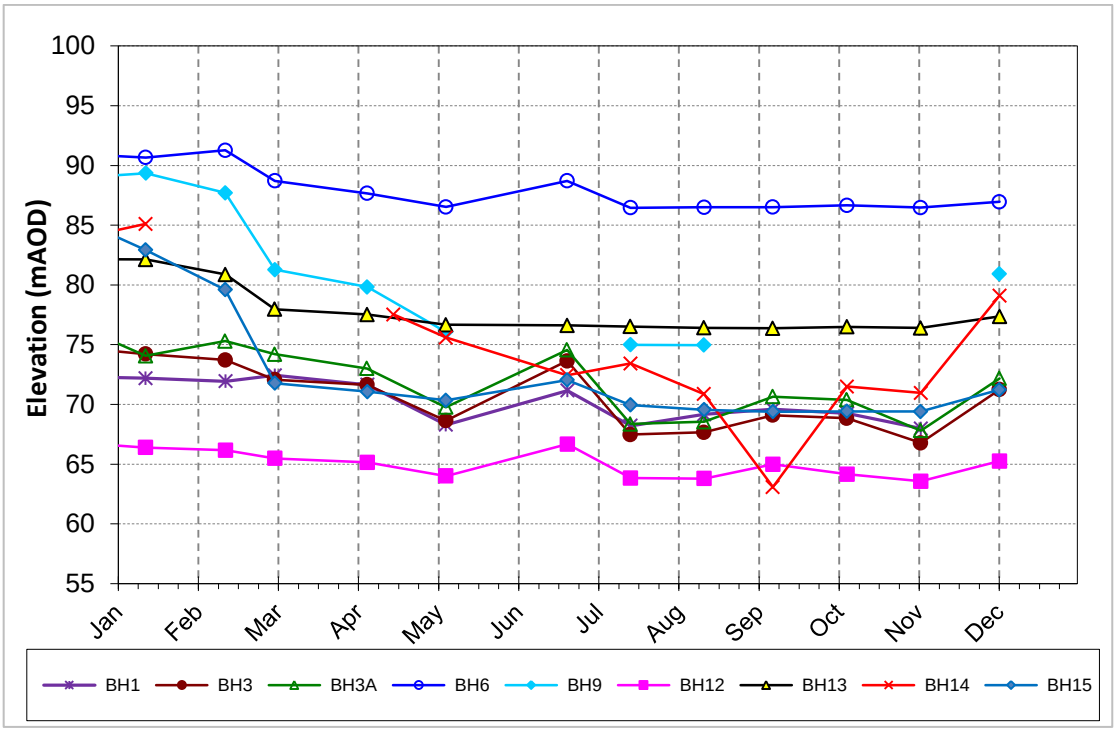
3.2.1 Groundwater Levels

Figure 4 presents the groundwater level data collected during 2016.

There were only four occasions when boreholes could not be dipped during the year (once at BH1 in December and in BH14 between February and April) due to the locations being inaccessible. In addition, BH9 was blocked in June, September, October and November. The borehole is known to be blocked and the dip probe cannot pass to the full depth of the installed well. This was established following a camera survey carried out in May 2015, at which time a second minor blockage was also removed. Therefore it is only possible to monitor this well under high groundwater level conditions.

In general, groundwater elevation during 2016 showed little change from that in the previous year (shown in Figure 5). Water levels were higher during January than previously, with the water levels in BH9 reaching their highest level for that month since 2005. The dip of 85.1 mAOD in BH14 in January was also the highest water level ever recorded in that well, although it was not monitored in either February, March or April afterwards due to a "quagmire in the horses field". It is assumed that the high water levels and muddy field are related to heavy rainfall. By May groundwater levels had largely returned to normal and the remainder of the year was consistent with previous data.

Figure 4 Groundwater elevation during 2016



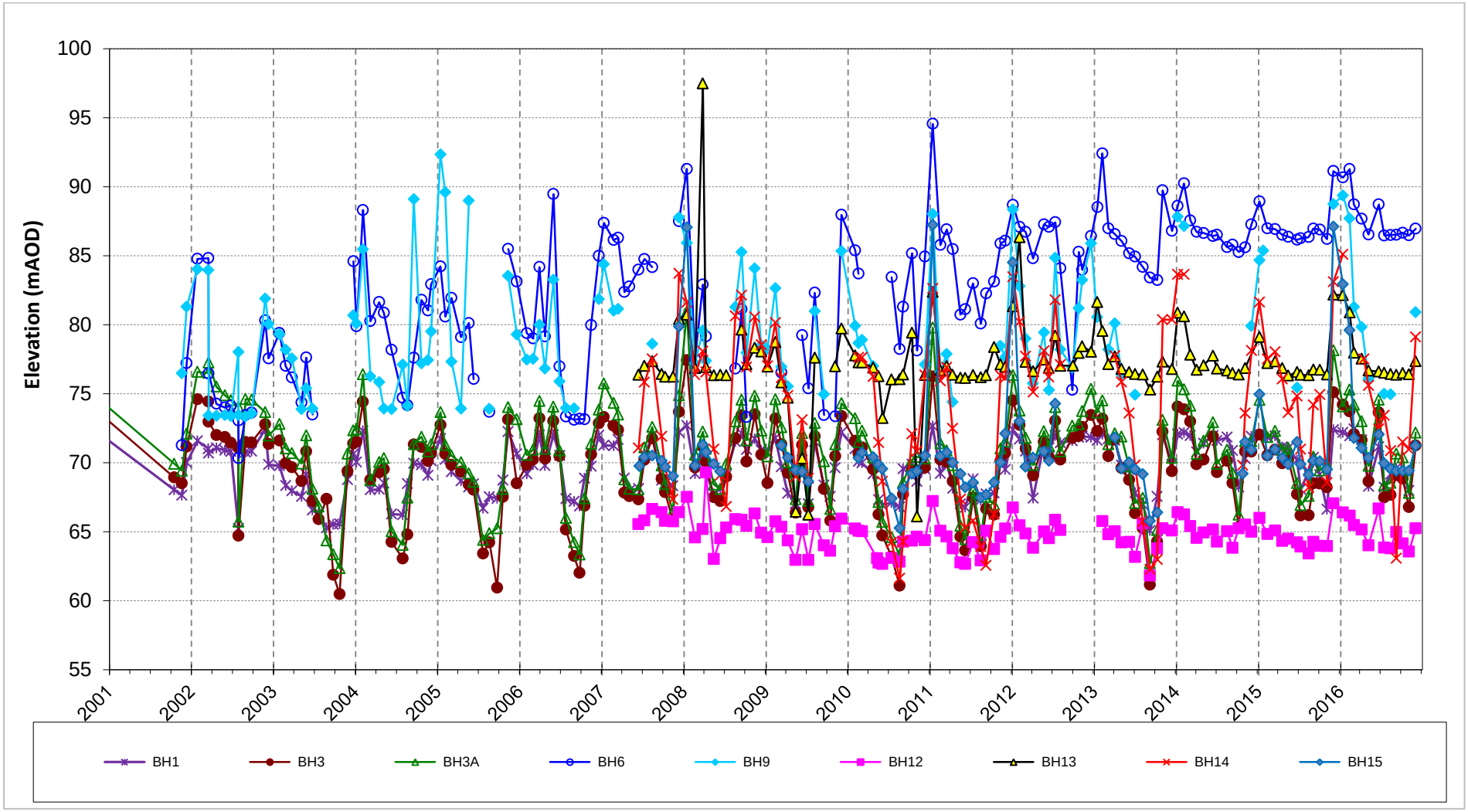
Historical observed water levels for all monitoring locations are shown in Figure 5. The groundwater levels monitored in BH3 and BH3A exhibit a similar trend to BH1, but with greater variation. The remaining monitoring locations all exhibit similar fluctuation timings, with varying degrees of variation, BH12 / BH13 showing the least variation and BH9 / BH14 showing the most.

Groundwater levels are generally more variable to the south-west where, historically, the variation in groundwater level is markedly greater in BH14, which continued to be the case during 2016. BH9 also showed a large variation in groundwater levels, although this borehole once again featured only a partial dataset during 2016.

Groundwater levels for BH12 and BH13 remain consistent throughout the year with the exception of the water level recorded for December. Groundwater levels in BH1, BH3 and BH3A all experienced a slight peak in May, before dropping to a low in July and remaining stable thereafter.

The range of water levels at the monitoring locations is typically around just under 7.0 m. The exceptions to this are BH9, BH14 and BH15, which record a 14.4 m, 22.0 m and 13.52 m variation over the course of 2016 respectively. Such variations are common in limestone aquifers that have limited storage potential.

Figure 5 Historical groundwater elevation



3.2.2 Groundwater Quality

Groundwater quality monitoring has been conducted in accordance with conditions specified in Schedule 4 of the PPC Variation Notice (LP3630MR) for stipulated parameters on an approximate monthly or quarterly frequency, and for additional parameters on an annual basis.

The entire data set for 2016 is presented in Appendix C.

Determinands for which compliance limits have been set

Compliance limits for selected groundwater quality parameters have been derived in order to quantitatively assess landfill performance. A review of defined compliance limits was conducted by CEMEX in 2008 and submitted to the Environment Agency, as the regulating authority at the time, which approved the revised levels. These came into effect in October 2008.

Compliance limits were subsequently revised as part of the 2016 HRA review (ESI, 2016) and these were agreed with NRW in July 2016.

Table 2 below details the compliance limits applied to the appropriate groundwater quality determinands at the required locations. There are no compliance limits specified for up-gradient boreholes BH3, BH3A, BH6, BH9 or BH15.

Table 2 Groundwater quality compliance limits

Monitoring Locations	Ammoniacal Nitrogen (mg/l)	Chloride (mg/l)	Iron as Fe (µg/l)	Potassium (mg/l)	Naphthalene (µg/l)
BH1	0.39	250	200	27 (12)	0.05
BH12				18.6 (14.73)	
BH13				12	
BH14					

Note: Numbers in brackets refer to old compliance limit prior to 2016 HRA review.

A statistical summary of groundwater quality compliance parameters is presented in Table 3. The data for potassium have been split over two rows, as there are separate compliance limits.

During 2016 there were a total of five compliance limit exceedances out of 107 individual analyses carried out. Four exceedances were for iron and there was one ammoniacal nitrogen exceedance (in BH1 in October).

Table 3 Statistical summary of groundwater compliance parameters in 2016

Determinand	No. of Results	Unit	Min	Max	Mean	95th Percentile	# > LOD	% > LOD	Limits No. Exceeding	Limits % Exceeding	Limits Action Level
Compliance parameters											
Ammoniacal Nitrogen as N	21	mg/l	<0.06	0.92	n.d.	0.1	3	14.3	1	4.76	0.39
Chloride	18	mg/l	11	85.7	35.7	83.3	18	100	0	0	250
Iron	21	mg/l	<0.12	2.9	0.294	1.4	5	23.8	4	19	0.2
Napthalene	16	mg/l	<1E-05	<4E-05	n.d.	n.d.	0	0	0	0	0.05
Potassium (BH1, 13, 14)	19	mg/l	0.65	18.1	7.34	17.5	19	100	0	0	12 / 27
Potassium (BH12)	12	mg/l	6.13	18.1	12.8	17.5	12	100	0	0	14.7 /18.6

Whilst there were few detections of ammoniacal nitrogen, the result of 1.19 mg/l in BH3 in January was in exceedance of the compliance limit. This is the highest concentration in this borehole since 2005. The cause of the spike in concentrations is unclear, but the subsequent result in April was back below the limit of detection, where results remained for the rest of the year.

Figure 6 shows groundwater chloride concentrations in 2016 – the maximum concentration was recorded in BH12 and was less than half the action level, reaching 86 mg/l in September. In general concentrations were in line with the data from previous years, with a smaller peak in BH12 actually being recorded in 2016.

Figure 6 Groundwater chloride concentrations in 2016

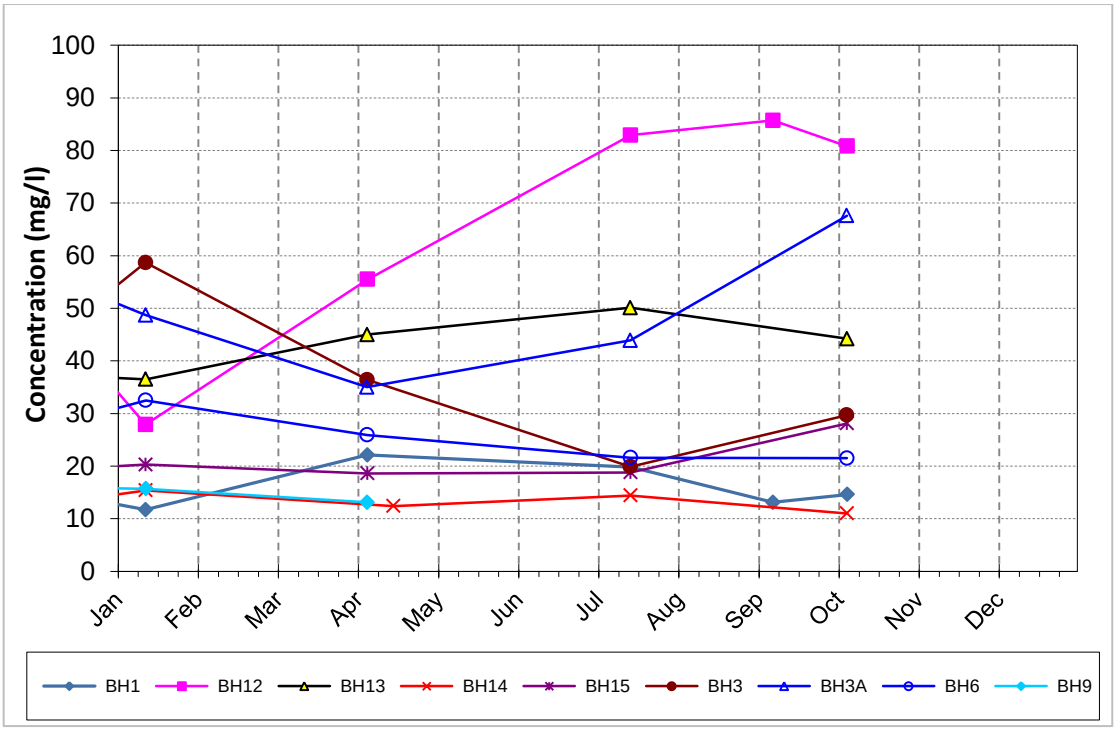
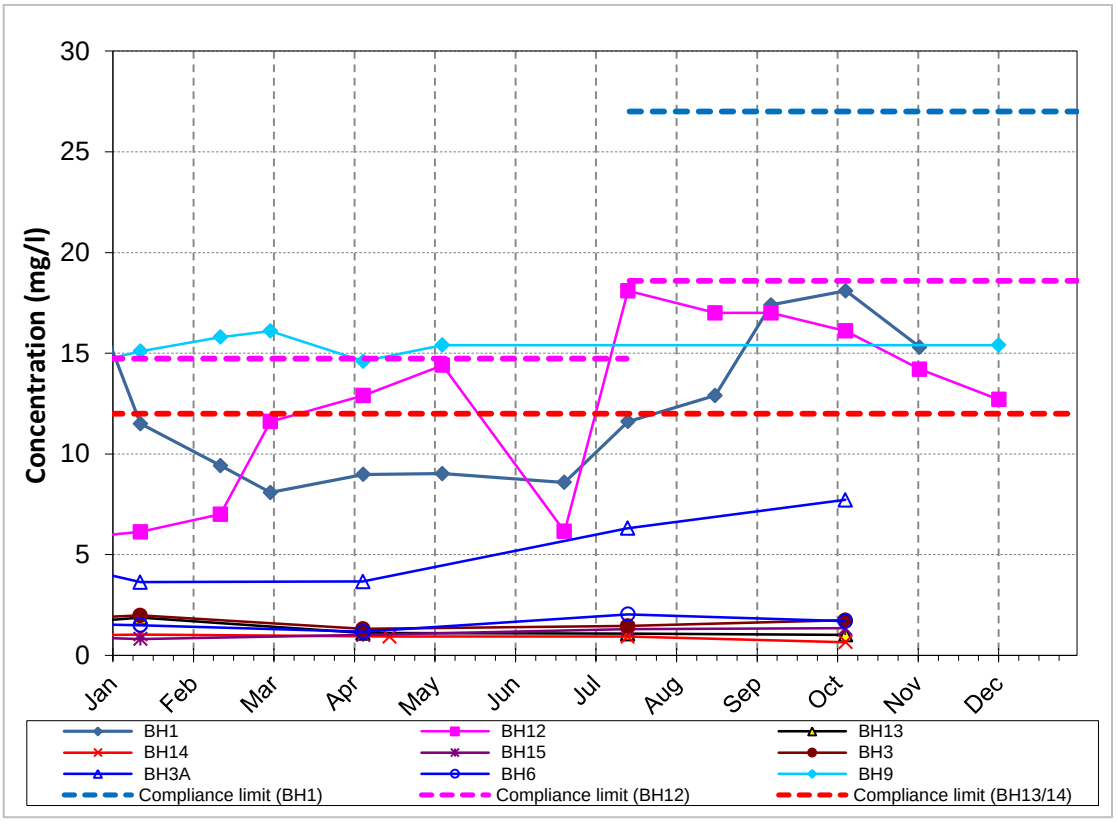


Figure 7 Groundwater potassium concentrations in 2016



Groundwater potassium concentrations during 2016 are presented in Figure 7. As reported in Table 3 there were no exceedances of any of the compliance limits. The highest concentration was recorded in BH12 in July at 18.1 mg/l.

ESI (2016) suggested that a plume containing potassium had originated from up hydraulic gradient of the Site and is currently passing through the Site. Historical potassium concentrations in BH9 (up hydraulic gradient) were higher (Figure 8) but now appear to have stabilised around 15 mg/l. Concentrations at BH1 and BH12 (down hydraulic gradient) have risen. BH12 concentrations appear to have peaked at 18.6 mg/l in July 2016 and are now declining. The highest concentration at BH1 was 18.1 mg/l in October 2016. The concentration was lower in the subsequent month, but no data are available for December as the location was inaccessible. Therefore it is too early to say with confidence that concentrations are declining at this location.

Whilst the concentration at BH12 has now reduced below its historical compliance limit, it is recommended that the compliance limit is not changed yet. The data should continue to be reviewed through 2017 and a decision taken in the 2017 annual report whether to lower the compliance limits at BH12 and / or BH1.

The issue with potassium in BH9 was discussed further in ESI (2016). During a camera survey in May 2015 the borehole was found to have been blocked at two separate depths, preventing routine sampling. The blockage higher up in the borehole was removed, allowing samples to be obtained during winter when the groundwater elevation in the Limestone is higher and above the deeper blockage (which is at 25.4 m bgl). The data continues to show that up-gradient groundwater quality continues to be impacted. It was hypothesised, based upon the site setting and available monitoring data, that the likely cause is a plume of contamination from the

historical up-gradient landfills. This was passing across the up-gradient boundary of Whitehall Landfill from around 2000 and water quality is now gradually improving (the 2016 concentrations in BH9 were amongst the lowest in this location since monitoring began).

Metals were detected at low concentrations during the year; only iron was above its respective DWS limit. The compliance limit for iron is also set at the DWS limit of 200 µg/l. CEMEX recently arranged for the laboratory to analyse samples via a different method in order to be able to determine whether exceedances were occurring. The new limit of detection is set at 120 µg/l. There were just four exceedances of the 0.2 mg/l compliance limit, which occurred in BH1, BH3A and BH12. None of the exceedances were maintained throughout the year, and they represent point-in-time increases for unclear reasons. The maximum result was 2.9 mg/l in BH12. It is also noted that BH3A is up-hydraulic gradient of the landfill, and so it can be assumed that the iron exceedances are not related to the landfill.

There were no naphthalene detections or exceedances during 2016 (see Table 3).

Other requisite determinands

A statistical summary of general groundwater quality at the Site is presented in Table 4. Determinands have been compared to the UK Drinking Water Standards (UK DWS) for reference.

Groundwater quality at the Site is generally good, with exceedances of the UK DWS only recorded during 2016 for sulphate, iron and ammoniacal nitrogen.

Whilst there have been five exceedances of the sulphate DWS, these have all occurred in BH12 (four results) and BH3A (one result). Historically these locations have always recorded the highest concentrations. Data for 2016 is in line with the historical dataset.

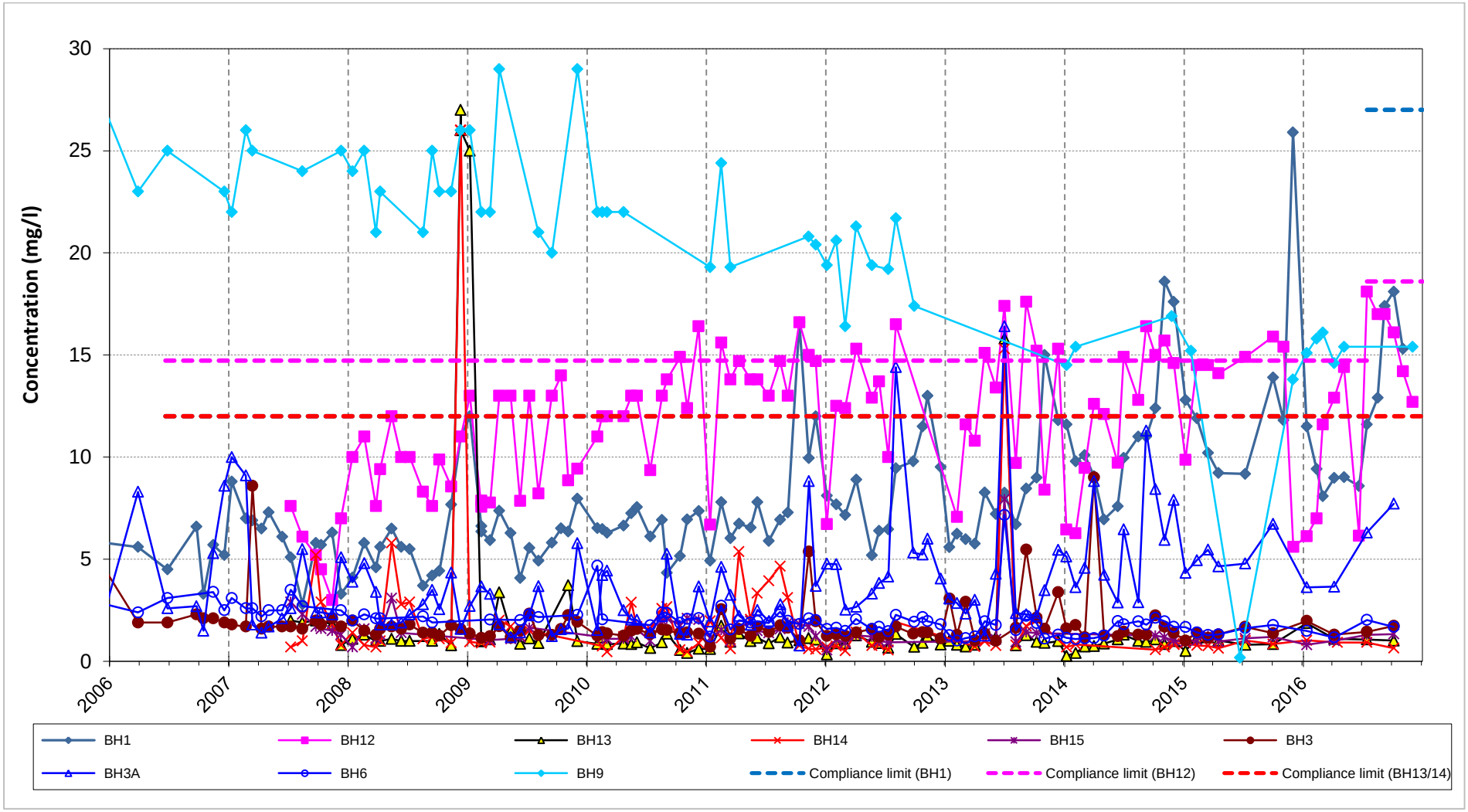
Table 4 Statistical summary of groundwater quality in 2016

	Determinand	No. of Results	Unit	Min	Max	Mean	Standard Deviation	5th Percentile	95th Percentile	# > LOD	% > LOD	UKDWS No. Exceeding	UKDWS % Exceeding	UKDWS Action Level
Field / lab parameters														
Conductivity- Electrical (Field)		52	µS/cm	3.35	1718	755	289	412	1248	52	100	0	0	-
Conductivity- Electrical 20deg		36	µS/cm	346	1260	672	226	405	1173	36	100	0	0	-
pH		36	pH	7.2	8.6	7.78	0.35	7.28	8.25	36	100	0	0	-
pH (Field)		52	pH	6.6	8.48	7.4	0.374	6.81	8.03	52	100	0	0	-
Major ions														
Alkalinity as CaCO3		36	mg/l	158	465	301	77.5	167	425	36	100	0	0	-
Calcium		36	mg/l	53.2	233	111	46.2	58.8	216	36	100	0	0	250
Chloride		36	mg/l	11	85.7	33.3	21.2	12.2	81.3	36	100	0	0	250
Magnesium		36	mg/l	6.8	41.7	25.6	10.1	9.35	39.1	36	100	0	0	50
Potassium		53	mg/l	0.65	18.1	8	6.27	0.93	17.2	53	100	0	0	-
Sodium		36	mg/l	3.91	52	16.1	12.9	5.28	49.4	36	100	0	0	200
Sulphate as SO4		36	mg/l	<4.4	436	75.8	133	n.d.	416	34	94.4	5	13.9	250
Metals														
Cadmium		11	µg/l	<0.6	<0.6	n.d.	n.d.	n.d.	n.d.	0	0	0	0	5
Chromium		11	µg/l	<2	3	n.d.	n.d.	n.d.	2	1	9.09	0	0	50
Copper		11	µg/l	<9	15	6.45	3.36	n.d.	13	2	18.2	0	0	2000
Iron		40	µg/l	<120	2900	242	597	n.d.	1448	6	15	5	12.5	200
Lead		11	µg/l	<6	6	n.d.	n.d.	n.d.	4.5	1	9.09	0	0	25
Manganese		11	µg/l	<7	34	9.55	9.17	n.d.	25.5	5	45.5	0	0	50
Nickel		11	µg/l	<3	4	2.45	0.82	n.d.	4	3	27.3	0	0	20
Zinc		11	µg/l	<18	20	11.9	6.85	n.d.	25	2	18.2	0	0	5000

Determinand	No. of Results	Unit	Min	Max	Mean	Standard Deviation	5th Percentile	95th Percentile	# > LOD	% > LOD	UKDWS No. Exceeding	UKDWS % Exceeding	UKDWS Action Level
Nitrogen species													
Ammoniacal Nitrogen as N	40	mg/l	<0.06	1.19	n.d.	n.d.	n.d.	0.141	5	12.5	2	5	0.39
Nitrate as N	11	mg/l	<0.7	5.7	1.94	1.98	n.d.	5.65	7	63.6	0	0	11
Nitrogen (total oxidised) as N	36	mg/l	<0.7	8.4	1.86	2.12	n.d.	5.88	20	55.6	0	0	-
Other parameters													
BOD + ATU (5 day)	2	mg/l	3	5	4	1.41	3.1	4.9	2	100	0	0	-
Napthalene	34	mg/l	<1E-05	<0.0001	n.d.	n.d.	n.d.	n.d.	0	0	0	0	-
TOC (filtered)	36	mg/l	0.9	13.9	3.84	2.95	1.15	9	36	100	0	0	-

Note: if significant number of results exceed action limit row is coloured as follows: 10 - 25% pale red, 25 - 50% darker red, >50% dark red. n.d. statistic not determinable. Mean statistics for non-detects are calculated at half the limit of detection.

Figure 8 Historical groundwater potassium concentrations



4 Other Reporting Requirements

4.1 Production and Treatment

Schedule 5 Table S5.2 requires the operator to report the annual production and treatment of surface water and or groundwater that has been disposed of off-site and/or disposed to any effluent treatment plant.

No surface water or groundwater has been taken off site or disposed of to any effluent treatment plant, thus no return is reported for 2016.

4.2 Contamination/Decontamination

There has been no contamination or decontamination of the site within the reporting period.

4.3 Topographical Survey

The most recent topographical survey undertaken in November 2015 is included in Appendix D.

4.4 Compliance Testing and Other Details

In 2016 an estimated 145,751 tonnes of was tipped at the Site.

All waste accepted on the site were from CEMEX Approved List (as detailed in the PPC Application document WHL IPPC Volume 2, Site Operation Plan). Therefore no waste characterisation was required or undertaken.

5 Summary

This review covers the period between January and December 2016 and reviews the landfill gas, groundwater level and groundwater quality dataset at the Site.

The review has shown the following:

- Landfill gas has been monitored on an approximately monthly basis in seven perimeter gas boreholes in accordance with the requirements specified in the variation notice.
- Methane was not detected above the instrument limit of detection (0.1 % v/v) during the year.
- Carbon dioxide concentrations did not exceed the 6 % v/v compliance limit during the year. The majority of monitoring locations recorded concentrations below 3 % v/v. Concentrations were highest in GM10, as in previous years, with a maximum concentration of 5.1 % v/v in October.
- There were no significant changes in groundwater elevation during 2016. Water levels in January were higher than those of the previous two years, but still within the typical range of the boreholes. Borehole BH14 displayed a slightly greater range in water levels than in previous years.
- Ammoniacal nitrogen was detected in just three out of 21 samples during 2016. There was one breach of the 0.39 mg/l compliance limit, which occurred in BH3 in January at 1.19 mg/l. It is noted that following this result, which was the highest in this location since 2005, concentrations subsequently returned to below the limit of detection in April.
- Chloride concentrations did not exceed the compliance limit in 2016 for any of the down-gradient boreholes. There were no significant changes in the dataset from that of previous years.
- Iron was detected in five out of 21 samples during 2016. Following discussion with NRW, CEMEX arranged for the laboratory to change their analytical method to accommodate a lower limit of detection. As such, there were just four exceedances of the 0.2 mg/l compliance limit during the year, peaking at 2.9 mg/l in BH12, although exceedances were also recorded in BH1 and BH3A, which is effectively up-hydraulic gradient. None of the exceedances were maintained.
- There were no exceedances of the potassium compliance limit in 2016. It is noted that new compliance limits came into effect in July, raising the BH1 limit from 12 mg/l to 27 mg/l, and the BH12 limit from 14.73 mg/l to 18.6 mg/l. Concentrations in BH9 appear to have stabilised and there is evidence that they are now falling at BH1 and BH12 which are the down hydraulic gradient locations where there were impacts prior to the compliance limit being raised.

6 References

ESI/Arup, 2005. Whitehall Landfill Conceptual Model, ESID Report.

ESI, 2016. Whitehall Landfill: Six-year Hydrogeological Risk Assessment Review. Report reference: 60080ADR1.

Lafferty, F. 1998. Landfill Gas Monitoring and Risk Assessment at Whitehall Quarry. M.Sc. Thesis, Applied Environmental Geology, unpublished.

Natural Resources Wales [NRW], 2016. Letter from Gwyn Jones to Gillian Ratcliffe, Re: Whitehall Quarry Hydrogeological Risk Assessment, dated 10 June 2016.

Wildgust, N.A., 1998. Hydrogeological Risk Assessment, Whitehall Quarry Landfill, Wenvoe, South Wales. M.Sc. Thesis, Applied Environmental Geology, Dept. of Earth Sciences, University of Cardiff. Unpublished.

Appendix A
Landfill Gas Monitoring Data

Appendix A Table 1 Gas monitoring data for 2016

Location	Date	Baro mb	CH4Peak %	CH4Stable %	CO2Peak %	CO2Stable %	DiffPress mb	O2Stable %
BH15	12/01/2016	985	0.1	0.1	0.3	0.1	-1.57	21.7
GM2	12/01/2016	989	0.1	0.1	1.4	1.2	-1.59	21.5
GM2	11/02/2016	992	0	0	1.3	1.3	-1.21	20.8
GM2	01/03/2016	999	0	0	0.9	0.9	-1.47	20.5
GM2	05/04/2016	1000	0	0	1.1	1.1	0.15	20.4
GM2	05/05/2016	1012	0	0	0.6	0.6	2.18	20.2
GM2	20/06/2016	1001	0	0	0.2	0.1	-0.17	21.4
GM2	14/07/2016	1016	0	0	0.1	0.1	0.17	20.9
GM2	16/08/2016	1012	0	0	1	1		20
GM2	06/09/2016	1017	0	0	0.2	0.1	0.4	22.4
GM2	04/10/2016	1019		0	1	1	-0.7	20.5
GM2	01/12/2016							
GM4	12/01/2016	988	0.2	0.1	0.2	0.2	-0.27	21.5
GM4	11/02/2016	991	0	0	0.3	0.3	-0.46	20.4
GM4	01/03/2016	1000	0	0	0.5	0.5	0.46	20.3
GM4	05/04/2016	998	0	0	0.5	0.5	0.63	20.4
GM4	05/05/2016	1010	0	0	0.1	0.1	1.95	20.6
GM4	20/06/2016		0	0	0.4	0.4	0.24	20.8
GM4	14/07/2016	1015	0	0	0.2	0.2	0.22	20.4
GM4	11/08/2016	1015	0	0	0.1	0.1	0.12	20.8
GM4	06/09/2016	1014	0.1	0	0.4	0.1	0.16	22.1
GM4	04/10/2016	1019	0	0	0.1	0.1	-0.64	21.7
GM4	01/11/2016	1014	0.4	0	0.1	0.1	-0.33	20.4
GM4	01/12/2016	1022	0.1	0.1	0.3	0.2	-0.02	21.7
GM5	12/01/2016	984	0.1	0.1	2.2	2.2	-1.77	19.2
GM5	11/02/2016	989	0	0	1.3	1.3	0.39	18.8
GM5	01/03/2016	995	0	0	0.9	0.9	-0.96	19.5
GM5	05/04/2016	996	0	0	1.4	1.4	0.61	18.6
GM5	05/05/2016	1007	0	0	1.2	1.2	2	19.1
GM5	20/06/2016	996	0	0	1.9	1.9	0	19.2
GM5	14/07/2016	1011	0	0	1.6	1.6	0.17	19.6
GM5	11/08/2016	1011	0	0	2.2	0.9	0.19	20.2
GM5	06/09/2016	1012	0	0	1.5	1.5	0.36	20
GM5	04/10/2016	1015	0	0	2	2	-0.64	19.2
GM5	01/11/2016	1011	0	0	2.2	2.2	-0.14	18.9
GM5	01/12/2016	1019	0.1	0.1	1.5	1.5	0.03	19.9
GM8	12/01/2016	984	0.1	0.1	0.8	0.8	-1.86	21
GM8	11/02/2016	989	0	0	0.6	0.6	0.36	20.4
GM8	01/03/2016	996	0	0	0.7	0.7	-0.78	20.6
GM8	05/04/2016	996	0	0	0.8	0.8	0.38	20.3
GM8	05/05/2016	1007	0	0	1	1	2.01	19.5
GM8	20/06/2016	997	0.1	0	2.1	2.1	0.09	19
GM8	14/07/2016	1012	0	0	2.4	2.4	0.32	18.9
GM8	11/08/2016	1012	0	0	3.7	2.4	0.1	19.2
GM8	06/09/2016	1012	0	0	1.5	1.5	0.33	20.9
GM8	04/10/2016	1015	0	0	1.5	1.5	-0.43	19.9
GM8	01/11/2016	1011	0	0	1	1	-0.34	20.6
GM8	01/12/2016	1019	0.1	0.1	1.1	1.1	-0.12	20.3
GM10	12/01/2016	986	0.1	0	3.9	3.9	-1.42	15.4

Location	Date	Baro mb	CH4Peak %	CH4Stable %	CO2Peak %	CO2Stable %	DiffPress mb	O2Stable %
GM10	11/02/2016	988	0	0	3.3	3.3	-0.49	16.7
GM10	01/03/2016	997	0	0	3.5	3.5	-0.27	14.7
GM10	05/04/2016	997	0	0	3.6	3.6	0.78	15.8
GM10	05/05/2016	1007	0	0	3.3	3.3	2.08	17.3
GM10	20/06/2016	998	0.1	0	4.5	4.5	0.39	15.4
GM10	14/07/2016	1011	0	0	4.8	4.8	0.02	16.6
GM10	11/08/2016	1012	0	0	4	4	0.1	16.8
GM10	06/09/2016	1012	0	0	4.4	4.4	0.48	16.1
GM10	04/10/2016	1015	0	0	5.1	5.1	-0.82	12.9
GM10	01/11/2016	1012	0	0	0.6	0.6	0.76	20.6
GM10	01/12/2016	1019	0.1	0.1	4	4	0.16	15.9
GM11	12/01/2016	986	0.1	0	1.2	1.2	-1.09	20
GM11	11/02/2016	988	0	0	1	1	-0.77	20.5
GM11	01/03/2016	997	0	0	0.7	0.7	-0.44	21
GM11	05/04/2016	997	0	0	0.8	0.8	0.7	19.9
GM11	05/05/2016	1007	0	0	1.3	1.3	4.13	19.8
GM11	20/06/2016	998	0.1	0.1	2	2	-0.17	19.8
GM11	14/07/2016	1011	0	0	1.1	1.1	0.1	20.2
GM11	11/08/2016	1012	0	0	0.4	0.4	0.02	21.1
GM11	06/09/2016	1012	0	0	0.2	0.2	0.24	21.8
GM11	04/10/2016	1015		0	2.3	2.3	-0.7	18.9
GM11	01/11/2016	1012		0	1.6	1.6	-0.29	20.2
GM11	01/12/2016	1019	0.1	0.1	1.7	1.7	-0.22	21

Appendix B
Groundwater Level Monitoring Data

Appendix B Table 1 Groundwater level data for 2016

Date	BH1	BH12	BH13	BH14	BH15	BH3	BH3A	BH6	BH9
12/01/2016	72.19	66.39	82.14	85.10	82.92	74.21	74.07	90.66	89.36
11/02/2016	71.94	66.16	80.88	[2]	79.60	73.72	75.30	91.27	87.70
01/03/2016	72.44	65.48	77.97	[2]	71.78	72.07	74.21	88.71	81.27
05/04/2016	71.65	65.15	77.53	[2]	71.07	71.64	73.01	87.67	79.83
15/04/2016				77.52					
05/05/2016	68.29	64.01	76.67	75.59	70.35	68.64	69.77	86.53	76.07
20/06/2016	71.16	66.67	76.61	72.45	72.04	73.64	74.56	88.71	Dry
14/07/2016	68.21	63.84	76.52	73.43	69.96	67.48	68.36	86.46	74.99
11/08/2016	69.17	63.80	76.42	70.87	69.56	67.66	68.55	86.50	74.96
06/09/2016	69.60	64.98	76.37	63.08	69.40	69.10	70.66	86.51	Dry
04/10/2016	69.24	64.15	76.49	71.49	69.42	68.85	70.38	86.66	Dry
01/11/2016	67.98	63.56	76.40	70.96	69.41	66.78	67.81	86.47	Dry
01/12/2016	[1]	65.25	77.36	79.11	71.23	71.24	72.18	86.95	80.91

[1] – *Location inaccessible - cannot get to the monitoring point.*

[2] – *Location could not be found.*

Appendix C
Groundwater Quality Data

Appendix C Table 1 Monthly / quarterly groundwater quality data for 2016

Location	Date	Alkalinity as CaCO3 mg/l	Ammoniacal Nitrogen as N mg/l	Calcium mg/l	Chloride mg/l	Conductivity-Electrical (Field) µS/cm	Conductivity-Electrical 20deg µS/cm	Iron µg/l	Magnesium mg/l	Naphthalene µg/l	Nitrogen (total oxidised) as N mg/l	pH pH	pH (Field) pH	Potassium mg/l	Sodium mg/l	Sulphate as SO4 mg/l	TOC (filtered) mg/l
BH1	12/01/2016	158	0.06	53.2	11.7	482	346	173	6.8	<0.02	<0.7	7.8	7.4	11.5	5.86	17.7	6.1
BH1	11/02/2016					389							7.53	9.42			
BH1	01/03/2016					400							7.72	8.08			
BH1	05/04/2016	224	<0.06	79.7	22.1	551	537	<120	13	<0.01	1	8.1	7.57	8.98	11.5	50.4	5
BH1	05/05/2016					602							7.5	9.02			
BH1	20/06/2016					613							7.48	8.58			
BH1	14/07/2016	259	<0.06	94	19.8	603	556	<120	15.5	<0.02	1.5	8.6	8.05	11.6	10.5	61.3	6.5
BH1	16/08/2016					421							8.48	12.9			
BH1	06/09/2016	163	<0.06	58.8	13.1	431	404	<230	8		1.5	7.4	6.9	17.4	6.54	28.6	13.9
BH1	04/10/2016	174	0.92	68	14.6	642	428	358	9.8	<0.04	1.6	7.2	7.4	18.1	7.44	46.6	11.1
BH1	01/11/2016		<0.06			796		1400					7.2	15.3			
BH1	01/12/2016	Location inaccessible - cannot get to the sample point; tree cutting, no safe access															
BH12	12/01/2016	338	<0.06	121	27.9	803	748	<120	22.5	<0.01	1.4	7.7	7.6	6.13	14.2	55.8	4.4
BH12	11/02/2016					756							7.18	7			
BH12	01/03/2016					1023							7.35	11.6			
BH12	05/04/2016	342	<0.06	174	55.5	1104	1140	<120	33.8	<0.01	1.9	8.1	7.27	12.9	34.6	271	5.1
BH12	05/05/2016					1252							7.26	14.4			
BH12	20/06/2016					651							7.43	6.15			
BH12	14/07/2016	306	<0.06	211	82.9	1245	1180	<120	39.5	<0.01	1.5	8.2	7.61	18.1	52	410	6.6
BH12	16/08/2016					1243							8.02	17			
BH12	06/09/2016	290	<0.06	229	85.7	992	1260	<230	36.7		2.7	7.5	6.7	17	49.1	435	7.6
BH12	04/10/2016	296	<0.06	233	80.8	1577	1170	<120	37	<0.01	1.9	7.4	7.3	16.1	50.4	436	6.3

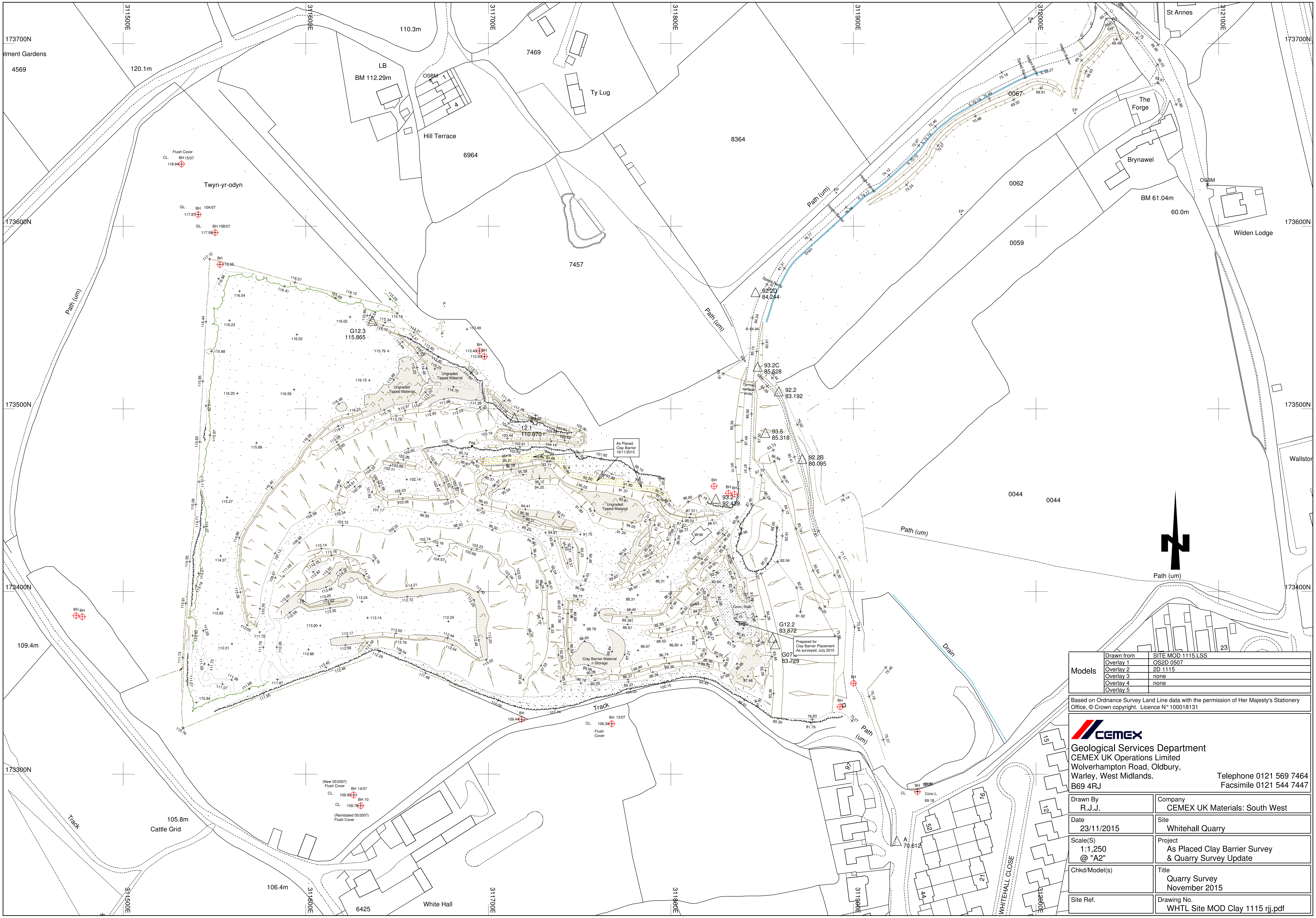
Location	Date	Alkalinity as CaCO3 mg/l	Ammoniacal Nitrogen as N mg/l	Calcium mg/l	Chloride mg/l	Conductivity-Electrical (Field) µS/cm	Conductivity-Electrical 20deg µS/cm	Iron µg/l	Magnesium mg/l	Naphthalene µg/l	Nitrogen (total oxidised) as N mg/l	pH pH	pH (Field) pH	Potassium mg/l	Sodium mg/l	Sulphate as SO4 mg/l	TOC (filtered) mg/l
BH12	01/11/2016		<0.06			1718		2900					7.1	14.2			
BH12	01/12/2016		<0.06			603		<230					7	12.7			
BH13	12/01/2016	349	0.1	90.2	36.5	748	686	208	36.3	<0.01	<0.7	7.6	7.6	1.87	11.3	7.3	3
BH13	05/04/2016	322	<0.06	80.7	45	693	680	<120	34.6	<0.01	<0.7	8.1	7.19	1.1	15	11.4	2.4
BH13	14/07/2016	322	<0.06	79.5	50.1	704	601	<120	37.4	<0.01	<0.7	8	7.64	1.07	19.7	13.5	1.9
BH13	04/10/2016	341	<0.06	86.7	44.2	847	643	<120	38.9	<0.01	<0.7	7.5	7.7	1.02	18.5	13	1.4
BH14	12/01/2016	459	<0.06	145	15.4	866	836	<120	41.7	<0.01	8.4	7.3	7	1.03	5.97	5.8	1.5
BH14	15/04/2016	398	<0.06	138	12.4		649	<120	36.1	<0.01	5.6	7.4		0.93	5.95	<4.4	1.2
BH14	14/07/2016	413	<0.06	122	14.4	771	633	<120	35.5	<0.01	5.6	7.9	7.44	0.93	4.82	4.9	2.1
BH14	04/10/2016	465	<0.06	134	11	951	720	<120	35.7	<0.01	4.4	7.2	7.6	0.65	3.91	<4.4	1.3
BH15	12/01/2016	296	<0.06	96.8	20.3	639	571	<120	16.6	<0.01	1.3	7.8	7	0.81	7.05	6	1.8
BH15	05/04/2016	298	<0.06	92.7	18.6	587	570	<120	17.4	<0.01	1.3	8	7.49	1.01	7.71	11	1.8
BH15	14/07/2016	314	<0.06	100	18.8	612	483	<120	20.5	<0.01	0.9	7.9	7.93	1.3	8.53	14.7	2.3
BH15	04/10/2016	306	0.08	92.4	28.1	727	557	<120	22.1	<0.01	<0.7	7.4	7.3	1.34	12.9	10.3	3.3
BH3	12/01/2016	294	1.19	97.7	58.7	911	752	<120	27.8	<0.01	<0.7	7.7	6.6	1.98	24.3	51.6	3.7
BH3	05/04/2016	234	<0.06	70.9	36.4	526	531	<120	18	<0.01	<0.7	8.1	7.26	1.31	14.8	19.8	1.8
BH3	14/07/2016	228	<0.06	68	19.9	485	405	<120	16	<0.01	<0.7	8.4	8.06	1.45	11.1	18.8	2.9
BH3	04/10/2016	281	<0.06	99.6	29.7	788	598	<120	24.4	<0.01	<0.7	7.4	7	1.74	15.4	60.2	2
BH3A	12/01/2016	223	<0.06	67.6	48.7	794	542	<120	16.8	<0.01	<0.7	8	7.6	3.63	23.1	55.7	4.5
BH3A	05/04/2016	210	<0.06	58.6	35	546	473	<120	14.3	<0.02	<0.7	8.1	6.93	3.66	21.2	8	8.3
BH3A	14/07/2016	270	<0.06	114	43.9	811	669	2350	27.8	<0.01	1.4	8.2	7.96	6.31	22.6	140	3.2
BH3A	04/10/2016	168	<0.06	190	67.6	3.35	1010	<120	32.6	<0.1	4.5	7.5	7.2	7.72	32.5	399	5
BH6	12/01/2016	340	<0.06	118	32.5	736	656	<120	22.3	<0.01	<0.7	7.6	7.5	1.49	11.8	8.8	1.2

Location	Date	Alkalinity as CaCO3 mg/l	Ammoniacal Nitrogen as N mg/l	Calcium mg/l	Chloride mg/l	Conductivity-Electrical (Field) µS/cm	Conductivity-Electrical 20deg µS/cm	Iron µg/l	Magnesium mg/l	Naphthalene µg/l	Nitrogen (total oxidised) as N mg/l	pH pH	pH (Field) pH	Potassium mg/l	Sodium mg/l	Sulphate as SO4 mg/l	TOC (filtered) mg/l
BH6	05/04/2016	313	<0.06	91.4	25.9	632	580	<120	20.6	<0.01	<0.7	8	7.33	1.17	10.4	11.1	1
BH6	14/07/2016	324	<0.06	91	21.6	646	491	<120	28.4	<0.01	<0.7	7.9	7.87	2.03	9.03	14	1.7
BH6	04/10/2016	347	<0.06	91.1	21.5	810	605	<120	35.8	<0.01	<0.7	7.4	7.3	1.69	8.05	16.4	0.9
BH9	12/01/2016	393	<0.06	129	15.7	815	753	<120	20.1	<0.01	6.4	7.6	7.6	15.1	6.66	5	2.8
BH9	11/02/2016					787							7.01	15.8			
BH9	01/03/2016					821							6.66	16.1			
BH9	05/04/2016	395	<0.06	121	13.1	727	713	<120	19.6	<0.01	5.7	7.9	7.36	14.6	5.43	5.8	2.7
BH9	05/05/2016					810							7.3	15.4			
BH9	14/07/2016		Insufficient liquid to obtain a sample														
BH9	20/07/2016		Insufficient liquid to obtain a sample														
BH9	16/08/2016		Insufficient liquid to obtain a sample														
BH9	08/09/2016		Borehole/surface water location dry														
BH9	04/10/2016		Borehole/surface water location dry														
BH9	01/11/2016		Borehole/surface water location dry														
BH9	01/12/2016		<0.06			575		<230					7.2	15.4			

Appendix C Table 2 Annually monitored groundwater parameters (metals / naphthalene) 2016

Location	Date	Cadmium µg/l	Chromium mg/l	Copper mg/l	Manganese mg/l	Nickel mg/l	Zinc mg/l	Lead mg/l
BH1	05/04/2016	<0.6	<0.002	<0.009	0.03	<0.003	<0.018	<0.006
BH1	06/09/2016	<0.6	<0.002	0.015	0.02	0.003	<0.018	<0.006
BH12	05/04/2016	<0.6	<0.002	<0.009	<0.007	<0.003	0.02	<0.006
BH12	06/09/2016	<0.6	<0.002	0.011	0.01	0.004	0.03	<0.006
BH13	05/04/2016	<0.6	<0.002	<0.009	0.01	<0.003	<0.018	<0.006
BH14	15/04/2016	<0.6	0.003	<0.009	0.01	0.004	<0.018	0.01
BH15	05/04/2016	<0.6	<0.002	<0.009	<0.007	<0.003	<0.018	<0.006
BH3	05/04/2016	<0.6	<0.002	<0.009	<0.007	<0.003	<0.018	<0.006
BH3A	05/04/2016	<0.6	<0.002	<0.009	<0.007	<0.003	<0.018	<0.006
BH6	05/04/2016	<0.6	<0.002	<0.009	<0.007	<0.003	<0.018	<0.006
BH9	05/04/2016	<0.6	<0.002	<0.009	<0.007	<0.003	<0.018	<0.006
BH9	14/07/2016	Insufficient liquid to obtain a sample						
BH9	04/10/2016	Borehole/surface water location dry						

Appendix D
Topographical Survey



Models		
	Drawn from	SITE MOD 1115.LSS
	Overlay 1	OS2D 0507
	Overlay 2	2D 1115
	Overlay 3	none
	Overlay 4	none
	Overlay 5	

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Facsimile 0121 544 7447

Drawn By: R.J.J.	Company: CEMEX UK Materials: South West
Date: 23/11/2015	Site: Whitehall Quarry
Scale(S): 1:1,250 @ "A2"	Project: As Placed Clay Barrier Survey & Quarry Survey Update
Chkd/Model(s)	Title: Quarry Survey November 2015
Site Ref.	Drawing No.: WHTL Site MOD Clay 1115 rjj.pdf