Kildare County Council
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Kerdiffstown Landfill Remediation Project

Kildare County Council

Environmental Impact Assessment Report (EIAR) Volume 4 of 4: Appendices (Part 2)

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Kerdiffstown Landfill Remediation Project

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Groundwater and Surface Water Monitoring Report - Quarter 1 2017

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Kerdiffstown Landfill Remediation Project

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A	03/05/17	Preliminary draft for comment	HF	MB	RR
B	26/07/17	Final	HF	MB	RR

Kildare County Council
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Contents

Executive Summary

This report presents the results and findings of groundwater and surface water sampling exercises completed at Kerdiffstown Landfill (located near Naas in County Kildare) during Quarter 1 of 2017 and has been completed by Jacobs on behalf of Kildare County Council (KCC). The landfill is situated within a sand and gravel overburden aquifer which overlies a limestone bedrock aquifer. The Morell River situated close to the site's eastern boundary has been identified as a sensitive surface water receptor.

During Quarter 1 of 2017, three rounds of sampling were undertaken. January was a normal monthly round of sampling as per the 2016 monthly monitoring rounds (15 wells and 8 surface water samples). February included a normal monthly round of sampling (15 wells and 8 surface water samples) in conjunction with the set-up and sampling for an extended biannual suite for 23 new wells installed in late 2016 throughout the site and surrounding lands in order to gain a more complete understanding of the effect that the landfill is having on the local groundwater. March included a normal round of monthly sampling (15 wells and 8 surface water samples) as well as resampling of each of the 23 new wells for a monthly analytical suite. Two rounds of monitoring were carried out on the new wells to confirm whether there was impact to the groundwater in the areas in which the new wells were installed, and therefore inform the sampling regime into the future.

Key results, particularly exceedances of water quality standards (Interim Guideline Value (IGV) and/or Groundwater Threshold Value (GTV) for groundwater obtained during the quarter are summarised in Table 1 below. For surface waters (Table 2), the results were compared against the Environmental Quality Standards (EQS).

Table 1: Summary of Groundwater Results Recorded Quarter 1 2017

Locations	Exceedances	Notable Results / Trends
On-Site Wells Exceedances of water quality standards are seen for many key determinands in all wells located on-site, e.g. chloride, ammoniacal nitrogen, iron, manganese, sulphate and arsenic.		
EMW11 (west)	Exceedances in calcium, potassium, sulphate, chloride, nitrate, iron and manganese	In January 2017, the highest concentration of cyanide was recorded at EMW11 since June 2014. Cyanide is normally not detected above the limit of detection (LOD) at this well, and had returned to below the LOD by February 2017. Also in January, the highest ever nitrate concentration was recorded, marginally above the previous peak recorded in October 2016. Concentrations subsequently decreased through the rest of the quarter.
EMW12 (north)	Exceedances in calcium, sulphate and nitrate	In January 2017, the highest concentration of cyanide was recorded at EMW12 since June 2014. Cyanide is normally not detected above the LOD at EMW12, and had returned to below the LOD by February 2017.
EMW13 (north-east)	Exceedances in calcium, potassium, sodium, chloride, ammoniacal nitrogen, iron, manganese and arsenic	Chloride, ammoniacal nitrogen, potassium, sodium and cyanide were all elevated during the quarter and in March 2017 the concentrations were the highest concentrations ever recorded at EMW13.
BH26 (north)	Exceedances in calcium, potassium, sodium, chloride, ammoniacal nitrogen, iron, manganese and arsenic.	In January 2017, the highest ever concentration of ammoniacal nitrogen was recorded at BH26, marginally exceeding the previous peak recorded in June 2015. Concentrations subsequently decreased through the rest of the quarter.
BH42 (centre south)	Exceedances in calcium, potassium, sulphate, chloride, ammoniacal nitrogen, iron, manganese and arsenic	In March 2017, chloride at BH42 increased to its highest concentration since the peak of August 2015, and was above the IGV for the first time since June 2016. There was a dramatic decrease in alkalinity recorded in March

Locations	Exceedances	Notable Results / Trends
		2017 at BH42, its lowest ever concentration.
BH68 (centre)	Exceedances in calcium, potassium, sulphate, phosphate, iron, manganese and nickel.	This new bedrock borehole recorded relatively high EC readings during sampling. However, chloride and ammoniacal nitrogen results were below the IGVs giving little evidence of leachate contamination although sulphate was elevated above the IGV. Alkalinity was also noted to be high.
Boundary Wells Localised evidence of leachate contamination continues to be recorded at a number of boundary wells along the north and north-eastern boundary. Results from new wells to the north indicate northerly movement of leachate contamination from Zone 1.		
EMW03 (north-east)	Exceedances in calcium, potassium, chloride, nitrate, ammoniacal nitrogen, iron, manganese and arsenic	Increases recorded in several determinands at EMW03, particularly in March 2017, but in line with previous years (e.g. chloride, ammoniacal nitrogen, potassium, sodium and alkalinity). Sharp increase in nitrate recorded, matching sharp increases recorded in the past, with March 2017 results the highest since December 2015.
DB02 (north)	Exceedances in calcium, magnesium, potassium, sodium, chloride, ammoniacal nitrogen, phosphates, iron, manganese, arsenic, barium, cadmium, chromium, copper, lead, nickel and zinc.	New well sampled for the first time in March 2017. Both chloride and ammoniacal nitrogen were elevated above their respective IGVs, with the chloride concentration comparable to nearby on-site well EMW13.
Off-Site Wells Continuing to be generally low in key leachate indicators such as ammoniacal nitrogen and chloride during Quarter 1 of 2017.		
DB03 (north - Kerdiffstown House)	Exceedances in calcium, potassium, chloride, nitrate, ammoniacal nitrogen, nitrite, phosphates, boron, iron, manganese, arsenic, barium, copper and mercury.	This new well was sampled in February and March 2017. Chloride and ammoniacal nitrogen concentrations recorded above the IGV during both rounds, with a slight increase recorded between February and March. An elevated mecoprop concentration was also recorded in February 2017.
EMW20 (north-east – Kerdiffstown House)	Exceedance in nitrate, iron and manganese.	Nitrate was detected above the IGV in March 2017, the highest concentration ever recorded at EMW20 and above the previous peak recorded in December 2016.
EMW28 (Foley's Field)	Exceedances in calcium, chloride, ammoniacal nitrogen, iron, manganese and arsenic.	In February 2017, ammoniacal nitrogen increased to its highest concentration at EMW28 since July 2016. Ammoniacal nitrogen tends to rise and fall in this well as evidenced by a reduction in March 2017 however concentrations have always been above the IGV since monitoring began in October 2012

Table 2: Summary of Surface Water Results Recorded Quarter 1 2017

Locations	Exceedances	Notable Results / Trends
Morell River		
Upstream (SW01)	No exceedances	In March 2017, large increases in iron and manganese were recorded at SW01, with iron at its highest concentration ever recorded.
Upstream	No exceedances	As with SW01, there were increased concentrations in

Locations	Exceedances	Notable Results / Trends
(SW02)		iron and manganese at SW02. Chloride was elevated at SW02 after the Hartwell confluence in January 2017, but reduced to the lowest concentration ever recorded in March 2017. In March 2017, SW02 had its highest recorded sulphate concentration to date.
Adjacent to the site (SW03, SW03A)	No exceedances	The high sulphate concentration recorded just upstream at SW02 in March was not seen in the further downstream samples of SW03 and SW03A where the sulphate concentrations relatively static.
Downstream (SW05)		The highest ever chloride concentration was recorded here in February 2017. However, the chloride concentration did reduce in March 2017. There was a similar increase in sulphate recorded in March (as seen in SW02 also) when it was at the highest ever recorded concentration at this sampling point.
Canal Feeder		
Upstream (SW13)	No exceedances	Decreases in both iron and manganese were noted through the quarter at SW13 following peak concentrations recorded in December 2016. Generally, higher concentrations were noted upstream than downstream for many determinands, likely as a result of winter road run-off as has been seen in the past.
Site Discharge	No exceedances	There were spikes in iron and manganese concentrations recorded at the site discharge point in January 2017, with both at their highest concentrations since January 2015. These concentrations subsequently reduced again in February 2017.
Downstream (SW11)	No exceedances	In Quarter 1 2017, results were similar to previous results recorded at this monitoring point. Generally lower concentrations were noted downstream than upstream.

The following table highlights results which are particularly noteworthy due to detailed quantitative risk assessment (DQRA) trigger value exceedances, notable increasing pollutant trends, and/or unusual detections or IGV/GTV exceedances. Suggested actions to address these results are included in the table.

Table 3: Noteworthy Groundwater Observations and Actions

Location	Description	RAG	Actions
Area north of Zone 1	The new wells located north of the site (boundary well DB02 and off-site well DB03) were found to be elevated in a number of key leachate indicators during Quarter 1, 2017, with IGV exceedances in ammoniacal nitrogen and chloride comparable to nearby Zone 1 well EMW13. The results suggest that leachate contaminated groundwater is leaving the site from Zone 1 in a northerly direction.		Add DB02 and DB03to the monthly monitoring from April 2017 onwards in order to further monitor this leachate movement northward.
North-east boundary	Continuing evidence of localised leachate migration from the site at EMW03, while nearby well EMW06 shows no evidence of leachate contamination, but is likely a perched waterbody. New bedrock well BB02 adjacent to EMW06 similarly shows little evidence of leachate contamination, with only chloride being above the IGV but ammoniacal nitrogen staying below the LOD.		Add BB02 to the monthly monitoring from April 2017 onwards in order to monitor for bedrock contamination along this north-eastern boundary.

Location	Description	RAG	Actions
Centre of the site	New bedrock well BH68 towards the centre of the site had elevated EC readings during Quarter 1, 2017 but key leachate indicators were generally below the IGVs indicating no obvious leachate contamination of the bedrock aquifer here.		Add BH68 to the monthly monitoring from April 2017 onwards in order to monitor for bedrock contamination in this central part of the site.

Table 4: Noteworthy Surface Water Observations and Actions

Location	Description	RAG	Actions
Morell River	There were a number of unusual results recorded at different points in the Morell River during the first quarter of 2017: In January 2017 there were increases in a number of determinands at SW02, likely caused by the inflow of the Hartwell just upstream of the sampling point possibly washing in some road run-off. Similar increases were not seen again in February or March. In February the chloride concentration at SW05 downstream of the site was the highest ever recorded to date. In March the highest ever sulphate was recorded at SW05 however chloride concentrations were noted to have decreased compared to the previous month. In March there were sharp increases in iron and manganese recorded at SW01 upstream of the site, with concentrations decreasing as the river flows past the site. See Section 2.2.3.1 for further detail.		Continued monthly monitoring to take place as scheduled.
Canal Feeder	During Quarter 1, 2017 concentrations of most determinands measured in the Canal Feeder were found to be higher upstream of the site than downstream. This trend has been generally seen since monitoring of the stream began. Increases recorded upstream may have been caused by runoff from roads and fields as seen previously. See Section 2.2.3.1 for further detail.		Continued monthly monitoring to take place as scheduled.

EPA Contaminated Land & Groundwater Risk Assessment Methodology		Report Reference	Report Date	Status
	STAGE 1: SITE CHARACTERISATION & ASSESSMENT			
1.1	PRELIMINARY SITE ASSESSMENT	Environmental Baseline Report Remedial Options Report	June 2013	Final
1.2	DETAILED SITE ASSESSMENT	Groundwater and Surface water Monitoring Reports	Monthly Reports from October 2013	Final
1.3	QUANTITATIVE RISK ASSESSMENT	Detailed Quantitative Risk Assessment	November 2014	Final
	STAGE 2: CORRECTIVE ACTION FEASIBILITY & DESIGN			
2.1	OUTLINE CORRECTIVE ACTION STRATEGY			
2.2	FEASIBILITY STUDY & OUTLINE DESIGN			
2.3	DETAILED DESIGN			
2.4	FINAL STRATEGY & IMPLEMENTATION PLAN			
	STAGE 3: CORRECTIVE ACTION IMPLEMENTATION & AFTERCARE			
3.1	ENABLING WORKS			
3.2	CORRECTIVE ACTION IMPLEMENTATION & VERIFICATION			
3.3	AFTERCARE			

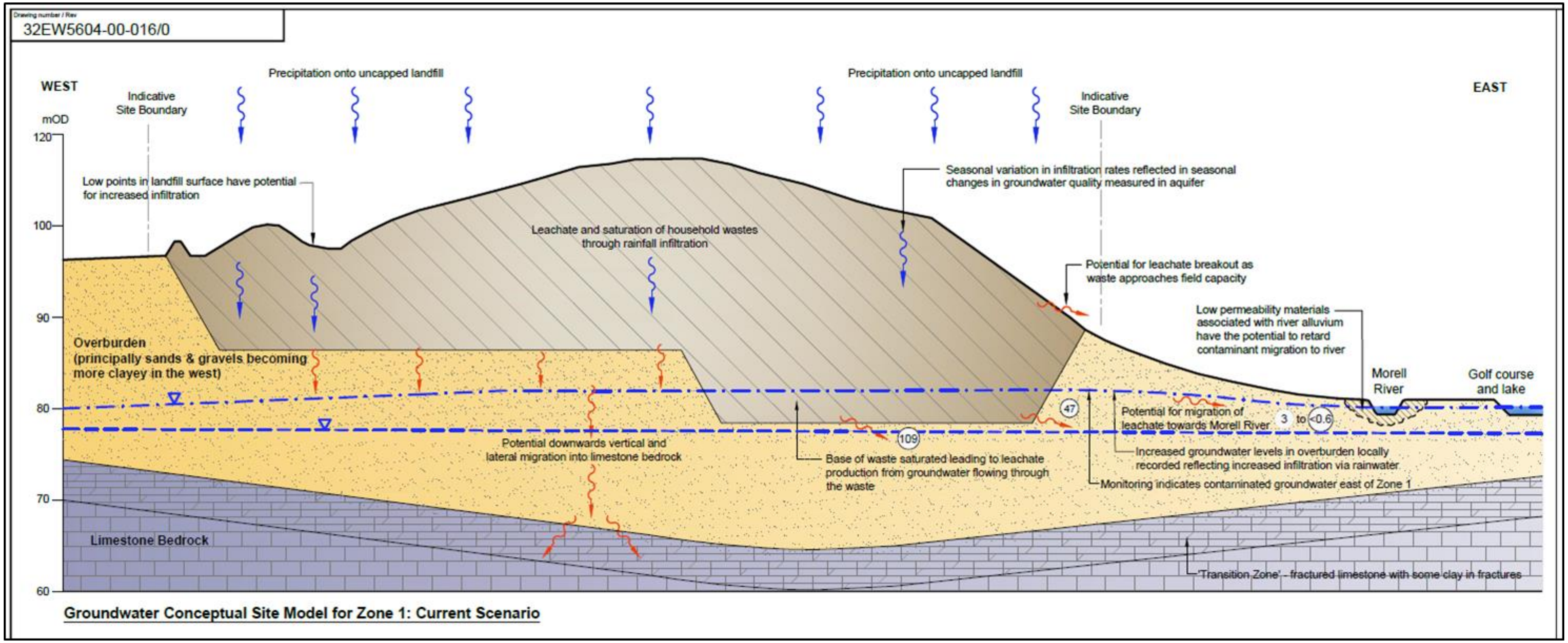


Diagram 1.1: Groundwater Conceptual Site Model (Version 4, 2016)

1. Introduction

1.1 Project Contractual Basis and Personnel Involved

In February 2013 SKM Enviros (now trading as Jacobs) was appointed as a framework contractor by the Environmental Protection Agency (EPA) to provide technical environmental support services in relation to the remediation of Kerdiffstown Landfill (hereafter referred to as the site). In June 2015 the control of the site was handed over to Kildare County Council (KCC) with the above mentioned framework contract being novated from the EPA to KCC.

Under the framework a Remedial Options Assessment was completed in July 2013. This assessment contained a number of key recommendations in relation to the future remediation of the site, which included a requirement to provide regular (monthly and six monthly[1]) on-going assessment of groundwater and surface water conditions in advance of remedial works using an existing network of groundwater monitoring wells installed on and around the site and pre-defined surface water monitoring locations.

This report presents the results and findings of groundwater and surface water monitoring completed by Jacobs during the first quarter of 2017. The monitoring was completed at the request of KCC and was completed in accordance with Jacob's proposal to KCC dated 28th February 2017. The monitoring results presented in this report were preceded by monthly rounds of monitoring completed since October 2013, the results of which have been reported separately.

Monitoring included the collection and analysis of groundwater samples for a range of potential contaminants. Samples were collected from on-site, boundary and off-site monitoring wells installed within overburden deposits and underlying bedrock. In addition, surface water samples were collected from the Morell River (located north-east of the site), from the canal feeder (a surface water course located south-west of the site), and from the site's surface water discharge. Analysis of the samples was completed by ALS Environmental.

1.2 Background Information

Waste operations ceased and the site was vacated during June 2010. Prior to this, Jacobs had been commissioned by the EPA to conduct an evaluation of potential environmental liabilities and related remedial costs associated with various closure scenarios for the landfill site. The results and findings of this study are presented in a previous report dated October 2010[2].

Since completion of the environmental liabilities assessment in 2010, Jacobs has been working with the EPA and as highlighted above was appointed as Framework Contractor in February 2013. Prior to this point Geosyntec Consultants (formerly Ford Consulting Group) had been commissioned by the EPA during 2011 to assess the condition of the site from the perspective of contaminated land and groundwater, and specifically to assess potential impacts from the site on sensitive environmental receptors. The results and findings of Geosyntec Consultants preliminary study are presented in a report dated April 2012[3].

Geosyntec subsequently completed groundwater and surface water monitoring rounds at the site in December 2011[4], May 2012[5], October 2012[6] and February 2013[7]. Jacobs has subsequently completed groundwater and surface water monitoring on a monthly basis since October 2013[8].

1 Monthly monitoring has been recommended from selected boreholes and for a reduced analytical suite. Six monthly sampling is recommended for all serviceable monitoring boreholes with analysis for an expanded suite. This report covers one monthly and one six-monthly rounds of sampling.
2 SKM Enviros, October 2010; Evaluation of Environmental Liabilities at Kerdiffstown Landfill.
3 Ford Consulting Group, April 2012; Preliminary Environmental Site Assessment – Kerdiffstown Landfill.
4 Ford Consulting Group, May 2012: Groundwater & Surface Water Monitoring at Kerdiffstown Landfill – December 2011 (Draft).
5 Ford Consulting Group, September 2012: Groundwater & Surface Water Monitoring at Kerdiffstown Landfill – May 2012 (Draft).
6 Geosyntec Consultants Ltd, January 2013: Groundwater & Surface water Monitoring at Kerdiffstown Landfill – October 2012 (Draft report).
7 Geosyntec Consultants Ltd, April 2013: Groundwater & Surface water Monitoring at Kerdiffstown Landfill – February 2013 (Draft report).
8 Groundwater and Surface Water Monitoring Reports at Kerdiffstown Landfill October 2013 to December 2016.

1.2.1 Physical Site Setting

The site is located c. 3.5km northeast of Naas and approximately 0.5km northwest of the N7 and Johnstown village as shown in Figure 1. To the northeast is parkland associated with Kerdiffstown House, to the north is a golf course and to the south west and south east are a mixture of land uses including residential, agriculture and worked out quarries.

The L2005 County Road from Sallins to Johnstown runs adjacent to the western and southern site boundaries, with the nearest residential property approximately 10m from the site boundary, with the boundary being interpreted as the former redline boundary for waste licence W0047-02.

It should be noted that the redline boundary as shown on all figures in this report is the boundary of the waste facility authorised by, and as specified in, waste license number W0047-02 granted to 'Neiphin Trading Limited'. This redline boundary is used for illustrative purposes only in this report to show the location and approximate outline of the former waste facility and does not imply any legal ownership boundaries or any limitation on the area within which any action is being or can be taken by the KCC under Section 56 of the Waste Management Act 1996 (as amended).

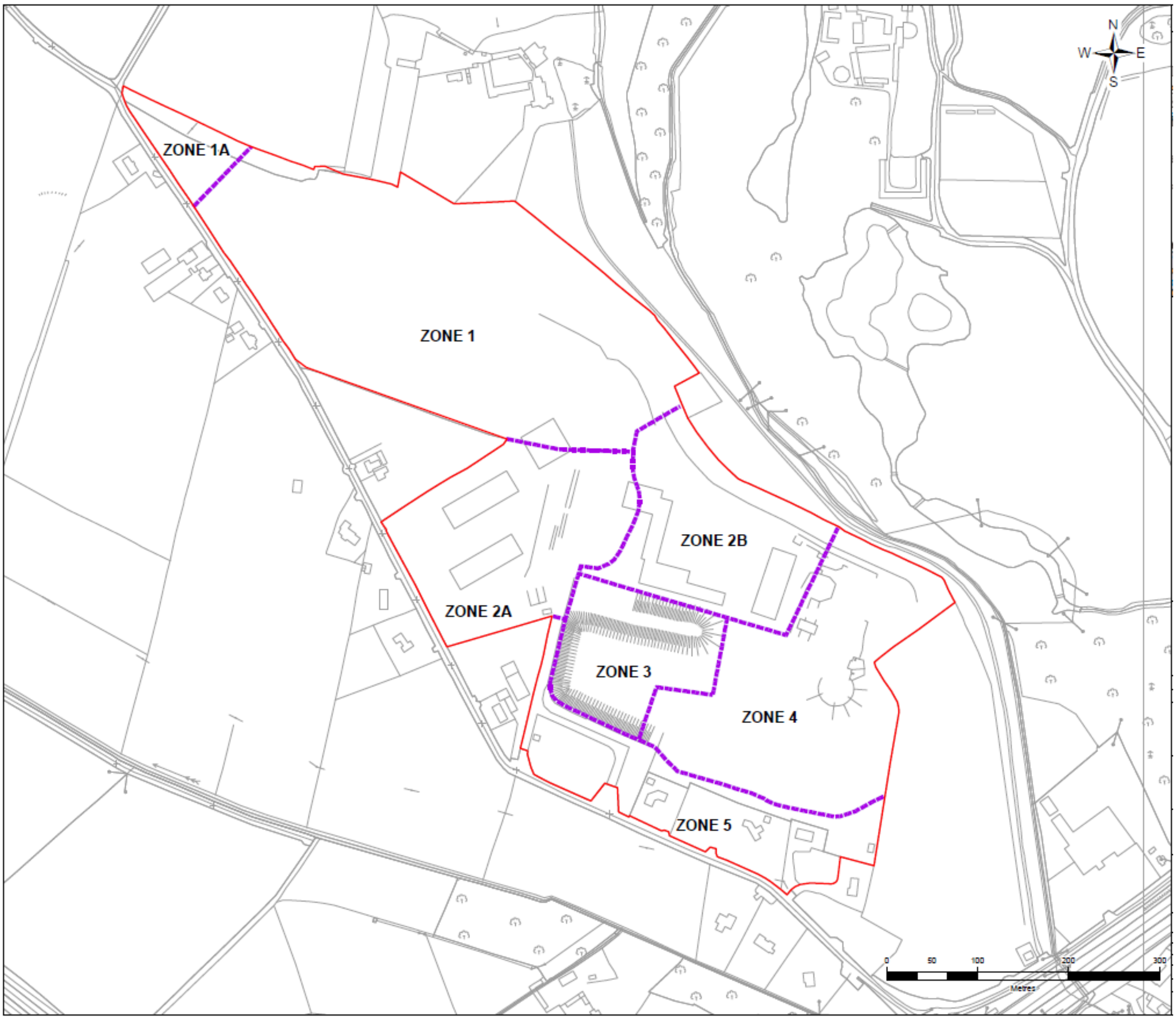
The closest surface water body to the site is the Morell River, which flows generally northwards within 50 m of the north-eastern site boundary to flow into the River Liffey. The River Liffey itself lies approximately 3km north-west of the site at its closest point, also flowing generally northwards, before following a more eastward flow direction some 5 to 6 km north of the landfill site. There is a major public water supply abstraction from the River Liffey at Leixlip, which serves Fingal, Kildare and north Dublin, located approximately 15 km north-east of the landfill site.

The canal feeder is an engineered feature that collects surface water run-off from lands generally to the south and south-west of the site. The canal feeder flows generally westward to the Grand Canal, which is located approximately 2 km west of the site.

1.2.2 Current Site Layout

The current site layout is attached in Figure 2. Plate 1 below which also shows the site sub-divided into a number of discrete geographical areas, or zones, each of which has their own unique characteristics. The layout of the various zones as shown below with information on the key characteristics of the materials within the zones summarised in the following table.

Plate 1: Site Layout



Key Characteristics of the Landfill Zones

Zone	Zone Key Characteristics
1	Wastes deposited in the north-west area of the site which account for approximately 65% of the entire estimated volume of waste on site. The wastes in this area are typically unprocessed, highly odorous and principally comprise non-hazardous mixed construction and demolition (C & D) wastes and household wastes. C & D wastes noted to contain varying amounts of clay, gravel, concrete, brick, wood, textile, plastic, rubber and metal. Wastes in this area of the site are uncapped and unlined and localised areas of free leachate are likely to be present within the wastes. In the south and east of this zone, wastes are present beneath the groundwater table.
1A	Sub-zone of Zone 1 where waste appears to be absent.
2A	Much of this zone in the west-central portion of the site is covered by thick, reinforced concrete pads, which form a low permeability layer over the wastes and reduce direct rainwater ingress. Wastes noted to be domestic waste mixed in with C & D materials with varying amounts of clay, gravel, brick, concrete, wood, textile, paper, plastic, rubber and metal. The smaller area of wastes not covered by concrete allows rainwater to infiltrate in a similar manner to Zone 1.
2B	Much of this zone in the east-central portion of the site is covered by thick, reinforced concrete pads, which form a low permeability layer over the wastes and reduce direct rainwater ingress. Wastes noted to be principally unprocessed non-hazardous mixed C & D waste with varying amounts of clay, gravel, brick, concrete, wood, textile, paper, plastic, rubber and metal. The smaller area of wastes not covered by concrete allows rainwater to infiltrate in a similar manner to Zone 1. Below much of this zone some wastes are present beneath the groundwater table.
3	This area is lined (the 'lined cell') with processed waste materials filling 60% of the existing void space. Wastes in this area comprise processed non-hazardous C & D materials with domestic waste mixed through. C & D wastes contain varying amounts of clay, gravel, concrete, brick, wood, textile, plastic, rubber and metal. The leachate generated within the lined cell is contained and removed for off-site treatment/disposal. There will be a long term requirement for removal and treatment of leachate from the lined cell.
4	Containing redundant infrastructure and concrete tanks/bays/walls in the lower yard area. The area also contains a surface water soakaway lagoon which is cut into waste deposits and into which water from the adjacent waste stockpiles drains. The bottom 1 to 2m of a small amount of the wastes is below the water table in this area.
5	No significant waste deposits are present in this area. This area also has a number of residential properties located on it which are within the site red line boundary.

1.2.3 Groundwater Monitoring Network

Following vacation of the site in 2010, the EPA and KCC have commissioned a number of site investigations to establish groundwater conditions as summarised in the Table 1.1 with the locations of installed monitoring wells shown in Figure 3. Investigations have involved installation of approximately 90 groundwater monitoring wells on and off site to collect data to define the hydrogeological site setting and provide groundwater monitoring points. Subsequent rounds of groundwater monitoring have been undertaken to establish the chemical quality of the groundwater with the most recent round prior to this report being undertaken by Jacobs in December 2016.

In late 2016 an additional 45 monitoring wells were installed both on-site and off-site. The borehole locations were positioned in order to further establish the condition and flow of the local groundwater and for geotechnical purposes. During February and March 2017, sampling was undertaken of all new wells which held sufficient water to sample (25 in total). This report includes analysis of the results obtained from these wells as well as the established wells. Further details of the groundwater quality monitoring are provided in Chapter 2 of this report.

Table 1.1: Summary of Groundwater Site Investigations

	Dates of Site Investigation	No. of boreholes drilled	No. of monitoring wells installed	On / off site	Monitoring Well Numbers
EPA SI	10/05/10 to 12/05/10	10	9	Off site	EMW01* to EMW10
EPA SI	06/06/11 to 19/06/11	7	7	On site	EMW11 to EMW17
Phase 1 SI	09/01/12 to 06/02/12	24	4	On site	BH2, BH6, BH7, BH24
Phase 2 SI	14/08/12 to 21/09/12	61	21 (17 GW, 1 leachate (now dry), 2 Inclinometer, 1 Gas)	On and off site	BH26, BH36B, BH39B, BH40B, BH42, BH48, EMW18 to EMW24, BHEMW27 to EMW33.
Phase 3 SI	October 2016	45	45 (although some wells have remained dry to date)	On and off site	RM01 to RM06, BB01 to BB04, DB01 to DB15 (excluding DB13), BH60 to BH80.
Former abstraction wells	Not relevant	2	2	On site	GW1D, GW2D

* EMW01 was backfilled due to health and safety concerns.

Figure 3 also shows a series of surface water monitoring locations, including the locations along the Morell River and the Canal Feeder where samples were collected during the Quarter 1 monitoring events.

1.3 Geological and Hydrogeological Conditions

1.3.1 Bedrock Geology

The majority of the site is underlain by bedrock in the Ballysteen Formation which is described as dark muddy limestone/shale. However, the far northwest corner of the site is underlain by the Waulsortian Limestone, which is described as a pale grey muddy limestone. The bedrock (both the Ballysteen Formation and Waulsortian Limestone) is classified by the Geological Survey of Ireland (GSI) as being a locally important aquifer which is moderately productive only in local zones.

The GSI's vulnerability classification for the bedrock aquifer in the vicinity of the site is 'high'. However, the limestone in this formation are stated to be quite 'muddy' and not susceptible to processes which would cause an increase in permeability such as karstification. As such groundwater abstractions from the bedrock are rare and have low yields where they are present. It is known, however, that there was an abstraction well on site which is described as being 'deep' although the details of it are not known and it is uncertain if this well did abstract from the limestone.

Investigations in 2012 reached the bedrock in four monitoring wells (EMW12, EMW19, EMW22 and EMW24) but at these locations no description of the rock type is provided in the borehole log. The recently undertaken investigation in 2016 installed a further eight boreholes which reached the bedrock. Cores recovered from the bedrock showed the limestone rock to be highly fractured near the surface with clay infilling some of the fractures. It is this upper fracture zone which will provide the principal pathways for groundwater movement in the bedrock.

The depth to bedrock has been recorded in the borehole logs as being between 6.7 and 26.8 m below ground level (mbgl) in boreholes where bedrock has been encountered.

1.3.2 Overburden Geology and Hydrogeology

On a regional scale the site is indicated to be in an area of glacio-fluvial sands and gravels which extend over an area of 2 km^2. However, the GSI overburden aquifer designation map does not show this deposit to be a recognised aquifer in the vicinity of the site.

In September 2010, Apex Geoservices provided a report which interpreted the geological data that was available at that time. They concluded that:

- To the west, northwest and south of the landfill, the upper 1.6 m comprised silt and clay type material overlying an average of 18.8 m of sand and gravel;

- To the east and northeast of the landfill the upper 1.5 m comprised dominantly alluvium, silt and clay overlying an average of 7.4m of silt/clay and sandy gravelly silt/clay overlying bedrock; and

- East and southeast of the landfill the rock levels generally range from 75 to 78mAOD. South and west of the landfill the rock levels generally range from 71 to 75mAOD.

Based on the information gained in previous site investigations, a greater thickness of glacial sands and gravels are found directly to the west, northwest and south of the landfill with a thickness in the region of 20 to 24m. In general, this glacial overburden is characterised by an initial, more silty, clayey sand and gravel horizon approximately 3m thick underlain by gravelly sands approximately 10m thick and then sandy gravels around 7m thick. To the east and northeast of the landfill the thickness of the sands and gravels decreases and in the Morell River valley, clayey alluvium is also present although the borehole logs do show that frequent sandy lenses are present in the clay-dominated alluvium.

The recently undertaken investigation in 2016 involved the drilling of over fifty boreholes at the site, with collection of data on the overburden geology. It is noted that in monitoring wells located to the north-eastern site boundary and within the grounds of Kerdiffstown House, significantly deeper superficial deposits are found and that there is a buried channel in the bedrock surface running in a north-south direction.

1.4 Project Objectives

The primary objectives of the Quarter 1 2017 monitoring events were to collect data from existing monitoring wells, as well as the newer wells drilled in 2016, and to use these data to update and refine the CSM developed from past investigations and monitoring events and then to use the groundwater quality data set to observe if any emerging trends are notable in groundwater quality at the site and surrounding area.

1.5 Scope of Works

1.5.1 Rationale and Strategy

The scope of work completed for the Quarter 1 2017 monitoring event is presented below:

January 2017
Collection of groundwater samples from 7 on-site monitoring wells (EMW11 to EMW13, EMW15, EMW16, BH26 and BH42).
Collection of groundwater samples from 3 boundary wells (EMW03, EMW06 and EMW19).
Collection of groundwater samples from 5 off-site monitoring wells (EMW05, EMW08, EMW20, EMW28 and EMW29).
Collection of surface water samples from 8 monitoring locations (SW01 to SW03A, SW05, SW11, SW13 and a sample from the site discharge to the canal feeder).
Analysis of the collected groundwater and surface water samples for a suite of inorganic parameters including major ions and metals/metalloids.
Associated data assessment and reporting
February 2017
Collection of groundwater samples from 14 on-site monitoring wells (EMW11 to EMW13, EMW15, EMW16, BH26, BH42, BH68 to BH72, BH77 and BH78).
Collection of groundwater samples from 11 boundary wells (EMW03, EMW06, EMW19, RCBB01 (bedrock), BB01 (overburden), BB02, BB04, DB05, DB06, DB08 and DB10).
Collection of groundwater samples from 13 off-site monitoring wells (EMW05, EMW08, EMW20, EMW28, EMW29, RM01 to RM06, DB03 and BB03).
Collection of surface water samples from 8 monitoring locations (SW01 to SW03A, SW05, SW11, SW13 and a sample from the site discharge to the canal feeder).
Analysis of all new groundwater well samples (all DB, BB and RM wells and BH wells from BH68) for an expanded suite of inorganic parameters including major ions and metals/metalloids as well as a broad suite of organic compounds including polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), speciated phenols and pesticides.
Analysis of all other collected groundwater and surface water samples for the smaller suite of inorganic parameters including major ions and metals/metalloids.
Associated data assessment and reporting
March 2017
Collection of groundwater samples from 13 on-site monitoring wells (EMW11 to EMW13, EMW15, EMW16, BH26, BH42, BH68, BH70 to BH72, BH77 and BH78).
Collection of groundwater samples from 13 boundary wells (EMW03, EMW06, EMW19, RCBB01 (bedrock), BB01 (overburden), BB02, BB04, DB02, DB04 to DB06, DB08 and DB10).
Collection of groundwater samples from 13 off-site monitoring wells (EMW05, EMW08, EMW20, EMW28, EMW29, RM01 to RM06, DB03 and BB03).
Collection of surface water samples from 8 monitoring locations (SW01 to SW03A, SW05, SW11, SW13 and a sample from the site discharge to the canal feeder).
Analysis of the collected groundwater and surface water samples for a suite of inorganic parameters including major ions and metals/metalloids.
Analysis of one groundwater sample (DB02) for an expanded suite of inorganic parameters including major ions and metals/metalloids as well as a broad suite of organic compounds including polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), speciated phenols and pesticides.
Associated data assessment and reporting (i.e. this report).

Monitoring wells had been sampled previously by Geosyntec consultants in June 2011, September 2011, December 2011, May 2012, October 2012 and February 2013. Jacobs has completed monthly sampling of groundwater monitoring wells since October 2013. The results obtained from these monitoring rounds as well as previous rounds were reviewed to assess possible trends in groundwater levels and groundwater quality.

1.5.2 Meteorological Conditions

Weather conditions in Quarter 1 during the sampling period were as follows:

- January 2017:
  - 30th: Dry, cool (4 to 11°C), moderate breezes
  - 31st: Dry, cool (8 to 10°C), moderate breezes
- February 2017:
  - 20th: Dry, cool (11 to 12°C), moderate breezes
  - 21st: Showery, cool (9 to 12°C), fresh breezes
  - 22nd: Wet, cool (8 to 10°C), moderate breezes
  - 23rd: Storm Dorris – no site work carried out due to safety concerns
  - 24th: Dry, cold (2 to 8°C), moderate breezes
  - 27th: Dry, cold (2 to 6°C), gentle breezes
  - 28th: Showery, cold (2 to 8°C), moderate breezes
  - 1st March: Dry, cold (2 to -8°C), moderate breezes
- March 2017:
  - 21st: Dry, cold (1 to 7°C), moderate breezes
  - 22nd: Wet, cold (3 to 5°C), moderate breezes
  - 27th: Dry, cool (8 to 13°C), light breezes
  - 28th: Showery, cool (5 to 13°C), gentle breezes
  - 29th: Dry, cool (11 to 14°C), moderate breezes

Details of rainfall during the month are presented below. The quarter started out drier than average, with January 2017 continuing the low rainfall trend seen in the second half of 2016. Rainfall levels increased in February and March, with the Casement Met Station average being exceeded during both months.

Table 1.2: Average Rainfall

	Site Weather Station Rainfall (mm)	Casement Long Term Average Rainfall (1981 -2010) (mm)	% Above / Below Average for Casement
Jan-17	43.2	63.8	68%
Feb-17	60.6	48.5	130%
Mar-17	63.0	50.7	124%

1.5.3 Groundwater Monitoring Wells

Inertial lift foot-valves and tubing dedicated to each groundwater monitoring well were used to purge the wells prior to sample collection. Monitoring well head parameters (temperature, conductivity, pH, dissolved oxygen and redox potential) were monitored during purging and the samples collected for laboratory analysis were only collected once these parameters had stabilised. Samples collected for metals/metalloid analysis were filtered in the field into sample bottles containing dilute nitric acid preservative.

1.5.4 Surface Water

Surface water samples were collected either directly into laboratory-supplied sample bottles or through use of an extendable pole with a stainless steel sampling container.

1.6 Laboratory Analyses

The water samples were stored in cool boxes containing frozen ice packs for collection. The samples were dispatched from the site to the subcontracted laboratory via over-night courier on the day of sampling or by 14:00 the following day together with completed chain-of-custody documentation.

Table A.1 provides the sampling and analysis inventories for the Quarter 1, 2017 monitoring rounds.

2. Results and Discussion of Monitoring Programme

2.1 Site Hydrogeology and Groundwater Flow

2.1.1 Groundwater Levels and Rainfall

Groundwater elevations have been used to update groundwater contour plans for the superficial overburden deposits and the underlying bedrock recorded between January and March 2017. For the purpose of this report Figures 4a to 4c, and 5a to 5c show indicative flow directions in January, February and March 2017 for the overburden and bedrock aquifers respectively. Tables A.2a to A.2c provides details of the groundwater level data recorded for those three months.

The interpretation of patterns of groundwater flow identified have changed from previous assessments based on the information obtained from the new wells drilled in late 2016. In general, the flow continues to be shown to be approximately south to north in both the overburden and the bedrock with the highest water levels recorded in the south of the site. The biggest change is to the contours drawn for the overburden boreholes where a number of deep overburden wells which were previously used in defining the overburden groundwater levels have now been excluded as the water levels are more representative of levels in the bedrock. These wells are EMW03, EMW11, BH36B and DB01.

In general groundwater levels increased during Quarter 1 of 2017. With the exception of EMW13 and EMW28 all of the groundwater wells showed increases in groundwater levels in March 2017 when compared to levels recorded in December 2016. Increases of between 0.01m and 0.82m were recorded during that time, the greatest of which was measured in EMW27. In all but seven of the 33 new wells which were not dry there were also increases recorded between February and March 2017 (between 0.02m to more than 2.98m) with the largest increase noted in DB04. This well was dry in February 2017, but when revisited in March DB04 had almost 3m of water in it.

Only two wells showed marginal groundwater level decreases between December 2016 and March 2017. EMW13 decreased by 0.01m and EMW28 decreased by 0.04m. There were some decreases recorded in the new wells also when February 2017 was compared to March 2017. The decreases ranged from 0.02m to 0.79m, with the largest being in BH65.

Graph 2.2 shows the temporal variation in groundwater levels in selected monitoring wells sampled for this report from the start of monitoring up to and including March 2017. These monitoring wells are completed within the overburden and are located in the north-eastern and south-eastern areas of the site within the known footprint of the landfill.

Monitoring commenced in May 2011. There was a gradual increase in overall water levels up to January 2013, by between approximately 0.5m and 2m. This is likely to be the result of increased rainfall during 2012 (which was a wet year relative to 2011, with 861mm recorded at Casement weather station in 2012 compared to 429mm in the previous year).

The observed fall in groundwater levels visible on the chart from January 2013 onwards are as a result of the reduction in rainfall and therefore infiltration through the spring and summer months coupled with drier antecedent conditions in advance of the 2013 October and November monitoring and sampling visits.

Between December 2013 and March 2014 above average rainfall was experienced and as would be anticipated has led to an increase in groundwater levels. In subsequent months when recharge reduced, the groundwater levels responded to relatively dry conditions (June and July 2014). Notwithstanding that August 2014 was a wet month in comparison to the monthly historical average; groundwater levels at the end of 2014 were relatively low in comparison to previous winter levels. Little change was observed between August 2015 and December 2015 besides those expected from seasonal variation.

Between November 2015 and February 2016 there was a rise in water levels observed in the majority of the monitoring wells which is likely as a result of increased rainfall and groundwater recharge with above average rainfall being recorded. The levels have generally been decreasing from February to December 2016. This is due to the fact that rainfall reduced dramatically in March 2016 following four consecutive months of above average rainfall with April and May 2016 rainfall amounts being close to the long term average. Groundwater recharge (i.e. that rainwater which reaches the groundwater table) during the summer months usually falls to zero and the drop off in rainwater infiltration has caused decreases in water levels in the majority of monitoring wells. All but September 2016 had lower than average rainfall amounts in the second half of 2016 and in the winter of 2016/17 groundwater levels were observed to rise later in the season than previous years with the seasonal rise generally being recorded in January/February 2017.

As such, 2017 started with below average rainfall during January, continuing the trend of falling groundwater levels as seen during the second half of 2016. However, in terms of rainfall, February and March 2017 reversed the general recent trend with above average rainfall during both of those months, resulting in increases in groundwater levels in the majority of the wells.

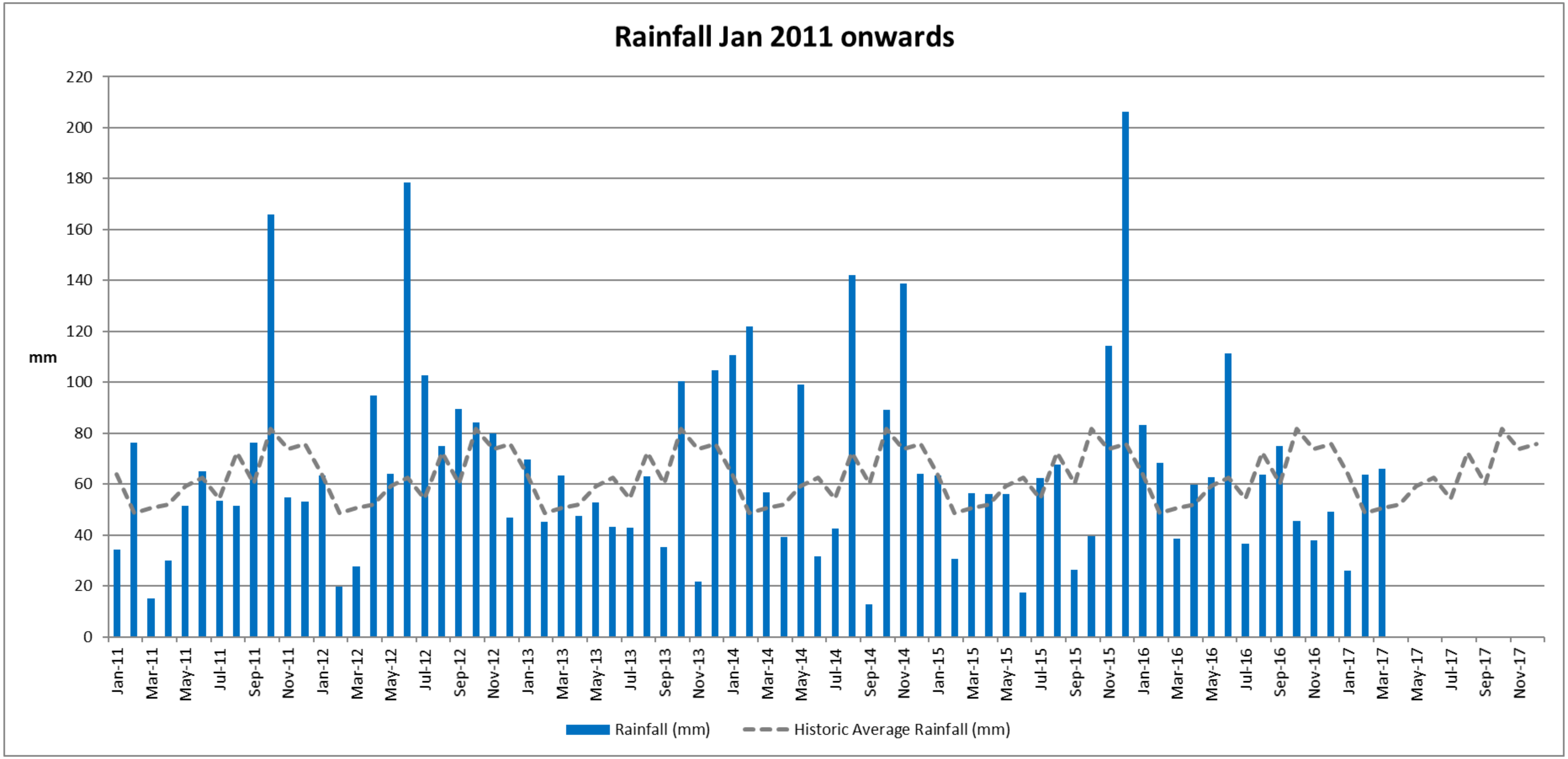
Monthly rainfall data are shown in Table 2.1 and Graph 2.1.

Table 2.1: Historical Rainfall Comparison

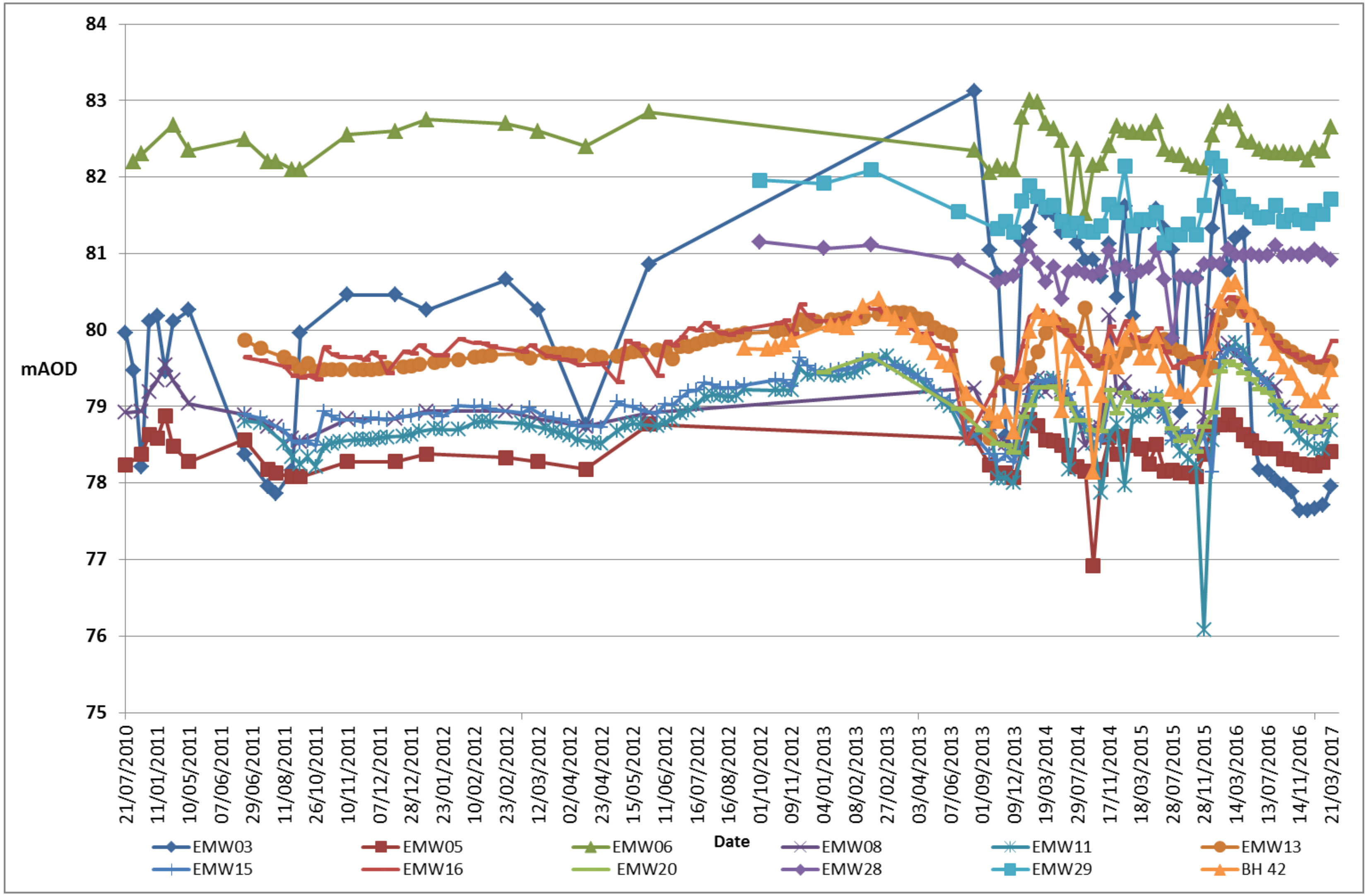
	Casement Rainfall (mm)	Long Term Average (mm) (1981 – 2010)	% of Average
Jan-13	69.5	63.8	109%
Feb-13	45.2	48.5	93%
Mar-13	63.3	50.7	125%
Apr-13	47.5	51.9	92%
May-13	52.8	59.1	89%
Jun-13	43.2	62.5	69%
Jul-13	42.7	54.2	79%
Aug-13	62.9	72.3	87%
Sep-13	35.1	60.3	58%
Oct-13	100.4	81.6	123%
Nov-13	21.6	73.7	29%
Dec-13	104.7	75.7	138%
Jan-14	110.7	63.8	174%
Feb-14	122	48.5	252%
Mar-14	56.7	50.7	112%
Apr-14	39.3	51.9	76%
May-14	99.1	59.1	168%
Jun-14	31.7	62.5	51%
Jul-14	42.6	54.2	79%
Aug-14	142.2	72.3	197%
Sep-14	12.8	60.3	21%
Oct-14	89.1	81.6	109%
Nov-14	138.9	73.7	188%
Dec-14	64.9	75.7	86%
Jan-15	63.4	63.8	99%
Feb-15	30.5	48.5	63%
Mar-15	56.4	50.7	111%
Apr-15	56.4	51.9	109%
May-15	56.2	59.1	95%
Jun-15	17.4	62.5	28%

	Casement Rainfall (mm)	Long Term Average (mm) (1981 – 2010)	% of Average
Jul-15	62.4	54.2	115%
Aug-15	67.7	72.3	94%
Sep-15	26.2	60.3	43%
Oct-15	39.4	81.6	48%
Nov-15	114.3	73.7	155%
Dec-15	206.3	75.7	273%
Jan-16	83.2	63.8	130%
Feb-16	68.3	48.5	141%
Mar-16	38.7	50.7	76%
Apr-16	59.7	51.9	115%
May-16	62.6	59.1	106%
Jun-16	111.4	62.5	178%
Jul-16	36.6	54.2	68%
Aug-16	63.8	72.3	88%
Sep-16	74.9	60.3	124%
Oct-16	45.4	81.6	56%
Nov-16	38.2	73.7	52%
Dec-16	49.2	75.7	65%
Jan-16	43.2	63.8	68%
Feb-16	60.6	48.5	130%
Mar-16	63.0	50.7	124%

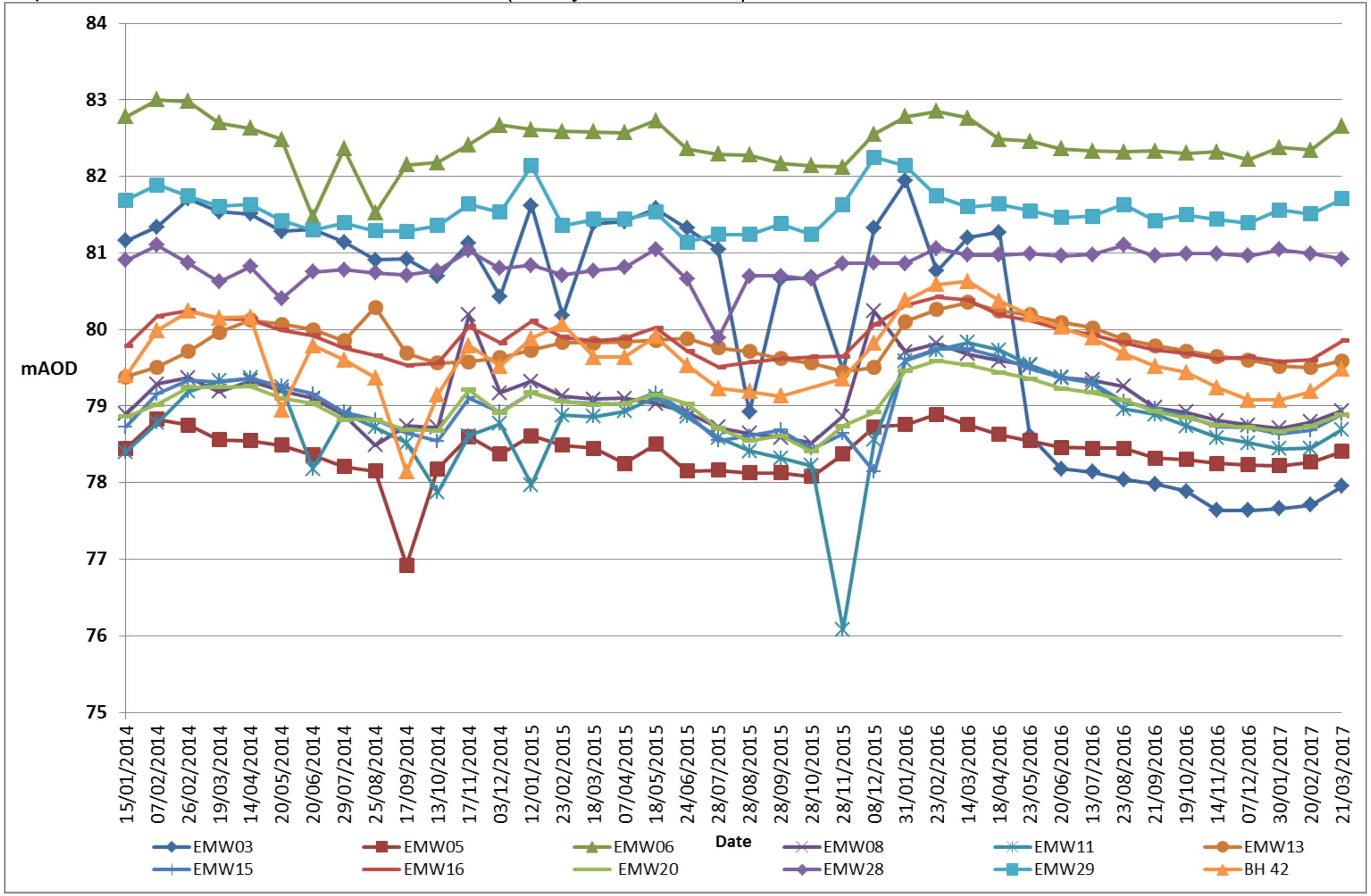
Graph 2.1: Rainfall since January 2013 compared to the historical average



Graph 2.2a: Variations in Water Levels 2011 – Present (Monthly Overburden Wells)



Graph 2.2b: Variations in Water Levels 2014 – Present (Monthly Overburden Wells)



With respect to groundwater levels recorded in overburden deposits during Quarter 1 of 2017 relative to Ordnance Datum, these are shown in Figures 4a to 4c. The reassessment of the data including that collected from the new wells in February and March has changed the shape of the overburden contours while still showing a general fall from south to north indicating a broadly north-easterly flow with groundwater discharging to the Morell River in the east.

The highest water level in Zone 1 has been recorded in borehole EMW06 at between 82.34 mAOD to 82.66 mAOD although this appears to be monitoring a perched aquifer. The lowest groundwater level in Zone 1 during Quarter 1 has been recorded in the deep overburden borehole EMW03 at 77.66 mAOD to 77.95 mAOD and this water level is a notable low point but is at an elevation that represents the groundwater level recorded in bedrock boreholes. This borehole has recorded the lowest groundwater level for the last ten months having previously shown fluctuations month-on-month with the high levels being representative of the groundwater levels in the overburden deposits. The fluctuations appear to show that the groundwater level flips from the bedrock groundwater level during times of low water levels to the overburden level when water levels are higher.

A weir on the Morrell River adjacent to the site has an elevation of 79.79 mAOD indicating that groundwater to the east is likely to be in hydraulic connection with the river based upon the level and pattern of observed groundwater contours. The new well, RM05, is closest in proximity to the Morrell River and in February and March 2017 it had a groundwater level of 79.31 mAOD and 79.37 mAOD respectively suggesting the river and groundwater are in hydraulic connection.

To the south of the site, recorded groundwater levels during Quarter 1 of 2017 were in the region of 79 to 81 mAOD. There are a number of wells in the area which appear to be perched levels with, for example, BH2 (84.72 mAOD to 84.78 mAOD), DB09 (87.68 mAOD to 87.97 mAOD) and DB10 (88.25 mAOD to 88.36 mAOD) all having water levels much higher than measured at the other wells in this part of the site. There are also a number of high groundwater levels recorded at a number of the new waste boreholes in Zones 2 and 3, again likely to be perched water levels.

Previous spot measurement of the water level in the canal feeder drain has shown this feature to be at an elevation of around 80.6 mAOD adjacent to the site (monitoring point SW10). This suggests as previously that the canal feeder may be in hydraulic connection with groundwater, although the observed general groundwater flow direction (i.e. south to north) indicates that there is likely to be little groundwater input to this stream from the vicinity of the site. A very flat hydraulic gradient is observed in the south-east of the site in Zone 4.

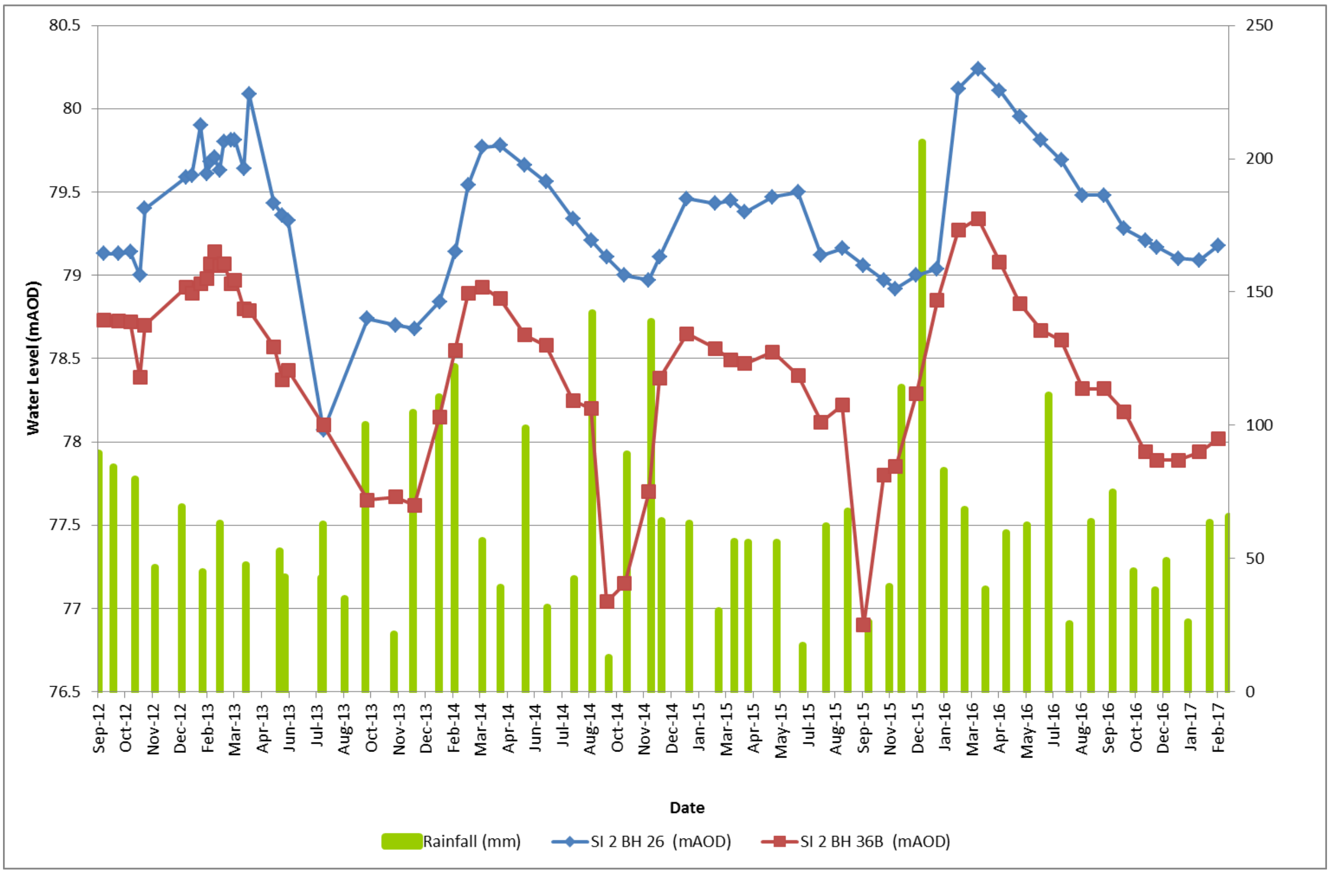
There are ten monitoring wells in the bedrock aquifer from which water levels were obtained during the quarter's sampling rounds (EMW12, EMW19, EMW22, EMW24, GW1D, BH68 and BB01 to BB04). The pattern of inferred contours is shown in Figures 5a to 5c and as with previous monitoring rounds shows a generally south to north flow. Water levels measured in the bedrock generally increased throughout the quarter at all wells with the largest overall increase recorded at EMW24 at 0.59m between December 2016 and March 2017.

Comparison of measured water levels between the overburden and bedrock aquifers for Quarter 1 2017 indicates higher water levels within the overburden deposits across the site. This is consistent with previous observations and provides a mechanism for potential downward flow of groundwater (and potential contamination) from the wastes in the landfill into the bedrock aquifer.

With respect to groundwater levels and the base of the waste in Zone 1, the data show that over much of the zone, the waste was above the groundwater level in Quarter 1 of 2017. However, in an area in the centre and north-east of Zone 1 (and parts of Zone 2B) the waste is recorded to be at, or slightly deeper than 80 mAOD which would indicate that the wastes in these areas is below the groundwater table.

Graph 2.3 shows the groundwater levels recorded in BH26 and BH36B, situated in the north-eastern part of the site (Zone 1) since their installation in August 2012. It can be seen that the groundwater levels began to recover in both wells during the quarter, having been continually reducing since the highest levels recorded in March 2016. The above average rainfall from November 2015 to February 2016 (including almost three times the average in December 2015) is likely to have caused those high groundwater levels. The below average rainfall for the second half of 2016 caused the downward trend in levels since March 2016. The increase in rainfall during February and March 2017 have caused the groundwater levels at these wells to begin increasing again.

Graph 2.3: Variations in Water Levels in BH26 and BH36B (showing rainfall)



2.1.2 Groundwater Flux

Previous estimates of the groundwater flux from Zone 1 to the Morell River have been made ranging from 160 to 640 m^3/day with the data used in the calculations shown below.

Approximate width of groundwater flow to Morell River	500 m
Sand/Gravel aquifer thickness	2.5-5 m
Hydraulic gradient beneath north-east boundary	0.005-0.02 (unitless)
Hydraulic conductivity (median for 2012 off-site wells)	25.4 m/day
Darcy velocity (calculated)	0.13-0.51 m/day
Actual velocity (calculated) assuming 25-30% porosity	0.4-1.7 m/day
Groundwater flux estimate	160-640 m^3/day

Estimated groundwater velocity is quite high at 0.4-1.7 m/day (146-620 m/year), even using the median hydraulic conductivity value. The sand and gravel aquifer seems to have high permeability and the hydraulic gradient is inevitably steep as the topographic gradient steeply falls away from the landfill to the river valley.

The resultant groundwater flux is therefore estimated at 160-640 m3/day. The mean flow in the Morell River adjacent to the site has been measured from 2009 to 2013 at 66,500 m3/day. Therefore, based on these data there is a dilution factor for any groundwater contaminants discharging to the river of between 415 and 104. However, it should be noted that during the 2016 site investigation, measurements of hydraulic conductivity at the time of drilling showed much lower hydraulic conductivity values (typically 0.1 m/day to 1 m/day). Using these values for the hydraulic conductivity will result in less water discharging to the river and a higher dilution rate.

2.2 Groundwater Results

The following sections describe and relate observed groundwater parameters measured in the field and reported by the laboratory. The nature, magnitude and extent of contaminants of primary concern are discussed. Trend graphs are provided for key indicator parameters and the trends observed in each of the zones are discussed. The below section should be read in conjunction with Figure 3 Groundwater and Surface Water Monitoring Locations.

2.2.1 Field Measured Groundwater Parameters

Field-measured parameters comprising pH, dissolved oxygen, electrical conductivity (EC), temperature and redox potential, were recorded during purging and sample collection.

The measurements are presented in appended Table A.2 and summarised below.

Table 2.2: Quarter 1 2017 Field Results

Parameter	Unit	Month	Range	Location of min/max results	IGV
pH	-	Jan-17	6.5 to 7.2	EMW16 / EMW06	6.5-9.5
		Feb-17	6.5 to 8.0	EMW16 / BH71	
		Mar-17	6.5 to 8.1	EMW16 / BH71	
Dissolved Oxygen (DO)	mg/l	Jan-17	0.2 to 8.4	EMW03, EMW13, EMW15, BH42 / EMW06	No abnormal change
		Feb-17	0.1 to 9.6	BH42, DB03, RCBB01, BH68, BH71, BH72 / DB09	
		Mar-17	0.1 to 10.1	RM01, BB01, BH71 / DB09	
Electrical conductivity (EC)	µS/cm	Jan-17	523 to 3268	EMW06 / BH26	1,000
		Feb-17	371 to 3570	DB09 / EMW13	
		Mar-17	439 to 3448	DB09 / DB02	
Redox potential (Eh)	mV	Jan-17	-103 to +235	EMW13 / EMW12	-
		Feb-17	-97 to +284	EMW15 / EMW11	
		Mar-17	-114 to +343	BH71 / BH68	
Temperature (T)	°C	Jan-17	9.7 to 28.3	EMW08 / BH26	25
		Feb-17	7.4 to 28.2	RM02 / BH26	
		Mar-17	8.2 to 28.0	RM01 / BH26	

IGV –Interim Guideline Values

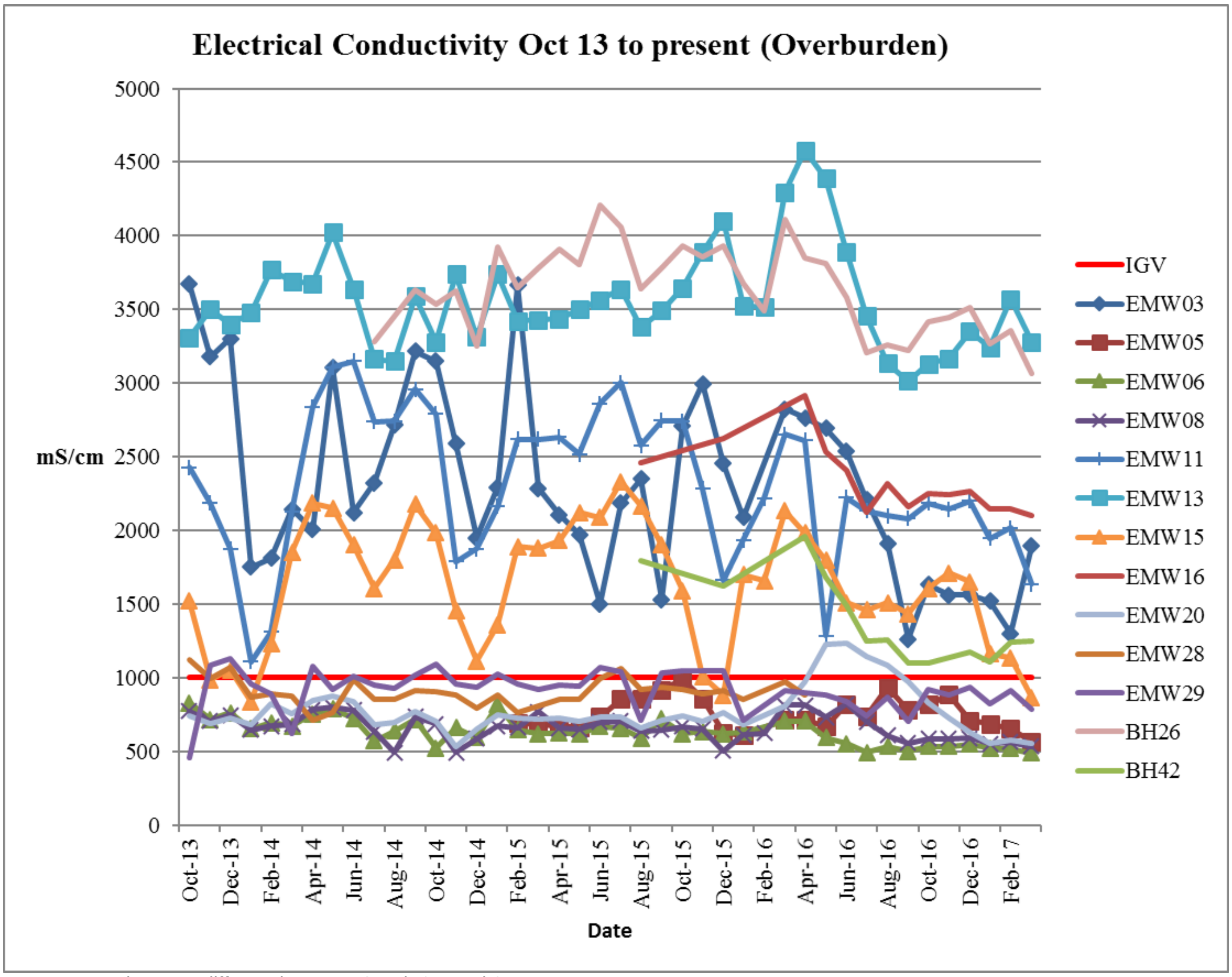
The following general observations are made in relation to the field-measured parameters. In common with earlier monitoring rounds, EC readings were generally above the IGV of 1,000 µS/cm in on-site monitoring wells and some boundary wells, including new wells DB02 and DB03 north of the site within the grounds of Kerdiffstown House. In off-site monitoring wells the majority of EC readings were below the IGV.

Graph 2.4 shows the variation in EC readings for overburden monitoring wells that are monitored monthly. These include on-site locations in Zone 1 and near to the north-eastern site boundary. It can be seen that there are some seasonal variations in EC values, which is most pronounced in EMW03, EMW11, EMW13 and EMW15.

As previously, BH26 recorded the highest EC value at 3,268 µS/cm in January 2017, which is a decrease on December 2016. However, in February 2017, EMW13 recorded the highest EC of all of the wells sampled at 3570 µS/cm, while new well DB02 had the highest EC value in March 2017 at 3448 µS/cm (DB02 was only sampled in March 2017 in Quarter 1 2017). All three of these wells are to the north, with BH26 and EMW13 being in Zone 1 of the site and DB02 being just to the north of Zone 1.

Some of the north-eastern boundary well readings were above the IGV in some instances. The highest of these was recorded in new northern boundary monitoring well DB02 (3448 µS/cm in March 2017). This monitoring well is very close to the northern boundary of the landfill and the result is consistent with readings from nearby on-site well EMW13.

Graph 2.4: Overburden Electrical Conductivity Variations (Oct 2013 to present)

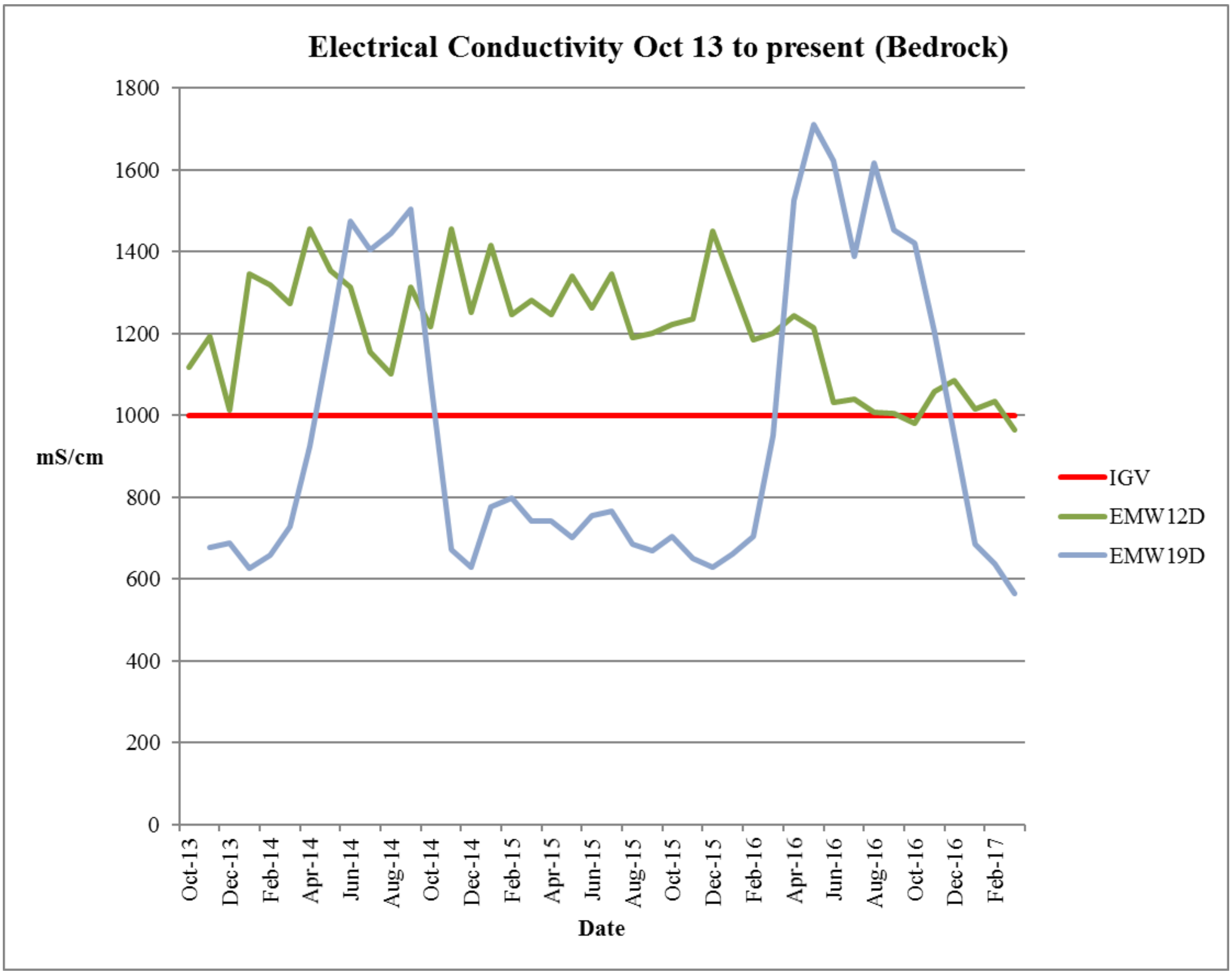


Note: Axes values are different between Graph 2.4 and 2.5

Graph 2.5 shows the EC values for samples from two of the bedrock wells, namely EMW19D and EMW12. The value for the sample from EMW19D has continued to decrease since August of 2016 with the March 2017 reading of 565 µS/cm being the lowest ever recorded in this well. The electrical conductivity measured at EMW12 has fallen below the IGV to 965 µS/cm, representing only the second time that the EC has been below the IGV in this well.

Of the new wells, only BH68, located within the site, had an EC value above the IGV of 1000 µS/cm. The value was approximately 1200 µS/cm for both February and March 2017 in this well. All other new bedrock wells had EC values significantly below the IGV, ranging between 497 µS/cm and 748 µS/cm.

Graph 2.5: Bedrock Electrical Conductivity Variations (Oct 2013 to present)



Note: Axes values are different between Graph 2.4 and 2.5.

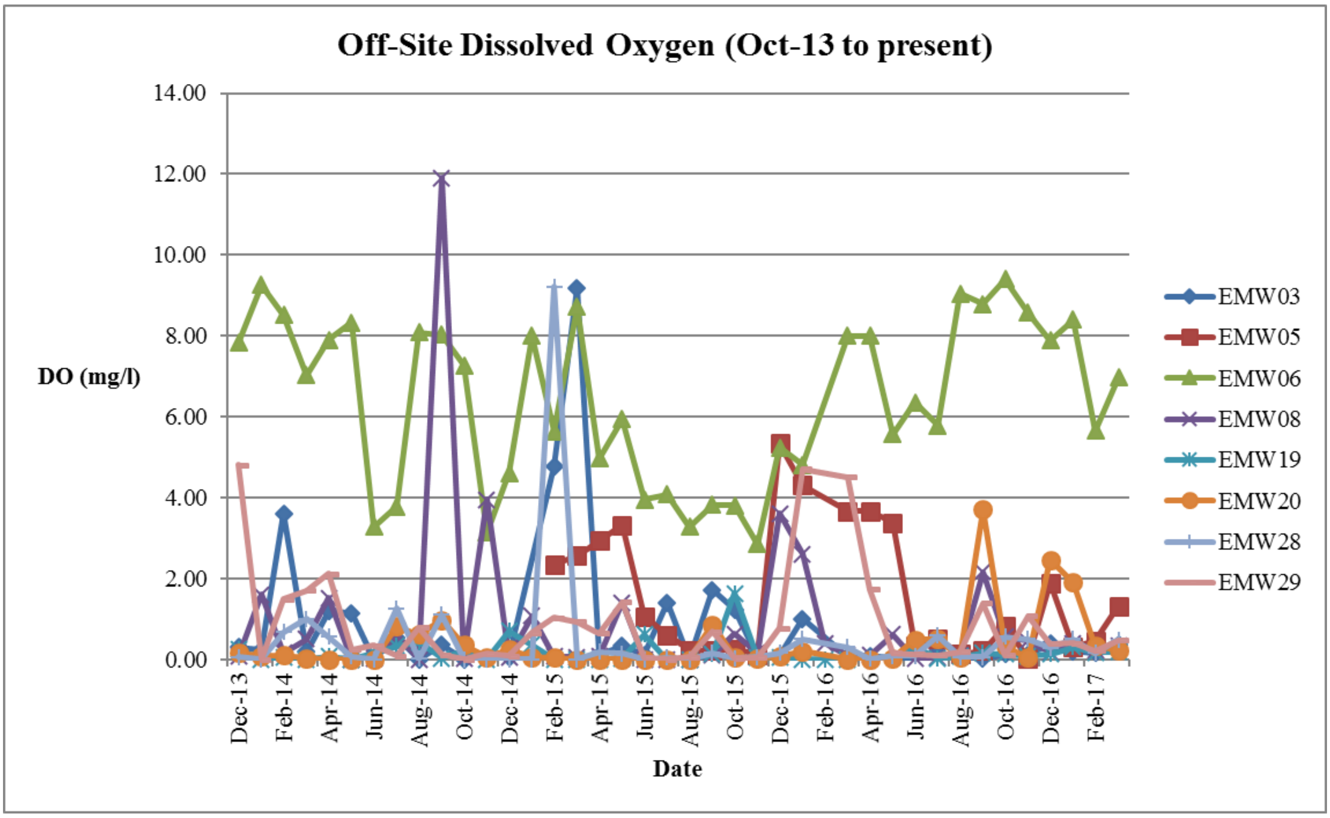
Groundwater redox potential was found to be negative (reducing) in monitoring wells situated within Zone 1 of the site and also within monitoring wells close to the north-east and east of the site (e.g. EMW08, EMW15, EMW19, EMW20 and new wells DB05, DB06, RCBB01 and BB01). On-site wells in the south-eastern end of the site were also found to be generally reducing (BH42 BH69, BH70, BH71, and BH72). Only occasional slight reducing-type odours were noted in monitoring wells where negative redox conditions were observed.

Dissolved oxygen (DO) readings show generally consistent concentrations month on month as shown in Graphs 2.6 and 2.7. The highest DO reading of all wells monitored during Quarter 1 was in new well DB09, located just outside of the site boundary near the south-east corner (10.1 mg/l in March 2017). Many of the other off-site and boundary boreholes measured generally low DO concentrations (less than 2 mg/l) with the exception of EMW06 (8.4 mg/l in January, 5.7 mg/l in February and 7 mg/l in March), RM02 (3.5 mg/l in February and 4.7 mg/l in March), DB02 (2.3 mg/l in March), DB04 (4.4 mg/l in March), DB05 (3.8 mg/l in February and 5.1 mg/l in March), DB10 (8.1 mg/l in February and 9 mg/l in March), BB02 (7.5 mg/l in February and 6.8 mg/l in March) and BB03 (4.5 mg/l in February and 3.2 mg/l in March).

Similarly, on site wells tended to have generally low DO concentrations (less than 2 mg/l), with the exception of EMW11 and EMW12. EMW11 rose from 3.8 mg/l in January to 6.9 mg/l in February to 7.5 mg/l in March, while

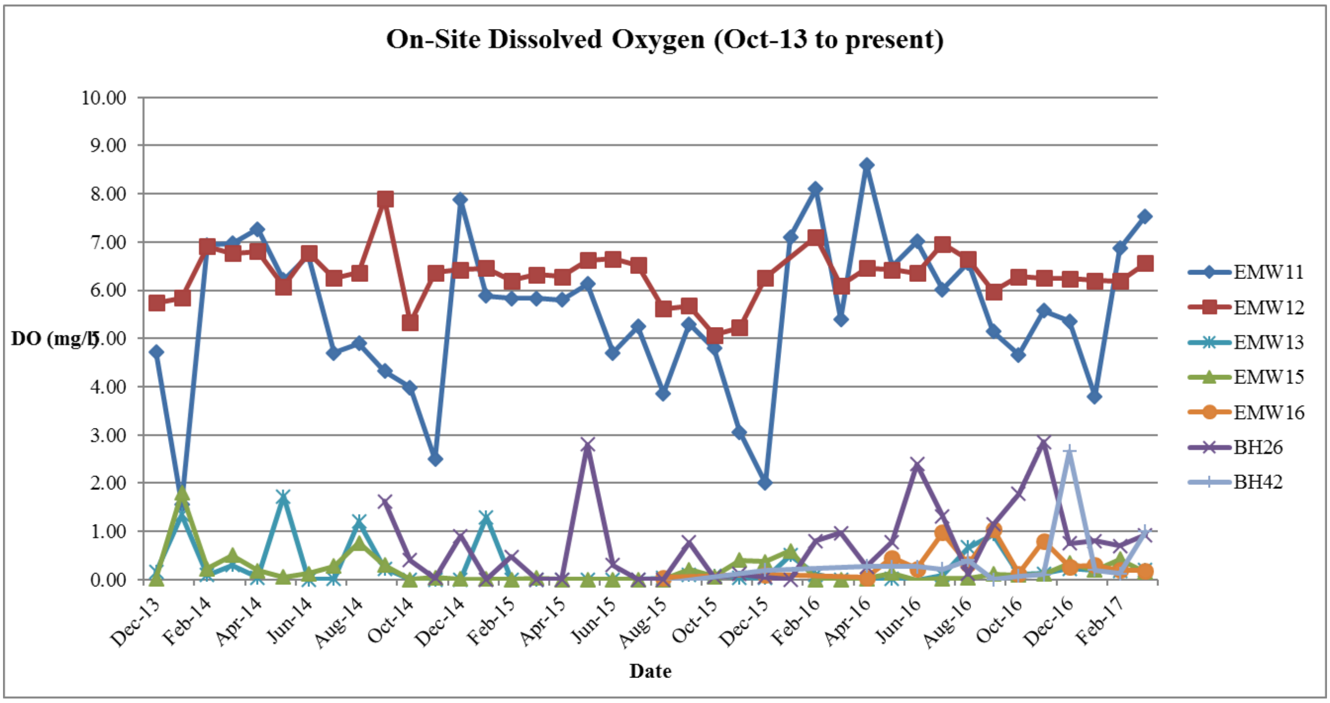
EMW12 was less variable with the concentration at 6.2 mg/l for January and February, increasing slightly to 6.6 mg/l in March.

Graph 2.6: Field Recorded Dissolved Oxygen Readings – Off-Site



Note: Axes values are different between Graph 2.6 and 2.7

Graph 2.7: Field Recorded Dissolved Oxygen Readings – On-Site



Note: Axes values are different between Graph 2.6 and 2.7.

Groundwater temperatures in on and off-site monitoring wells were within the range of those recorded during previous sampling rounds. EMW13 (17.3 to 19.6°C in Quarter 1 2017) has been noted as having a consistently high temperature previously. During sampling rounds completed since October 2013 high temperatures have also recorded in BH26 (28 to 28.3°C in Quarter 1, 2017). These temperatures noted within Zone 1 are thought to be as a result of the microbial activity within the decomposing waste mass. The consistently elevated temperatures seen in EMW13 are likely being heated by groundwater flow from beneath the waste mass in the direction of EMW13.

pH displayed little variability when compared to previous sampling events recorded since October 2013.

2.2.2 Laboratory Analytical Results – Groundwater

During Quarter 1 of 2017 sampling was undertaken each month. Samples were collected from 15 existing wells and tested for a reduced suite of parameters as was done monthly throughout 2016. In addition to these 15 wells, wells which were installed in late 2016 were also sampled. In February 2017 there were a total of 23 new wells sampled for a full biannual suite with the remaining 22 new wells noted to be dry or having insufficient water in them to sample. In March the new wells were sampled again, with 24 wells containing sufficient water to obtain a sample. All of these wells were sampled for a reduced monthly suite, with the exception of DB02 which was sampled for the extended suite as this was the first time this well could be sampled. The sampling undertaken is outlined in Tables A.1a to A.1c.

Summaries of the analytical results are presented in Tables A.3, A.5, A.6 and A.6a. For the organic compounds, only those compounds detected in at least one monitoring well are listed in the relevant table.

A summary of the Quarter 1 2017 results is presented below. The laboratory reports containing the complete set of analytical data for the monitoring are included in Appendix B.

In order to ensure consistency with previous monitoring rounds and in order to follow current best practice, analysis, results for individual determinands have been screened against EPA Interim Guideline Values (IGVs)[9] and Groundwater Threshold Values (GTVs)[10] where they currently exist.

2.2.2.1 Ammoniacal Nitrogen, Major Ions, Alkalinity, COD and Chloride

Recovered groundwater samples have been analysed for the following: ammoniacal nitrogen (as an indicator of ammonia presence), major ions, alkalinity, iron and manganese, TOC, BOD and COD. These determinands are often found to be elevated in groundwater which has mixed with landfill leachate and are therefore good indicators of potential leachate impact. Table A.3 includes major ion and ammoniacal nitrogen results. TOC, BOD and COD results are included in Table A.5. Trend graphs are provided for each of the determinands split between the overburden and bedrock monitoring wells (also refer to Figures 3, 7a to 7c and 8a to 8c).

Ammoniacal Nitrogen

At sites such as Kerdiffstown where there is a history of disposal of municipal and commercial waste streams, ammoniacal nitrogen can typically be present at relatively high concentrations within leachate[11]. Important groundwater nitrogen species include ammoniacal nitrogen (linked to ammonia and ammonium from landfill leachate), nitrate (NO3) and nitrite (NO2). The latter is a transitional species and is usually present at relatively trace concentrations (as has been the case at Kerdiffstown Landfill). The IGV for ammoniacal nitrogen is set at 0.12 mg/l.

Graphs 2.8 and 2.9 show the variation in ammoniacal nitrogen concentrations for a select number of overburden and bedrock wells. Figures 7a to 7c provide a graphical interpretation of the ammoniacal nitrogen distribution across the site.

On-Site Wells

Graph 2.8 shows that EMW13, in Zone 1, consistently contains the highest ammoniacal nitrogen concentrations of all monthly wells. In Quarter 1 of 2017, the concentration ranged from 191 mg/l to 213 mg/l, representing increasing concentrations over the quarter. The March concentration of 213 mg/l is the highest ever recorded at EMW13 since monitoring began in June 2011.

BH26, also in Zone 1, consistently shows elevated concentrations of ammoniacal nitrogen. During Quarter 1 2017 the results ranged from 134 mg/l to 144 mg/l. The concentrations in BH26 steadily increased since monitoring began in October 2012 (29.7 mg/l) until June 2015 (142 mg/l). The concentrations were then seen to gradually decrease until April 2016 (100 mg/l), after which ammoniacal nitrogen concentrations were noted to increase gradually, possibly indicating a seasonal fluctuation. The January 2017 ammoniacal nitrogen concentration of 144 mg/l was the highest ever recorded in BH26.

Also within the northern part of the site (Zone 1A) is the bedrock well EMW12, where the ammoniacal nitrogen concentration has continued to remain below the LOD of 0.06 mg/l since March 2015.

EMW11 located in Zone 2A also continued to show ammoniacal nitrogen concentrations below the LOD throughout Quarter 1 of 2017, which has been the case since monitoring began here in June 2011.

Monthly wells EMW15 and EMW16 located along the north-east edge of the site continued to record relatively high ammoniacal nitrogen concentrations throughout Quarter 1 2017. EMW15 decreased through the quarter from 10.8 mg/l in January 2017 to 7.31 mg/l in March. In contrast, the concentration in EMW16 increased from 6.64 mg/l to 7.73 mg/l in the same period.

9 Environmental Protection Agency. Towards Setting Guideline Values for the Protection of Groundwater in Ireland. Interim Report.

10 Methodology for Establishing Groundwater Threshold Values and the Assessment of Chemical and Quantitative Status of Groundwater, Including an Assessment of Pollution Trends and Trend Reversal, EPA, 2010.

11 This is evidenced by routine chemical analysis of the leachate which is currently collected and removed from the lined cell in Zone 3 of the site where ammonia is detected.

Further east towards the north-east corner of the site, new well BH69 recorded an ammoniacal nitrogen concentration of 19.9 mg/l in February 2017. This was the highest ammoniacal nitrogen concentration recorded on-site outside of Zone 1. During this sampling round the well ran dry as it was being sampled. No sample was possible in March 2017 due to insufficient water in the well.

New wells BH70 in the lower yard of the site and BH71 beside the lined cell (Zone 3) had relatively high ammoniacal nitrogen concentrations during Quarter 1 2017. BH70 had concentrations of 6.73 mg/l and 6.52 mg/l in February and March respectively, while BH71 had concentrations of 6.75 mg/l and 7.21 mg/l in February and March 2017 respectively. Ammoniacal nitrogen concentrations in nearby monthly well BH42 increased from 3.31 mg/l to 4.1 mg/l from January to March 2017. Concentrations have generally remained steady in this well since monthly monitoring began in April 2016.

The remaining new wells on site showed relatively low ammoniacal nitrogen concentrations compared to the aforementioned wells; although most were still above the IGV of 0.12 mg/l. Bedrock well BH68 in Zone 2A had an ammoniacal nitrogen concentration below the LOD. Nearby in BH77 the ammoniacal nitrogen concentration exceeded the IGV in both months at 0.43 mg/l in February and 1.58 mg/l in March 2017. BH78 in Zone 2B during Quarter 1 had concentrations of 0.09 mg/l and 0.27 mg/l. In the south of the site, BH72 near the lined cell also had an ammoniacal nitrogen concentration above the IGV increasing at 0.15 mg/l in February and 0.22 mg/l in March.

Boundary Wells

Ammoniacal nitrogen concentrations remained elevated at some monitoring boreholes along the north and north-eastern boundary area of Zone 1. At EMW03, the ammoniacal nitrogen concentration ranged from 17.7 mg/l to 38.3 mg/l through the quarter. This includes a relatively large increase between February and March from 17.7 mg/l to 38.3 mg/l. The concentration in EMW03 tends to fluctuate a great deal which may reflect seasonal fluctuations with higher concentrations generally observed when rainfall and groundwater recharge are lower. EMW03 is almost consistently above the IGV despite these fluctuations.

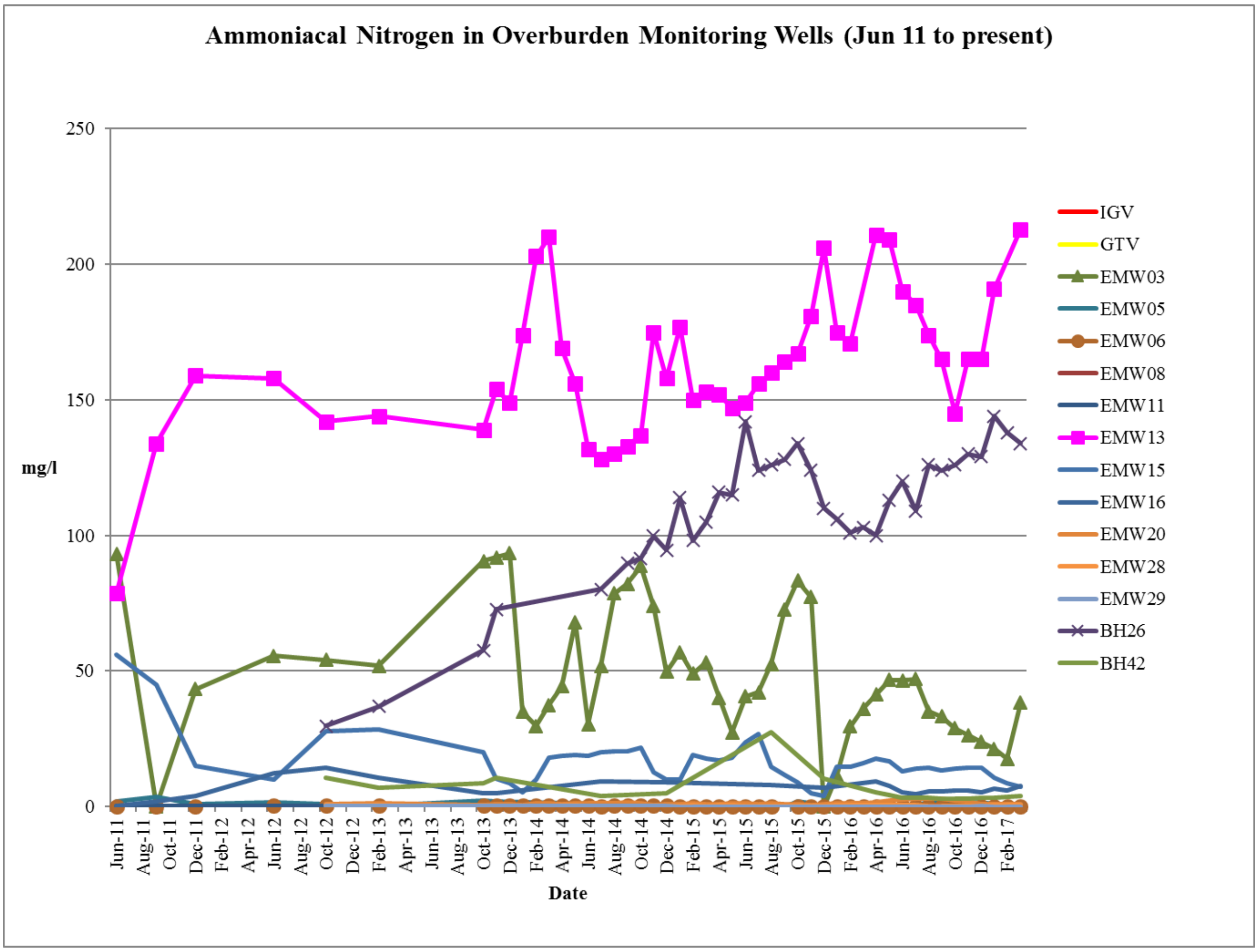
Nearby well EMW06 continued to have an ammoniacal nitrogen concentration below the LOD throughout the quarter, however it is likely that EMW06 is in a perched aquifer and therefore not representative of groundwater conditions in the area. However a number of new wells along that boundary, namely BB02 and DB04 near to EMW06 and DB05 to the south-east of EMW03 did not contain ammoniacal nitrogen above the LOD during the quarter. This indicates that the off-site impact due to leachate migration to the north-east remains localised.

In addition to the impact on the north-east boundary, there is evidence of impact to the north of the site as seen in new well DB02 in March where the ammoniacal nitrogen concentration was recorded at 1.36 mg/l. DB02 is near to the on-site well EMW13 and new off-site well DB03. All three wells in this area showed ammoniacal nitrogen concentrations in exceedance of the IGV.

Further to the south-east of EMW03 there are a number of wells along the site boundary, namely BB01, RCBB01, EMW19, DB06 and BB04. Monthly well EMW19 continued to show ammoniacal nitrogen concentrations decreasing from the high of 5.84 mg/l recorded in October 2016, with concentrations falling through Quarter 1, 2017 from 2.21 mg/l to 1.53 mg/l. To the north-west of EMW19, new boundary wells BB01 (1.93 mg/l to 1.75 mg/) and RCBB01 (1.97 mg/l and 1.77 mg/l) recorded similar ammoniacal nitrogen concentrations with decreasing trends evident. To the south-east of EMW19 new well DB06 remained steady during the quarter at 0.65 mg/l. Finally new well BB04, further to the south-east again recorded a concentration of 0.32 mg/l in February and 0.23 mg/l in March 2017. All of these wells were in exceedance of the IGV (0.12 mg/l) throughout the sampling undertaken during Quarter 1 of 2017.

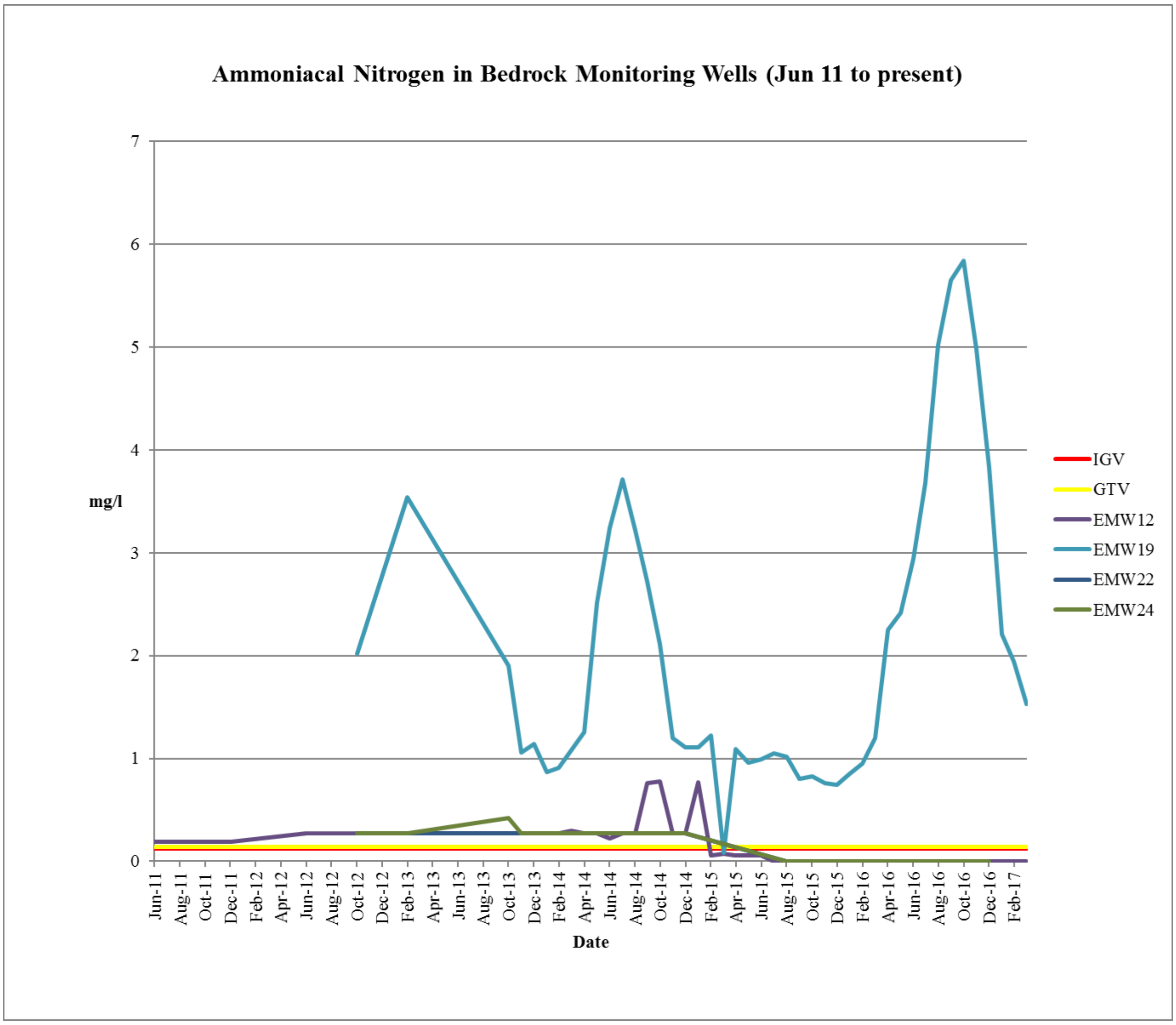
DB10 near the southern site boundary recorded ammoniacal nitrogen concentrations below the LOD in February and at 0.58 mg/l in March 2017.

Graph 2.8: Ammoniacal Nitrogen in Overburden Monitoring Wells (June 2011 to present)



Note: Axes values are different between Graph 2.8 and 2.9

Graph 2.9: Ammoniacal Nitrogen in Bedrock Monitoring Wells (June 2011 to present)



Note: Axes values are different between Graphs 2.8 and 2.9.

<u>Off-Site Wells</u>

For the off-site wells sampled during Quarter 1, 2017, DB03 north of the site behind Kerdiffstown House recorded the highest ammoniacal nitrogen concentration at 6.38 mg/l to 6.96 mg/l during the two months in which it was sampled. All other results during Quarter 1 were below 1.5 mg/l, with approximately half below the IGV of 0.12 mg/l.

Ammoniacal nitrogen concentrations recorded in DB03, were noted to be 6.38 mg/l in February 2017 and 6.96 mg/l in March 2017. The location of this well to the north of Zone 1, in the vicinity of on-site well EMW13 and boundary well DB02, suggests that contamination is migrating from the site in a northerly direction following the estimated flow direction of the groundwater based on groundwater level measurements.

Aside from DB03 there were five other off-site wells in Kerdiffstown House which had ammoniacal nitrogen concentrations in exceedance of the IGV, namely EMW05, EMW20, RM03, RM04 and RM06. At EMW05, the ammoniacal nitrogen concentration continued to reduce, falling from 0.91 mg/l in January to below the LOD (0.06 mg/l) in March 2017.

At EMW20, adjacent to the Morell River, the ammoniacal nitrogen concentration increased from 0.79 mg/l in January to 0.89 mg/l in March 2017. This represents the first increase since September 2016 when the concentration began to fall following a period of abnormally high concentrations. This likely represents a seasonal trend in this borehole.

A series of new wells adjacent to the Morell River (RM03, RM04 and RM06) all had concentrations above the IGV during both sampling rounds. In all three instances the March result was noted to be lower than the February with ammoniacal nitrogen concentrations in RM03 dropping from 0.67 mg/l to 0.60 mg/l, in RM04 from 1.45 mg/l to 0.84 mg/l and in RM06 from 0.33 mg/l to 0.29 mg/l.

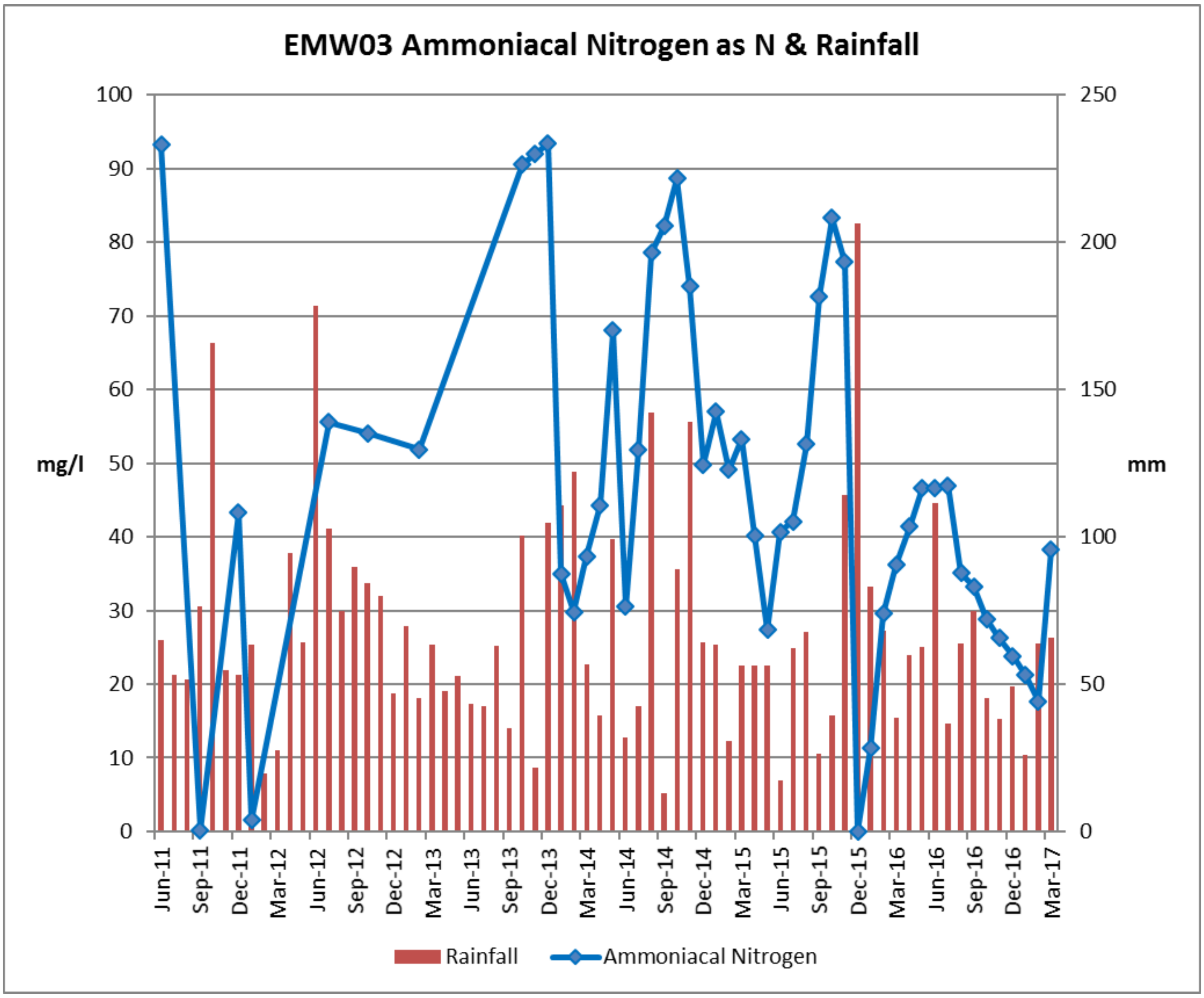
In Foley's field located south of the site, EMW28 was consistently above the IGV for ammoniacal nitrogen. The concentration here ranged from 0.5 mg/l to 0.61 mg/l during the quarter, remaining below the peak for this well of 0.7 mg/l recorded in July 2016. The ammoniacal nitrogen concentration in this well has fluctuated greatly in the past and has been consistently in exceedance of the IGV.

All other off-site wells had ammoniacal nitrogen concentrations below the IGV of 0.12 mg/l.

Evidence of Seasonal Variation

At EMW03 (Graph 2.10) the concentration of ammoniacal nitrogen can be seen fluctuating with higher concentrations observed during drier periods (e.g. Q4 2013) followed by lower concentrations after increases in rainfall and groundwater recharge in Q1, 2014. In December 2015 rainfall was recorded at 206 mm, the highest monthly total since monitoring commenced by the EPA in 2011 and almost three times the historical monthly average of 76 mm (1981 to 2010). This followed a relatively wet November in 2015 (with 155% of the monthly average). The corresponding ammoniacal nitrogen concentration recorded in EMW03 during December 2015 was below the LOD (0.06 mg/l) for the first time since monitoring commenced. Given that the average concentration of ammoniacal nitrogen at EMW03 is approximately 52 mg/l this shows the diluting effect of rainfall on the observed concentrations. In 2016, concentrations again increased, peaking in July (47.0 mg/l) and have subsequently decreased, even though the rainfall following June has been below the long term average and groundwater levels have continued to fall. In March 2017 the ammoniacal nitrogen concentration increased greatly.

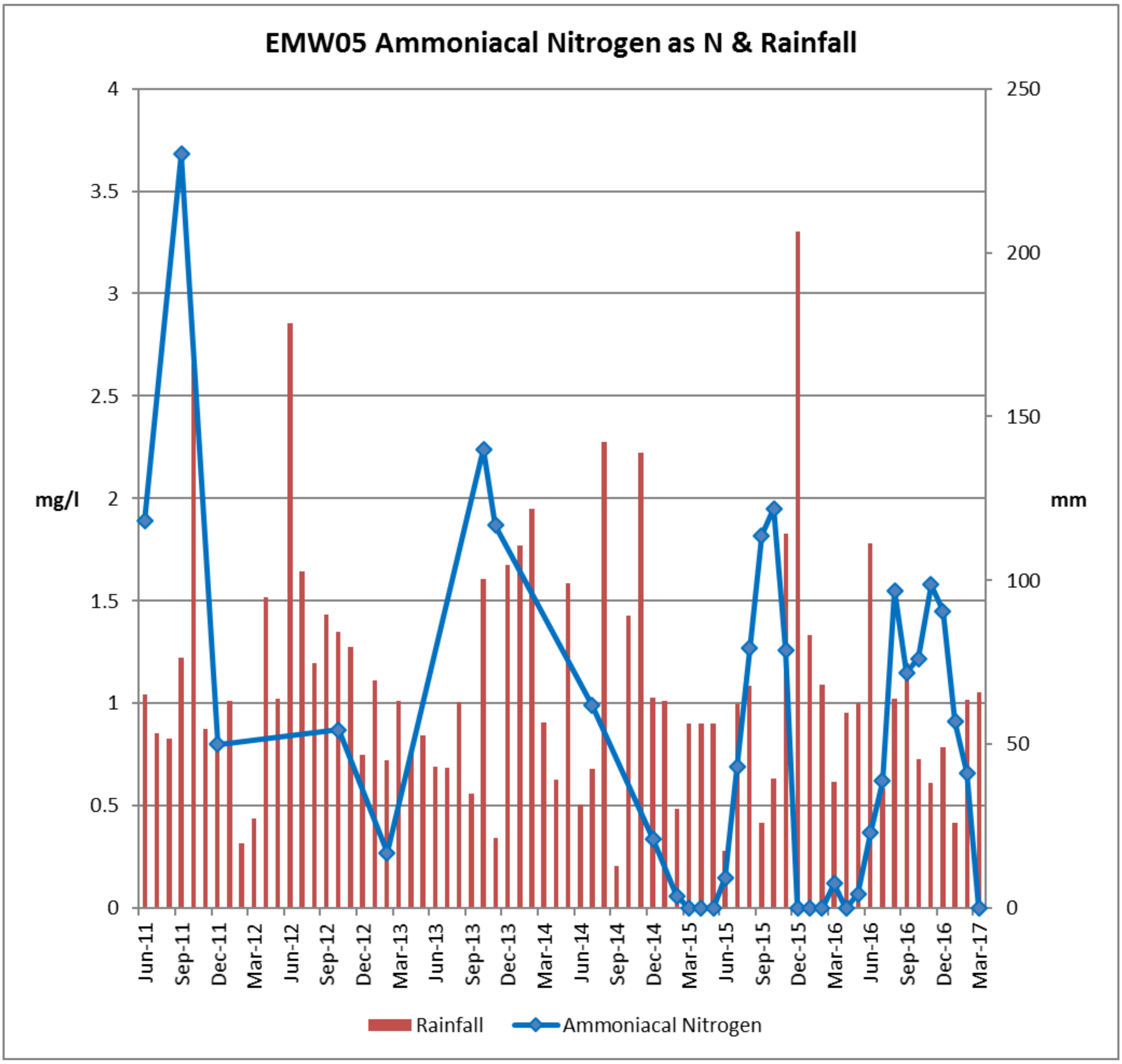
Graph 2.10: EMW03 Ammoniacal Nitrogen and Rainfall



Note: Axes values are different between Graphs 2.10, 2.11 and 2.12.

In EMW05 (Graph 2.11), a monitoring well completed relatively close to the Morell River, the ammoniacal nitrogen concentration decreased from 1.45 mg/l recorded in December 2016 to below the LOD in March 2017. Seasonal variation has been observed in this borehole previously with the IGV breached from June to November 2015 when concentrations ranged from 0.15 mg/l to 1.95 mg/l, following which there were six months where ammoniacal nitrogen concentrations were recorded below the IGV, followed by a similar pattern from June 2016 to February 2017.

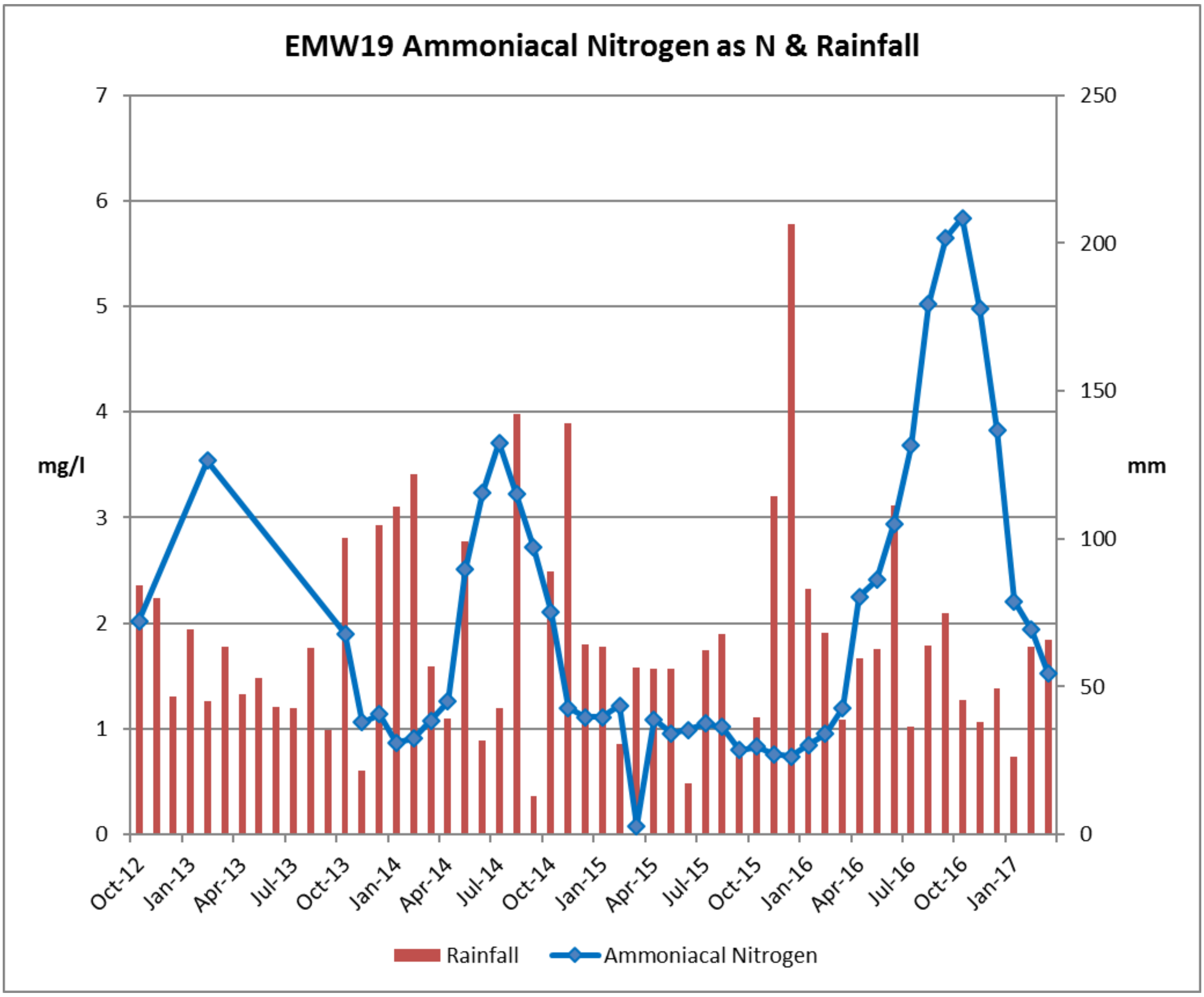
Graph 2.11: EMW05 Ammoniacal Nitrogen and Rainfall



Note: Axes values are different between Graphs 2.10, 2.11 and 2.12.

Ammoniacal nitrogen concentrations in EMW19 continued to decrease during the first quarter of 2017, decreasing from 2.21 mg/l in January 2017 to 1.53 mg/l in March 2017. EMW19 was the only bedrock well to record ammoniacal nitrogen above the IGV (0.12 mg/l) in Quarter 1 2017. The ammoniacal nitrogen concentration at EMW19 was noted to increase from December 2015 to October 2016. However, in recent months the concentrations have decreased. This may be due to seasonal fluctuation as recorded during the spring-summer of 2014 when an increase in ammoniacal nitrogen concentration was noted. Graph 2.12 shows ammoniacal nitrogen concentrations against rainfall since October 2012 when the well was installed. Decreasing amounts of rainfall and groundwater recharge since December 2015 have resulted in a gradual increase in ammoniacal nitrogen concentrations up until October 2016.

Graph 2.12: EMW19 Ammoniacal Nitrogen and Rainfall



Note: Axes values are different between Graphs 2.10, 2.11 and 2.12.

<u>**Nitrate**</u>

The IGV for nitrate is 25 mg/l, while the LOD is 3.1 mg/l. Graphs 2.13 and 2.14 show nitrate concentrations in overburden and bedrock wells respectively.

<u>On-Site Wells</u>

Nitrate concentrations in on-site monitoring wells during Quarter 1 2017 ranged from below the LOD (3.1 mg/l) to 90.1 mg/l. Nitrate was only detected above the LOD in four of the on-site wells during Quarter 1 2017, namely EMW11, EMW12, EMW13 and BH68. Of these, only EMW11 and EMW12 exceeded the IGV, as has been the trend on-site since monitoring began.

At EMW11, nitrate concentrations were noted to decrease through the quarter from 90.1 mg/l in January to 37.2 mg/l in March. The January 2017 concentration was the highest ever recorded in this well. EMW11 almost consistently contains the highest nitrate concentrations of all the on-site wells. There is a pattern of rise and fall seen in this well from 16.7 mg/l at its lowest in February 2014 to its peak of 90.1 mg/l in January 2017 representing a seasonal variation, with a general rise in the summer and fall in the winter.

Bedrock well EMW12 (Graph 2.14) recorded a fluctuating nitrate concentration ranging from 28.4 mg/l to 34.3 mg/l in Quarter 1. This well typically fluctuates around the GTV of 37.5 mg/l, with the lowest recorded concentration at 23.7 mg/l in March 2016 and the highest concentration at 47 mg/l in March 2015. New bedrock well BH68 also contained nitrate above the LOD at 18 mg/l and 21.8 mg/l in February and March respectively.

The nitrate concentration decreased at EMW13 from 6.1 mg/l to below the LOD through Quarter 1 2017. Nitrate concentrations at this well tend to fluctuate, with the highest concentration previously recorded at 10 mg/l in August 2016.

All other on-site wells did not contain nitrate above the LOD.

Boundary Wells

During Quarter 1 2017, all boundary wells had nitrate concentrations below the IGV of 25 mg/l with the exception of EMW03 and EMW06. EMW19, BB01, RCBB01, BB04, DB02, DB05, DB08 and DB10 had nitrate concentrations below the LOD of 3.1 mg/l.

In EMW03, there was a spike in the nitrate concentration towards the end of the quarter from 22.1 mg/l in January to 15.9 mg/l in February then to 154 mg/l in March 2017. Similar nitrate spikes have been recorded in the past at this well i.e. 165 mg/l in January 2014 and 185 mg/l in December 2015. A pattern of seasonality is emerging as more data is gathered (Graph 2.13). No other monitoring wells showed evidence of such a marked change in nitrate concentration during the monitoring period. An adjacent monitoring well, EMW02, has also shown some variability but not to the same extent (<3.1 mg/l to 83.3 mg/l), although this borehole is only sampled every six months so trends and spikes will not be as apparent.

EMW06, north-west of EMW03, recorded an unusual nitrate concentration in January 2017 of 36.1 mg/l as this well has been consistently below the LOD (3.1 mg/l). The result was queried with the laboratory; however no error was detected. The nitrate concentration returned to below the LOD for February and March. It is unknown what may have caused the unusual spike in concentration during January, 2017.

All other boundary wells were noted to be below the IGV for nitrate throughout the quarter. The concentration in BB02 adjacent to EMW06 ranged from 6.1 mg/l to 7.6 mg/l. A little further north along the site boundary, DB04 had a nitrate concentration of 11.4 mg/l. The only other boundary well to contain nitrate above the LOD was DB06 located on the eastern boundary near EMW19. This well recorded a concentration of 12.9 mg/l in February, reducing to below LOD in March. All other results were below the LOD.

Off-Site Wells

Nitrate was above the LOD in seven of the thirteen off-site wells in Quarter 1 2017. All but two of these seven wells were below the IGV (EMW05, EMW29, RM02, RM03 and BB03), with only EMW20 and DB03 exceeding the IGV at any point during the quarter.

At EMW20 nitrate was detected above the IGV at 29.7 mg/l in March 2017. This is the highest concentration ever recorded here and above the previous peak of 5.7 mg/l. This unusual result was queried with the laboratory and the data double checked with no error found. The nitrate concentration at EMW20 has consistently been near to or below the LOD of 3.1 mg/l during previous monitoring rounds therefore subsequent results will be closely monitored to check for a possible emerging trend.

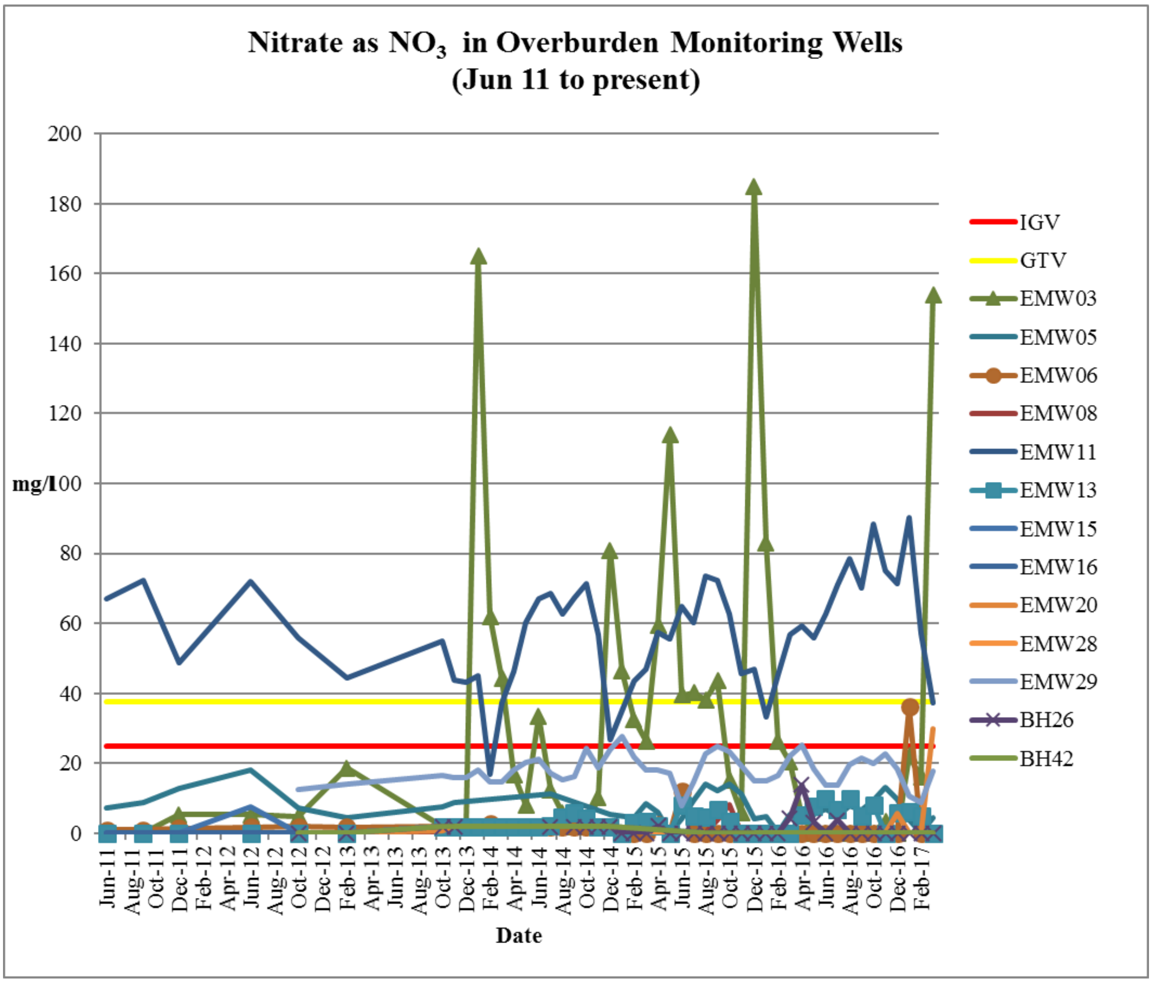
DB03, located north of the site, exceeded the IGV during February and March 2017, with a nitrate concentration of 28.5 mg/l and 30.7 mg/l respectively.

Aside from EMW20, a number of wells in the vicinity of the Morell River had low concentrations of nitrate present. EMW05 had a range of <3.1 mg/l to 4.5 mg/l over the quarter. RM02 recorded a concentration of 8.9 mg/l in February and 8.3 mg/l in March, while RM03 recorded a nitrate concentration below the LOD in February and 5.1 mg/l in March 2017.

In the fields to the south of the site, nitrate was detected above the LOD in EMW29, where it ranged from 8.7 mg/l to 17.8 mg/l over the quarter. These values are within previously recorded results at this well ranging from 7.8 mg/l to 27.7 mg/l.

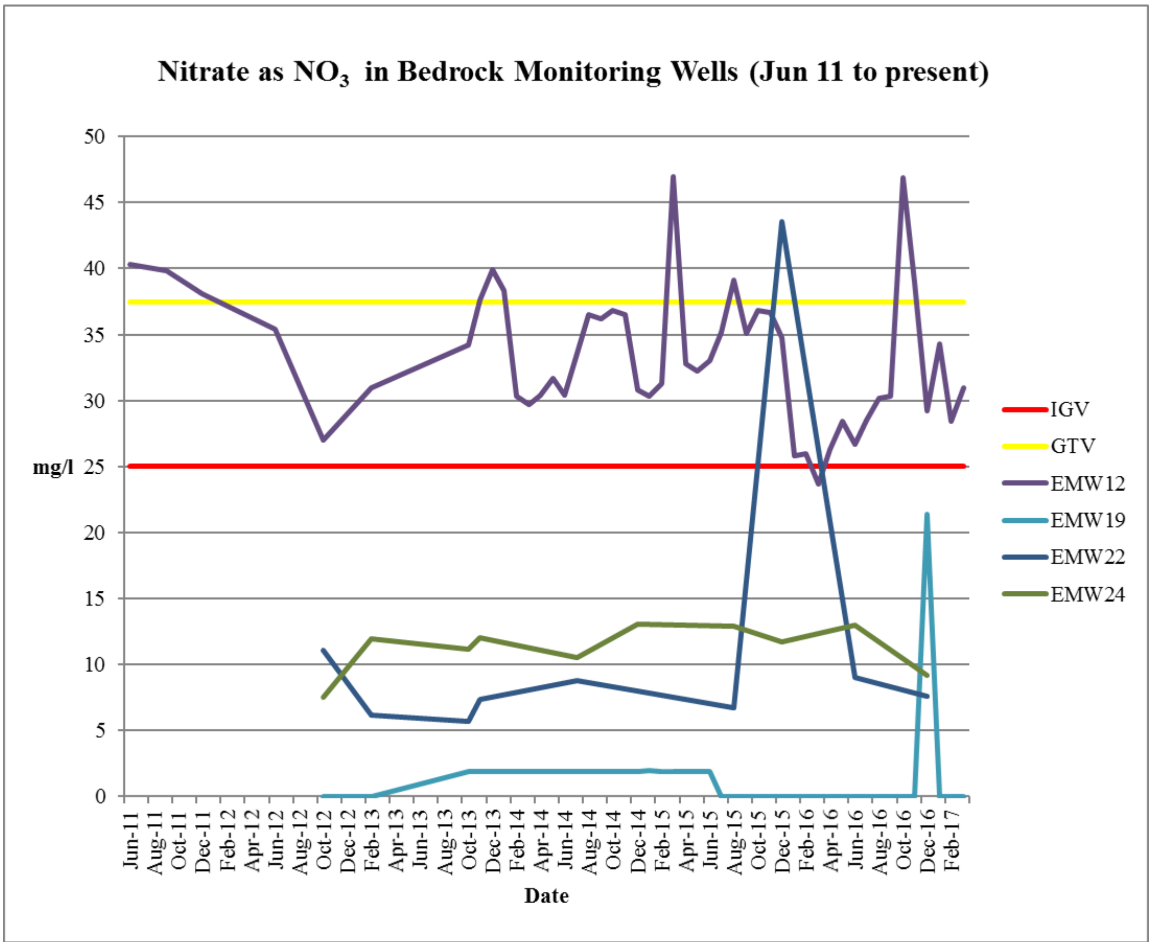
The nitrate concentration in nearby bedrock well BB03 was below the LOD in February and 4.1 mg/l in March 2017.

Graph 2.13: Nitrate as NO_3 in Overburden Monitoring Wells (June 2011 to present)



Note: Axes values are different between Graphs 2.13 and 2.14.

Graph 2.14: Nitrate as NO_3 in Bedrock Monitoring Wells (June 2011 to present)



Note: Axes values are different between Graphs 2.13 and 2.14.

Phosphate

Phosphates (analysed as total phosphate) can be elevated in landfill leachates compared to background groundwater or surface water concentrations. There is currently no IGV for total phosphate, with 0.03 mg/l being the IGV for orthophosphate only. The LOD is 0.37 mg/l. Phosphate was only monitored in the newly installed wells in February 2017 during Quarter 1 2017. Phosphate was detected above the LOD in 18 of the 25 wells sampled during the quarter.

On-Site Wells

Phosphate was detected in four of the seven wells sampled on site, namely BH68, BH69, BH77 and BH78. The highest concentration was recorded in BH69 in the eastern corner of the site at 3.06 mg/l. In the same month, BH77 near the centre of the site had a phosphate concentration of 1.9 mg/l. Nearby bedrock well BH68 recorded a concentration of 0.98 mg/l while BH78, also towards the centre of the site, had a phosphate concentration of 0.86 mg/l. BH70, BH71 and BH72 were all noted to be below the LOD, although in the case of BH72 the limit had to be raised by the laboratory to 7.35 mg/l due to interference from the internal standard.

Boundary Wells

Phosphate was detected above the LOD in seven of the nine boundary wells in Quarter 1 2017.

Phosphate was detected in all of the new wells along the boundary with Kerdiffstown House, namely DB02, BB02, DB05, BB01, RCBB01, DB06 and BB04. The highest boundary phosphate concentration was measured on the northern boundary at DB02 in March at 8.89 mg/l.

Moving south-east along the boundary from DB02, BB02 had a phosphate concentration of 1.16 mg/l. DB05 was higher at 4.29 mg/l, while BB01 and RCBB01 had concentrations of 2.57 mg/l and 4.6 mg/l respectively. Continuing south-east a phosphate concentration of 2.05 mg/l was recorded at DB06, with the lowest concentration being recorded in the furthest south-east well BB04 at 0.89 mg/l.

Phosphate was noted to be below the LOD around the south-eastern corner of the site, specifically at DB08 located near the south-east boundary in Foley’s field, and at DB10 on the southern site boundary.

Off-Site Wells

Seven of the eight new off-site wells sampled in Quarter 1 2017 had phosphate concentrations above the LOD of 0.37 mg/l. The highest phosphate concentration for all wells sampled was at BB03 located south-west of the site in Foley’s Field where a concentration of 11.65 mg/l was recorded. All other off-site wells sampled were located in the grounds of Kerdiffstown House.

Phosphate concentrations varied in the wells adjacent to the Morell River (RM01 to RM06). The highest of these was 5.52 mg/l detected at both RM01 and RM04. RM02 and RM03 in between these recorded 0.77 mg/l and 2.08 mg/l respectively. RM05 located further upstream of RM04 had a concentration below the LOD, while the well furthest upstream along the Morell had a concentration of 1.29 mg/l in February 2017.

The only other off-site well sampled in Kerdiffstown House was DB03 located behind the house. The phosphate concentration recorded here was 5.21 mg/l.

Alkalinity

Where dissolved organic matter derived from decomposing waste is present in leachate this can lead to removal of oxygen and nitrate from groundwater following mixing with leachate, which in turn can lead to increased concentrations of carbon dioxide in the groundwater and increased concentrations of alkalinity (a measure of carbonate and bicarbonate ion presence) due to dissolution of carbonate minerals in the aquifer, where they are present.

On-Site Wells

During Quarter 1 of 2017 there was little to no fluctuation in alkalinity concentrations in any of the sampled wells when compared with previous months, ranging from 135 mg/l to 5330 mg/l for Quarter 1, 2017. The only notable exception was at BH42 where there was a dramatic decrease in alkalinity recorded in March 2017, decreasing from 415 mg/l in February to 11.2 mg/l in March. This is the lowest concentration ever recorded in any of the wells and was queried with the laboratory. The result was checked and no errors were found. Subsequent concentrations will be closely monitored to check if a new trend is emerging at this location.

Of the new wells sampled on site during Quarter 1, BH69 contained the highest alkalinity concentration at 1330 mg/l in February 2017. There was insufficient water in the well for a sample in March. The next highest alkalinity concentration was recorded at BH72 in the south of the site. The alkalinity in this well was 1060 mg/l in February and 732 mg/l in March, 2017.

BH71, north of BH72, had the lowest on-site alkalinity concentration with 152 mg/l in February and 135 mg/l in March. Aside from the unusual low result in BH42, BH71 had the lowest alkalinity concentration of all wells sampled during the quarter.

Boundary Wells

Similar to the on-site wells, there was very little change to alkalinity concentrations in the boundary wells when compared to previous months. EMW03 fluctuated between 687 mg/l and 1070 mg/l during the quarter. Fluctuations in alkalinity are common in this well, with the Quarter 1 results within the previously recorded range for this well (75.7 mg/l to 1780 mg/l). As is usually the case, there was very little change in EMW06 throughout the quarter, ranging from 321 mg/l to 332 mg/l. Similarly, EMW19 had a stable alkalinity concentration decreasing slightly through the quarter from 346 mg/l in January to 312 mg/l in March 2017.

The alkalinity concentrations in the new boundary wells sampled during Quarter 1 were similar in the majority of wells, with most results ranging between 285 mg/l (DB06 in February) to 410 mg/l (DB05 in February). BB01, RCBB01, BB02, BB04, DB05, DB06 and DB08 were all noted to be within that range.

DB10 at the southern site boundary had a higher alkalinity during the quarter with 1380 mg/l and 2210 mg/l. DB02 on the northern site boundary had an alkalinity concentration of 4610 mg/l in March 2017. The highest alkalinity concentration of all wells sampled throughout Quarter 1 2017 was recorded in DB04 in March 2017 with a result of 12,700 mg/l. DB04 had been dry until March, 2017. When water was detected in March an attempt was made to develop and sample the well. However, the well kept going dry during development and was very silty when a sample was eventually taken. The increased amount of silt within the sample may account for the high alkalinity result.

Off-Site Wells

There was little to no change noted in alkalinity concentrations in many of the regularly sampled off-site monitoring wells during Quarter 1 of 2017. The only notable exception was at EMW20 where there was a spike in concentration going from 332 mg/l in December 2016 to 493 mg/l in January 2017, then back to 302 mg/l in February 2017. The concentration recorded at this spike was close to the previous peak in EMW20 at 497 mg/l (July 2016).

Of the new off-site wells sampled during the quarter, all were within the range of 268 mg/l to 506 mg/l except for DB03. These results are comparable to the concentrations recorded at the regularly sampled off-site wells. The lowest of these concentrations (268 mg/l) was recorded at RM05 in February 2017, and the highest (506 mg/l) was recorded in RM03 in February 2017. DB03, located north of the site behind Kerdiffstown House, recorded the highest alkalinity of all off-site wells in both February and March 2017 at 1020 mg/l and 1000 mg/l respectively.

Iron and Manganese

Iron and manganese oxides which may be present within the matrix of the overburden and bedrock aquifers can also be reduced within leachate impacted groundwater where oxygen concentrations are low leading to increased concentrations of total iron and manganese.

The IGV of 0.2 mg/l for iron and 0.05 mg/l for manganese was consistently exceeded in the majority of wells, both on-site and off-site, and in the overburden and bedrock. During Quarter 1 of 2017 there was only one well where the iron concentration was below the IGV, namely on-site bedrock well EMW12 where the IGV or LOD of 0.23 mg/l was not exceeded during any monitoring round in the quarter. There were only two exceptions when it came to manganese concentrations, namely again at EMW12 where the concentration ranged from 0.008 mg/l to 0.016 mg/l during the quarter, as well as off-site well EMW29 which was below the IGV in March when the concentration was recorded as being below the LOD of 0.007 mg/l.

On-Site Wells

During Quarter 1 of 2017, all wells with the exception of bedrock well EMW12 recorded iron and manganese concentrations above the IGV reflecting little to no change in both iron and manganese concentrations when compared to previous results. There was very little variation in iron and manganese concentrations at any of the on-site wells during the quarter.

The highest on-site concentration of both manganese and iron throughout the whole quarter was observed at BH72 in February 2017. The iron concentration was 69.4 mg/l, while the manganese concentration was 9.74 mg/l. In both cases, the concentrations in BH72 greatly reduced between February and March, with iron falling to 16.5 mg/l and manganese to 2.42 mg/l.

Boundary Wells

Iron and manganese were all within previous ranges at the regularly sampled wells EMW03, EMW06 and EMW19. EMW03 ranged from 28.9 mg/l to 55.1 mg/l iron and from 1.45 mg/l to 1.89 mg/l manganese during the quarter. Iron concentrations at EMW06 ranged between 1.21 mg/l and 1.99 mg/l, while manganese concentrations ranged from 0.249 mg/l to 0.396 mg/l. In both wells there was a large decrease between December 2016 and January 2017, with iron concentrations decreasing from 8.55 mg/l to 1.21 mg/l and manganese concentrations decreasing from 2.08 mg/l to 0.249 mg/l.

In EMW19, iron and manganese concentrations decreased through the quarter dropping from 10.8 mg/l in January to 8.59 mg/l in March 2017, while manganese decreased from 1.11 mg/l in January to 0.964 mg/l in March 2017. In the case of the manganese there has been a continual decrease since September 2016 with the drop between December 2016 and January 2017 being 1.53 mg/l to 1.11 mg/l.

Of the new boundary wells sampled during Quarter 1 of 2017, the highest iron concentration was recorded in RCBB01 in March 2017 at 51.8 mg/l, a relatively large increase on the February 2017 concentration of 19.9 mg/l. The highest manganese concentration was recorded in DB04 at 34.9 mg/l in March 2017. As with other results, this may be elevated by the high silt content in the sample caused by difficulties during well development.

Iron and manganese was high in most of the boundary wells, particularly wells within the grounds of Kerdiffstown House. As with other determinands northern boundary well DB02 contained relatively high concentrations of iron and manganese during the quarter, at 29.7 mg/l and 21.4 mg/l respectively in March (the only month sampled). The lowest iron and manganese concentrations along the Kerdiffstown House boundary were detected in BB04 with an iron concentration of 1.34 mg/l and manganese concentration of 1.07 mg/l in March 2017.

Outside of the Kerdiffstown House boundary, DB08 at the south-eastern boundary had the lowest iron and manganese concentrations with iron at 0.42 mg/l and 0.55 mg/l and manganese at 0.433 mg/l and 0.495 mg/l in February and March respectively. In contrast, DB10 on the southern site boundary contained relatively high concentrations of iron and manganese, with both increasing between February and March i.e. iron increased from 16.4 mg/l to 25.7 mg/l and manganese increased from 4.58/ mg/l to 6.61 mg/l. DB10 is located near on-site well BH72 which contained the highest iron and manganese concentrations of all of the on-site wells during Quarter 1.

Off-Site Wells

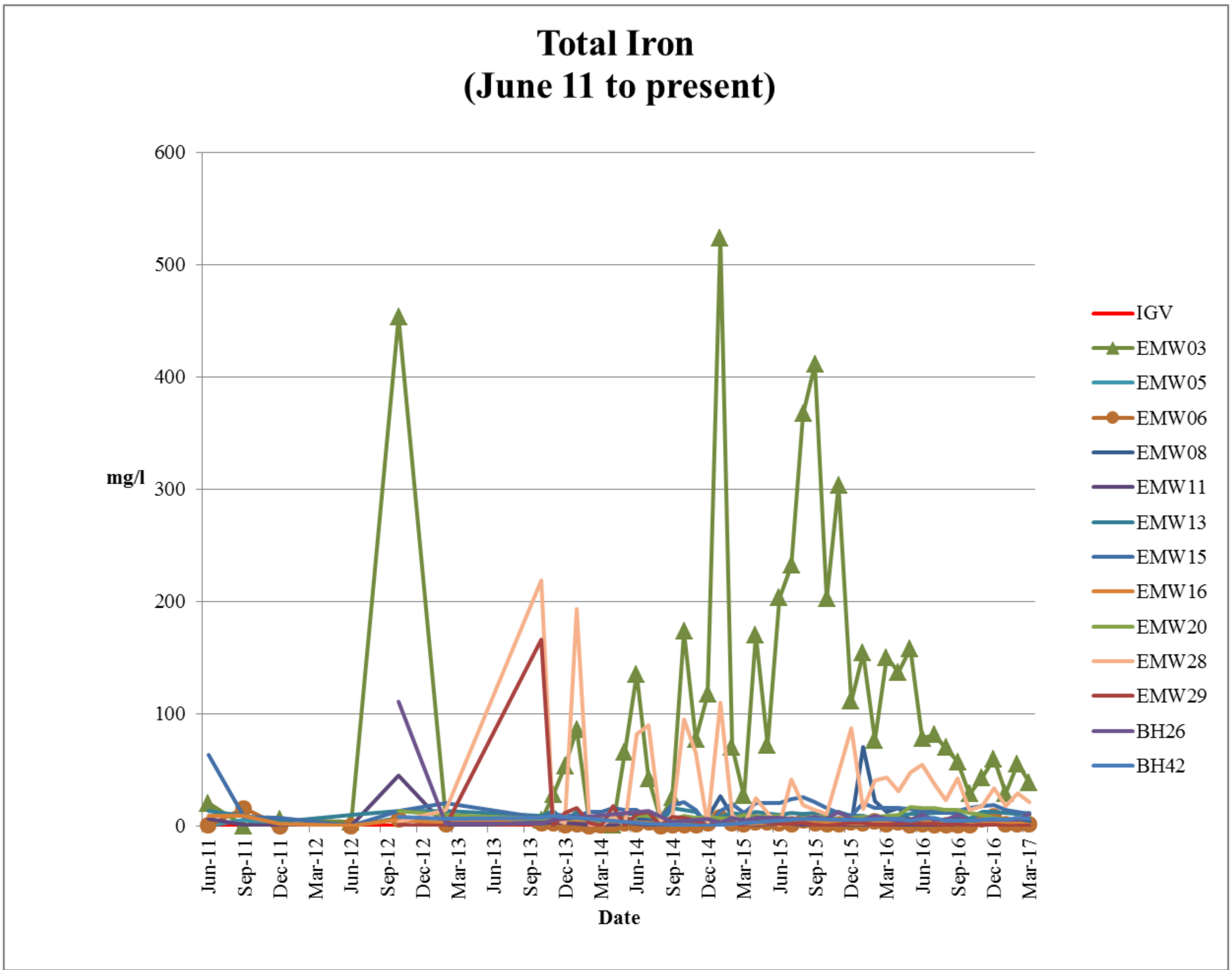
There were no unusual iron or manganese concentrations in the regularly sampled wells recorded during Quarter 1, 2017. The most noteworthy results were at EMW20 where both iron and manganese increased through the quarter, representing the first increases at this well since its peak in May 2016. Iron increased from 5.8 mg/l to 8.64 mg/l, significantly below the May 2016 peak of 16.8 mg/l. Manganese increased from 1.04 mg/l to 1.21 mg/l; again below the May 2016 peak of 2.19 mg/l.

The highest iron concentration recorded in the off-site wells during Quarter 1 2017 was at RM01, which recorded a concentration of 29.7 mg/l in March 2017, a relatively large increase on the February result of 13.9 mg/l. The highest manganese concentration recorded off-site during the quarter was at DB03 behind Kerdiffstown House, where the February result was noted to be 5.16 mg/l, decreasing to 3.72 mg/l in March, 2017.

The off-site well with the lowest iron and manganese concentrations during the quarter was EMW29 with iron concentrations ranging from 0.26 mg/l to 0.6 mg/l and manganese concentrations ranging from below the LOD

(0.007 mg/l) to 0.11 mg/l during the quarter. Iron and manganese have generally been low in the past at this well.

Graph 2.15: Total Iron in Selected Overburden Monitoring Wells (June 2011 to present)



Chemical Oxygen Demand (COD)

COD is a broad measure of the concentration of oxidizable organic contaminants present in the groundwater and therefore can be a useful indicator of the presence of landfill leachate.

On-Site Wells

There were no unusual COD results recorded at any of the on-site wells monitored during Quarter 1 2017 with little to no change between the results obtained during the quarter and those recorded during 2016.

BH26, generally the well with the highest COD, previously recorded a peak concentration of 4,160 mg/l in September 2015. COD values have since fallen, although the concentration increased through Quarter 1 from 447 mg/l in January 2017 to 505 mg/l in March 2017. The COD concentration at EMW13 in the north of the site also increased during the quarter from 360 mg/l in January to 458 mg/l in March 2017. Bedrock well EMW12 recorded low COD concentrations with less than 11 mg/l in January and February and 12 mg/l in March 2017.

The highest COD concentration recorded in the new wells on site was 316 mg/l in February at BH69 in the south-eastern corner of the site. COD at BH72 was also relatively high at 196 mg/l in February and 174 mg/l in

March 2017. BH77 had a high concentration at 248 mg/l in February, subsequently reducing to 43 mg/l in March, while BH78 increased in the same period from 87 mg/l to 161 mg/l.

BH70 in the lower yard of the site had the lowest COD of the new on-site wells with a concentration of 23 mg/l and 24 mg/l recorded during the quarter. Only EMW12 in the north of the site had a lower COD level during the quarter.

Boundary Wells

The highest COD of all wells during the quarter was 6000 mg/l at boundary well DB04. As stated previously this well gave a very silty sample with many concentrations noted to be elevated likely due to the presence of the sediment. Therefore, the results from this well may not be representative of the groundwater quality in this area. Aside from DB04, the highest COD concentration along the site boundary was recorded in DB02 on the northern boundary. The COD concentration here was noted to be 362 mg/l in March 2017.

A number of other boundary wells also contained relatively high COD concentrations during the quarter. EMW03 which historically had the highest COD concentrations outside of the site ranged from 74 mg/l in January up to 124 mg/l in March. DB10 on the southern boundary also had relatively high COD concentrations with 227 mg/l recorded in February and 304 mg/l in March, 2017.

All other boundary wells had lower COD concentrations below 60 mg/l. The lowest concentrations were recorded at BB04, DB06 and DB08 with concentrations below the LOD of 11 mg/l during the quarter (BB04 in March, and DB06 and DB08 in February). EMW19 had its lowest COD concentrations since early 2016, with a January concentration of 16 mg/l noted, decreasing to 13 mg/l in February before increasing to 21 mg/l in March, 2017.

Off-Site Wells

During Quarter 1 of 2017, the off-site wells had COD concentrations ranging from less than 11 mg/l to 440 mg/l. Within the grounds of Kerdiffstown House, the COD concentrations were generally low ranging from below the LOD (RM01 in February, RM02 in February, and RM05 in February and March) to 86 mg/l (RM04 in February). The exception to this is north of the site at DB03 where the concentration was considerably higher at 196 mg/l in February and 380 mg/l in March 2017. This higher result at DB03 is in keeping with other elevated results at this well during Quarter 1 and, along with nearby boundary well DB02, indicates a northward movement of leachate contaminated groundwater from the site.

Away from the grounds of Kerdiffstown House, EMW28 recorded relatively high COD concentrations during the quarter ranging from 121 mg/l to 184 mg/l. These concentrations are within previously recorded ranges, being below the 2015 high of 440 mg/l. Nearby, new bedrock well BB03 recorded the highest off-site COD concentration at 440 mg/l in March 2017, an increase from February's 144 mg/l. Meanwhile at the other end of Foley's Field, EMW29 had low COD concentrations ranging from 12 mg/l to 16 mg/l during the quarter, similar to the results obtained throughout 2015.

Chloride

Chloride is a common key indicator of landfill leachate presence. The IGV for chloride is 30 mg/l. Graph 2.16 shows the variation in chloride concentrations for selected monitoring wells within the overburden. A very similar pattern of variation in chloride concentrations is shown for EC and ammoniacal nitrogen for the corresponding monitoring wells with decreased concentrations generally observed in those samples collected during the winter / spring months. As with EC and ammoniacal nitrogen this is particularly pronounced within EMW03.

Chloride concentrations recorded within bedrock monitoring wells are shown in Graph 2.17.

On-Site Wells

Chloride was found during Quarter 1 of 2017 to be highest in the on-site monitoring wells BH26 (406 mg/l to 418 mg/l) and EMW13 (234 mg/l to 296 mg/l) in Zone 1 of the site, similar to concentrations recorded previously at these wells. A number of other on-site wells are also consistently in exceedance of the IGV. The chloride concentration recorded at EMW11 decreased from 50.8 mg/l to 41.3 mg/l, remaining above the IGV as is often the case for this well. As has been the case since monitoring began, chloride at EMW16 remained elevated above the IGV ranging from 157 mg/l to 167 mg/l during the quarter, within the previously recorded range of 135 mg/l to 238 mg/l. Nearby well EMW15 had a chloride concentration which reduced through the quarter from 38.4 mg/l in January to just below the IGV at 29.4 mg/l in March. EMW15 shows a seasonal variation in chloride concentration, with the IGV being exceeded through the majority of the year and dropping below the IGV during the winter months.

BH42, in contrast to EMW15, showed increased chloride concentrations through the quarter from 23.2 mg/l in January to 38.4 mg/l in March. In the past, BH42 has fluctuated around the IGV, with March 2017 being the first exceedance of the IGV since June 2016. BH70 and BH72, near to BH42, also exceeded the IGV during the quarter. BH70 in the lower yard of the site recorded chloride concentrations at 32.6 mg/l and 33.7 mg/l, while BH71 recorded concentrations at 46.3 mg/l and 40.9 mg/l in February and March 2017. The only other on-site well in exceedance of the IGV for chloride during the quarter was BH69 in the south-eastern corner of the site which had a chloride concentration of 35.4 mg/l in February 2017.

All other on-site wells sampled during Quarter 1 of 2017 were below the IGV for chloride, namely EMW12, BH68, BH72, BH77 and BH78. The lowest of these were at BH78 where the concentration recorded was 10.7 mg/l to 9.4 mg/l and at BH77 with a concentration of 10.7 mg/l and 11.4 mg/l in February and March respectively.

Boundary Wells

The IGV for chloride was exceeded in six of the thirteen boundary wells during Quarter 1 of 2017. As has been the case with many determinands, DB02 is the highest of the boundary wells. DB02 is located on the northern site boundary near to EMW13 and contained 294 mg/l of chloride during March 2017. This result is very close to the EMW13 result for the same month at 296 mg/l indicating that leachate contaminated groundwater is flowing north from the site.

The next highest chloride concentrations were recorded at EMW03 ranging from 55.8 mg/l to 87.5 mg/l. These results are within the range previously recorded for this well (32.4 mg/l to 201 mg/l). To the north-west along the site boundary, BB02 also had a concentration in exceedance of the IGV at 39.7 mg/l in February and 42.5 mg/l in March. South along the boundary from EMW03, RCBB01 breached the IGV in March only, increasing from 23.8 mg/l in February to 30.3 mg/l in March. Continuing south-east along the boundary, BB04 exceeded the IGV during both monitoring rounds at 31.6 mg/l and 36.6 mg/l.

The last of the boundary wells to exceed the IGV for chloride during the quarter was DB08 to the east at the Foley's Field boundary. Here there was almost no change between the two monitoring rounds with the chloride concentrations just marginally above the IGV at 30.4 mg/l and 30.3 mg/l in February and March respectively.

EMW06, EMW19, BB01, DB04, DB05, DB06 and DB10 were all below the IGV for the whole quarter. As is usually the case EMW06 had the lowest chloride concentration of the boundary wells. The chloride range in this well during the quarter was 6.9 mg/l to 9.9 mg/l with the lowest result being in March 2017. The IGV has never been exceeded at this well. The chloride concentration in EMW19 continued to decrease through the quarter falling from 23.1 mg/l in January to 19.8 mg/l in March, 2017. This is a continuation of the decreases which have been recorded at this well since a peak of 50.2 mg/l recorded in June 2016.

Off-Site Wells

All off-site monitoring wells remained below the IGV for chloride of 30 mg/l, with the exception of three wells. These wells were EMW28 located south of the site in Foley's Field, RM03 located north-east of the site near the Morell River and DB3 located north of the site behind Kerdiffstown House.

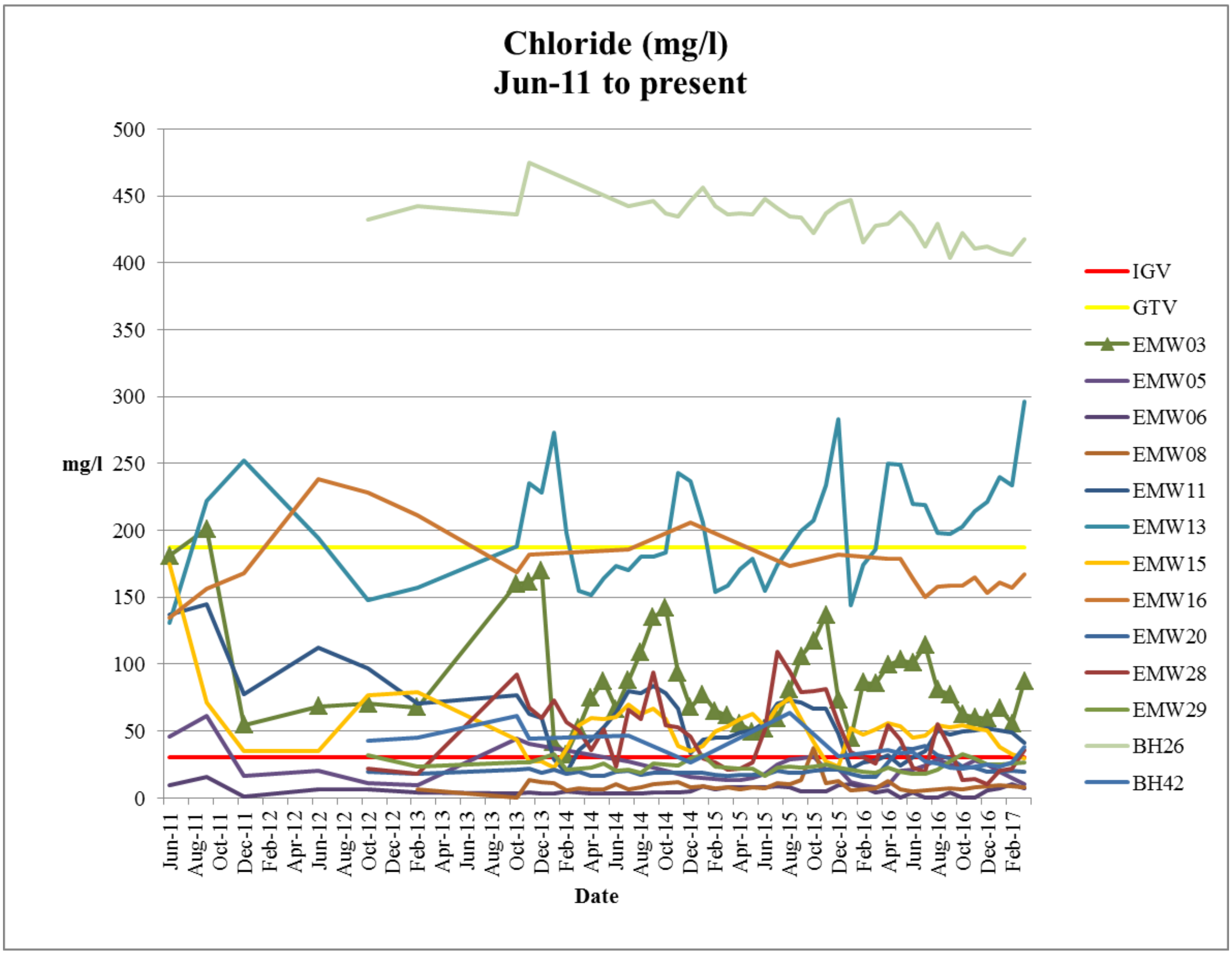
Chloride at EMW28 tends to fluctuate, with results above and below the IGV being common. During Quarter 1 2017, the chloride concentration increased from 19.9 mg/l in January to 39.9 mg/l (above the IGV) in March, 2017. These values are within the previously recorded range for this well (9.9 mg/l to 109 mg/l). Other wells in Foley's Fields were noted to be below the IGV for the whole quarter, with BB03 ranging from 10.1 mg/l to 22.9 mg/l and EMW29 ranging from 25.2 mg/l to 26.8 mg/l.

The highest chloride concentration in any of the off-site wells was recorded at DB03 behind Kerdiffstown House at 111 mg/l in February and 123 mg/l in March 2017. This mirrors the high concentrations recorded for other determinands at this well and also mirrors the high concentrations recorded in nearby boundary well DB02.

The only other off-site well to exceed the IGV for chloride was RM03 near the Morell River, where the concentration of chloride was noted to be 38.4 mg/l in February and 33.6 mg/l in March 2017. All other wells adjacent the Morell River were below the IGV during the quarter, ranging from 16.3 mg/l (RM02 in March) to 22.3 mg/l (RM04 in February).

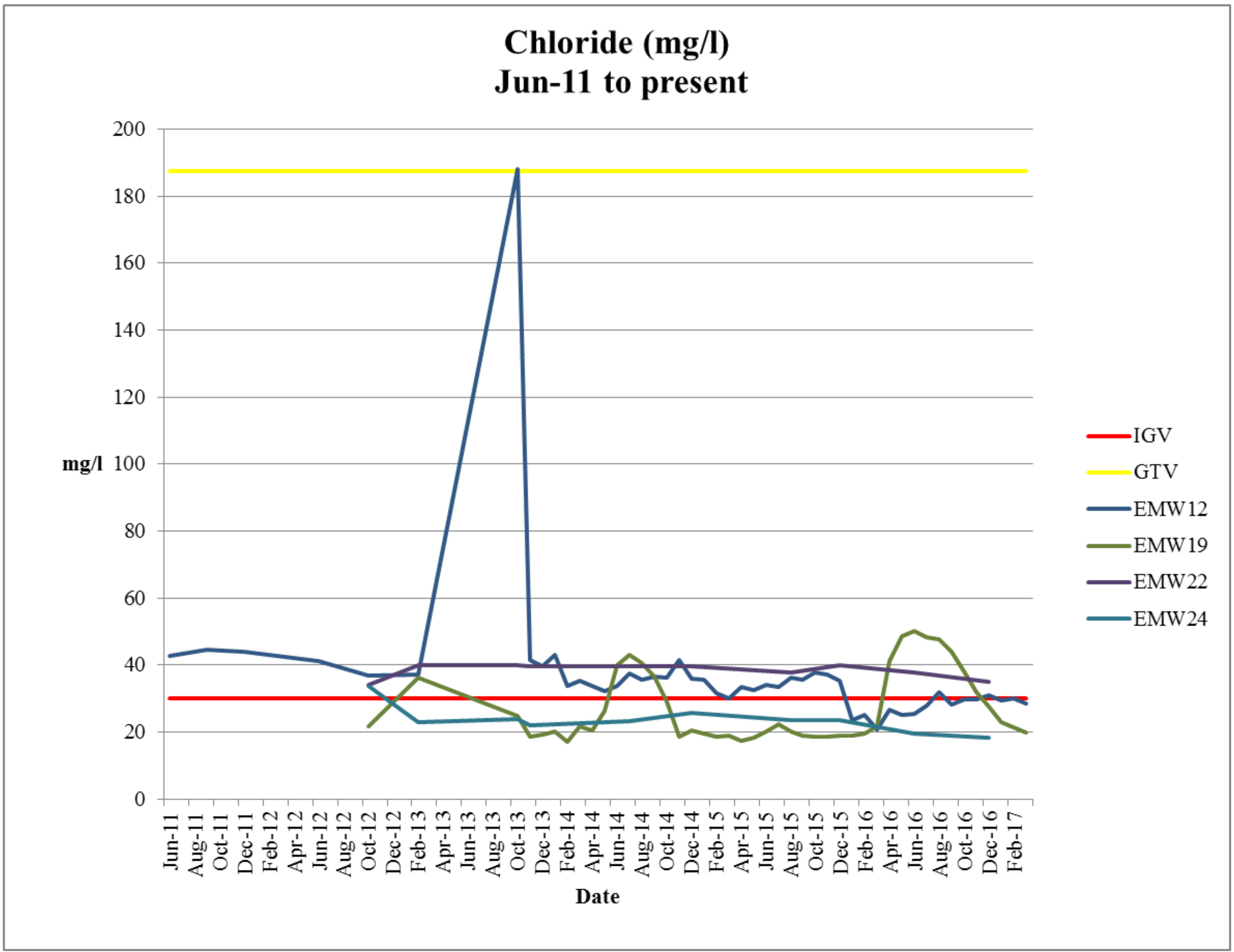
No other off-site well exceeded the IGV for chloride during Quarter 1 of 2017, with the lowest concentration of chloride being recorded at EMW08 where the chloride concentration decreased through the quarter from 9.7 mg/l in January to 7.6 mg/l in March.

Graph 2.16: Chloride in Overburden Monitoring Wells (June 2011 to present)



Note: Axes values are different between Graph 2.16 and 2.17

Graph 2.17: Chloride in Bedrock Monitoring Wells (June 2011 to present)

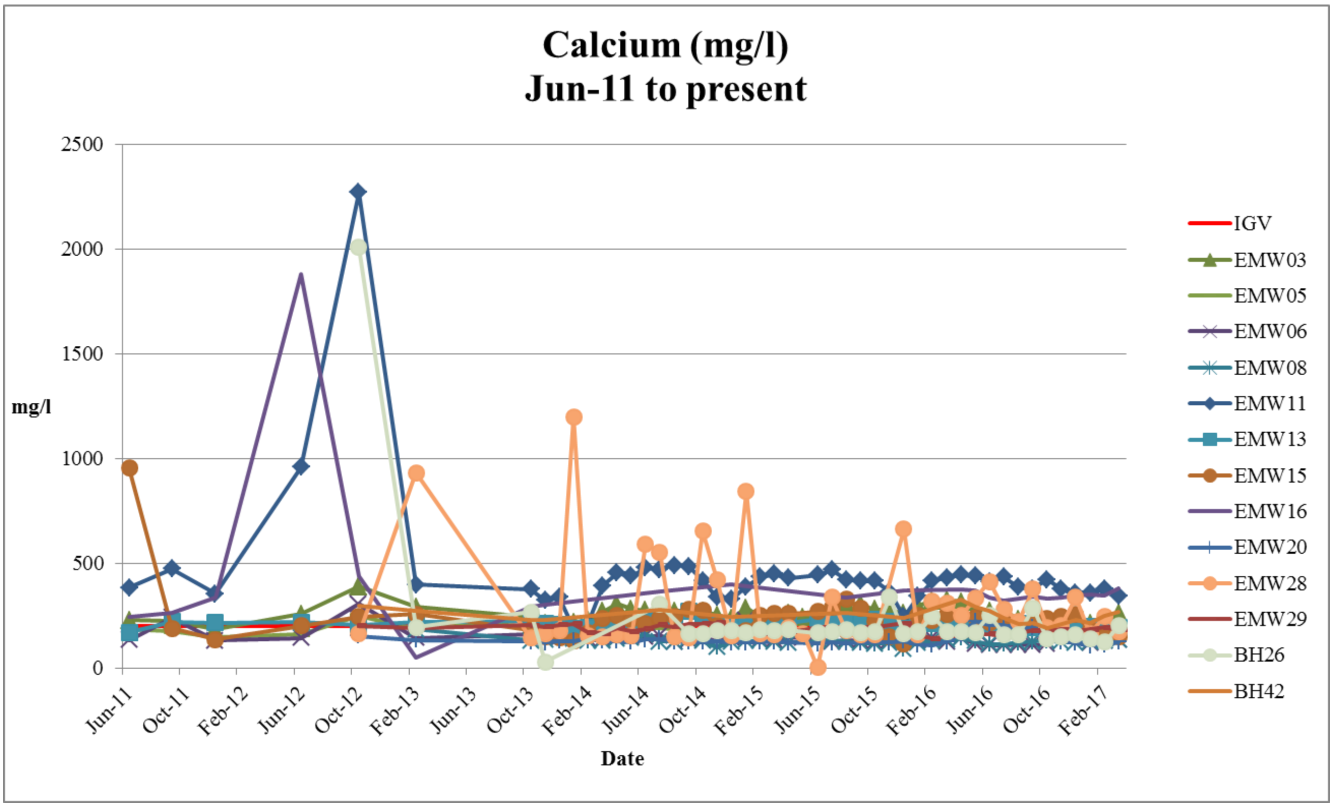


Note: Axes values are different between Graphs 2.16 and 2.17.

Calcium

Where geology of limestone bedrock and limestone dominated subsoils are common, groundwater is often hard, containing high concentrations of calcium, magnesium and bicarbonate. The IGV for calcium is set at 200mg/l. Sixteen of the forty wells sampled during Quarter 1 of 2017 had at least one calcium concentration above the IGV. Graph 2.18 shows calcium concentrations in selected wells.

Graph 2.18: Calcium in Selected Overburden Monitoring Wells (June 2011 to present)



<u>On-Site Wells</u>

Nine of the fourteen on-site wells recorded IGV exceedances for calcium during the quarter. A new well in the eastern corner of the site, BH69, recorded the highest calcium concentration at 564 mg/l in February 2017. This well was unable to be resampled in March due to insufficient water. The other wells sampled in this area, EMW15 and EMW16 recorded lower calcium concentrations during the quarter. EMW15 decreased through the quarter remaining below the IGV (184 mg/l to 151 mg/l), while EMW16 was above the IGV (200 mg/l) for the whole quarter ranging from 348 mg/l to 379 mg/l. The calcium concentration in this well has remained consistently above the IGV since October 2013.

All of the existing, regularly sampled wells had calcium concentrations within previous ranges throughout the quarter. The concentration at EMW11 ranged from 346 mg/l to 380 mg/l and within the previous range of 191 mg/l to 2270 mg/l. At the northern tip of the site, bedrock well EMW12 exceeded the IGV in February and March, ranging from 193 mg/l to 213 mg/l. The calcium concentration at this well has always fluctuated around the IGV of 200 mg/l. Similarly EMW13 tends to have calcium concentrations close to the IGV, with Quarter 1 2017 results all being just under the IGV (191 mg/l to 197 mg/l).

BH26 generally tends to have calcium concentrations below the IGV but displays the occasional sudden increase above the IGV. This was seen again in the Quarter 1 results, with the calcium concentration starting in January 2017 at 142 mg/l, decreasing in February to 124 mg/l before increasing to 203 mg/l in March, 2017. This type of peak has been seen multiple times since monitoring began at this well, with the March 2017 result lower than the highest peak of 339 mg/l in November 2015.

Aside from BH69, three other new on-site wells recorded calcium concentrations above the IGV. Bedrock well BH68 was just above the IGV during both February and March, 2017 (202 mg/l and 215 mg/l). BH71 in the centre of the lower eastern part of the site showed a slight decrease between February and March from 315 mg/l to 298 mg/l. Nearby well BH42 was also consistently noted to be in exceedance of the IGV, ranging from

214 mg/l to 271 mg/l during the quarter. Finally, just a little further south the calcium concentration in BH72 decreased significantly between February and March from above the IGV at 454 mg/l to below it at 144 mg/l.

Boundary Wells

Only four of the 13 boundary wells had calcium concentrations above the IGV during the first quarter of 2017, namely DB02, DB04, EMW03 and DB10. The highest of these was at DB04 on the north-eastern boundary, where the concentration was 3900 mg/l in March 2017. This was the highest concentration of all wells sampled during the quarter. However due to difficulties encountered when developing the well causing a high amount of silt in the sample, this result is likely not to be fully reflective of groundwater conditions at this location. On the northern boundary, there was also a high calcium concentration recorded at DB02 at 1300 mg/l in March 2017.

The calcium concentration at EMW03 was in exceedance of the IGV throughout the quarter, increasing from 211 mg/l in January to 264 mg/l in March, 2017. The calcium concentration is almost consistently above the IGV at this location ranging from 186 mg/l to 389 mg/l in previous months.

The only other boundary well which had a calcium concentration in exceedance of the IGV was DB10 on the southern site boundary. The calcium concentration at DB10 increased from 592 mg/l to 773 mg/l between February and March.

Off-Site Wells

Three of the thirteen off-site wells exceeded the IGV for calcium during Quarter 1 of 2017, namely BB03, DB03 and EMW28, with two of these wells located in Foley’s fields to the south of the site. EMW28 exceeded the IGV in February only at 248 mg/l. In January and March the concentration remained below the IGV at 163 mg/l and 175 mg/l respectively. Calcium concentrations at EMW28 have tended to fluctuate around the IGV in the past, with some of these fluctuations quite sudden. In the field to the north of EMW28, new well BB03 also exceeded the IGV with a concentration of 253 mg/l noted in February and a concentration of 226 mg/l in March, 2017.

The only other off-site well to exceed the IGV during the quarter was DB03, located north of the site behind Kerdiffstown House. The calcium concentration reduced however from 618 mg/l in February to 502 mg/l in March, 2017. This represented the highest calcium concentration of all of the off-site wells sampled.

Sodium

Sodium is naturally present in groundwater and is also present in landfill leachate. The IGV for sodium is 150 mg/l. Out of the forty wells sampled during Quarter 1 of 2017 only three had sodium concentrations exceeding the IGV, namely BH26, EMW13 and DB02.

As with previous monitoring, both Zone 1 wells BH26 and EMW13 were consistently above the IGV during the quarter. BH26 had a concentration ranging from 197 mg/l to 294 mg/l over the period. BH26 has been consistently above the IGV since monitoring began although the February 2017 concentration of 197 mg/l was the lowest ever level recorded at this well. In contrast, EMW13 recorded the highest sodium concentration increasing from 224 mg/l in January to the new peak of 287 mg/l in March 2017.

The only other well at which the IGV for sodium was exceeded was new well DB02 on the northern boundary near EMW13. The sodium concentration recorded here in March 2017 was 205 mg/l.

All other wells had sodium concentrations below the IGV. Of these the highest concentration was recorded at EMW16 in March at 137 mg/l. The sodium concentration at this well tends to remain near to, but below, the IGV with only one exceedance recorded previously when a concentration of 193 mg/l was recorded in June 2012.

Sulphate

Sulphates exist in nearly all natural waters, the concentrations varying according to the nature of the terrain through which they flow. In polluted waters in which the dissolved oxygen is low, sulphate is readily reduced to sulphide causing noxious odours. The IGV for sulphate is 200 mg/l.

On-Site Wells

Sulphate was only recorded above the IGV in on-site wells during Quarter 1 of 2017. The IGV was exceeded in eight of the fourteen on-site wells, namely EMW11, EMW12, EMW16, BH42, BH68, BH69, BH70 and BH71. The highest concentration of sulphate on-site during the quarter was detected in EMW11 at 775 mg/l in February 2017. Sulphate concentrations have generally been at their highest at this well during past monitoring rounds and during this quarter the concentrations ranged from 676 mg/l to 775 mg/l and within the previous range for this well (168 mg/l to 1230 mg/l).

New well BH71, towards the centre of the south-eastern part of the site, had similarly high sulphate concentrations at 774 mg/l and 769 mg/l in February and March respectively. BH42, near to BH71, had a sulphate concentration increasing during the quarter from 391 mg/l to 499 mg/l. This range is within the previously recorded range for this well (337 mg/l to 664 mg/l).

At BH69 in the eastern corner of the site, there was a similarly high sulphate concentration recorded in February 2017 at 621 mg/l. Nearby well EMW16 had a sulphate concentration through the quarter ranging from 398 mg/l to 443 mg/l (the March concentration of 443 mg/l is the highest concentration recorded at this well, being marginally higher than the previous peak of 439 mg/l recorded in October 2012).

The three remaining wells in exceedance of the IGV had concentrations below 400 mg/l through the quarter. EMW12 increased through the quarter from 320 mg/l in January to 355 mg/l in March, remaining below the peak at this well of 481 mg/l. BH68 in the bedrock towards the centre of the site had a sulphate concentration of 221 mg/l and 231 mg/l, while EMW70 in the lower yard recorded a concentration of 201 mg/l and 230 mg/l for February and March, 2017.

The lowest on-site sulphate concentration was recorded at BH26 in February 2015 at 5.9 mg/l. This was the lowest sulphate concentration ever recorded at this well.

Boundary Wells

None of the boundary wells sampled during the first quarter of 2017 had sulphate concentrations in exceedance of the IGV. The highest concentration recorded at the boundary was at new well DB04 on the north-eastern boundary. The concentration recorded here was noted to be 106 mg/l in March 2017.

The next highest sulphate concentration range was at north-eastern boundary well EMW03 with a range from 50.8 mg/l to 79.5 mg/l noted during the quarter and within the previously recorded range of 12.4 mg/l to 290 mg/l. As with other determinands, there appears to be a seasonal influence on the concentrations at EMW03 with peaks generally seen in the spring.

EMW19 on the eastern boundary had a sulphate concentration ranging from 34.6 mg/l to 54.8 mg/l, within the previously recorded range. All other boundary wells had sulphate concentrations below 50 mg/l.

Off-Site Wells

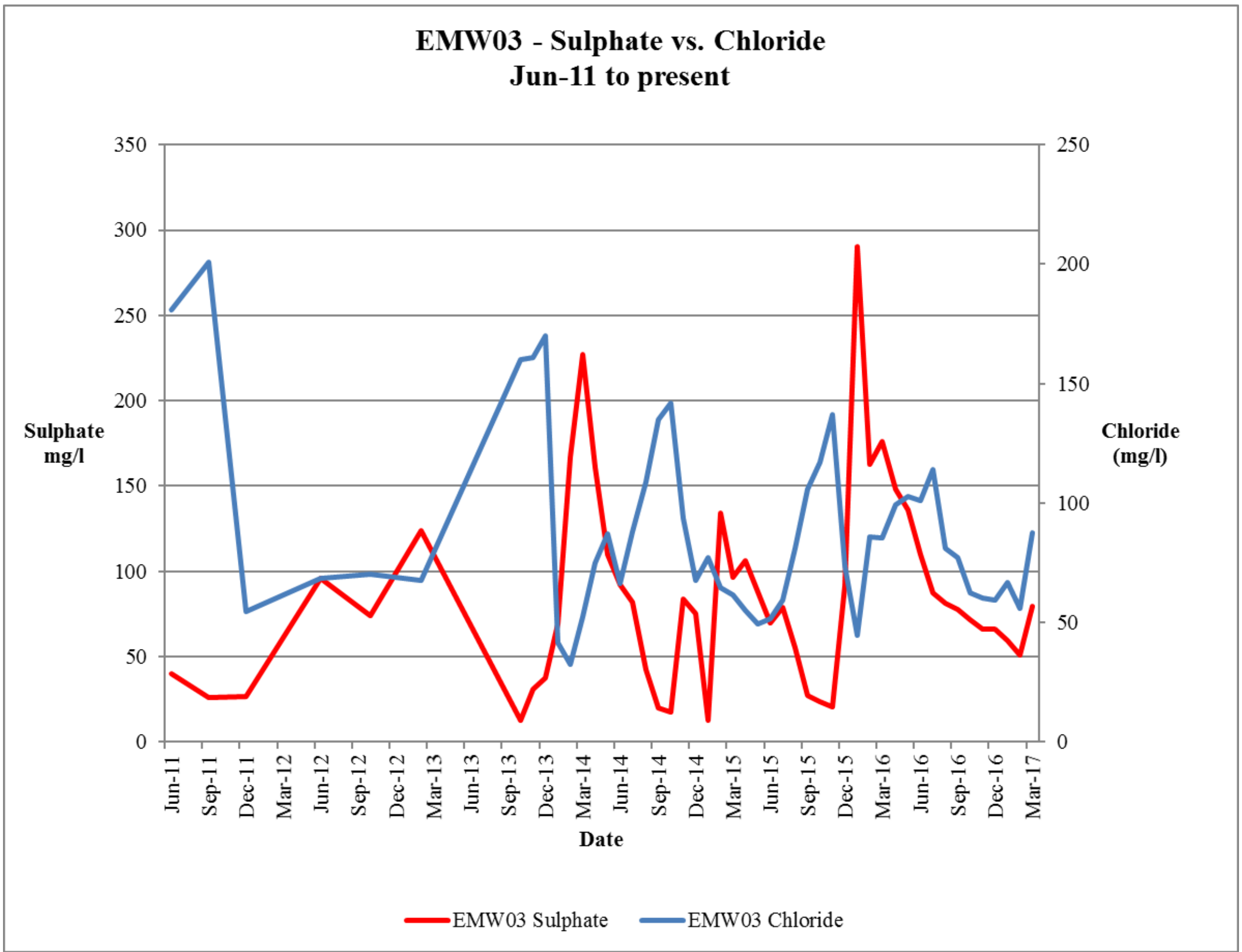
All off-site wells recorded sulphate concentrations below the IGV. The highest sulphate concentration was recorded at EMW29 where the concentration ranged from 87.1 mg/l to 116 mg/l, within previously recorded concentrations at this well (12.8 mg/l to 124 mg/l). However, the February 2017 concentration of 116 mg/l sulphate represents the highest concentration recorded at this well since October 2012 (124 mg/l).

New well RM03 near the Morell River had a sulphate concentration of 69.7 mg/l in February, reducing to 63.7 mg/l in March 2017. This was the highest sulphate concentration recorded in the vicinity of the Morell River, with all other adjacent wells showing concentrations no higher than 24.2 mg/l throughout the quarter.

Sulphate v Chloride

As noted above, low sulphate concentrations may be indicative of landfill leachate as sulphate is reduced to sulphide. As such, an increase in parameters such as chloride and a reduction in sulphate concentrations may indicate the presence of landfill leachate and comparing the two determinands may show impacts from leachate. In EMW03 and EMW13, there has been an observed seasonal change when concentrations of sulphate are compared to chloride as can be seen in Graphs 2.19 and 2.20.

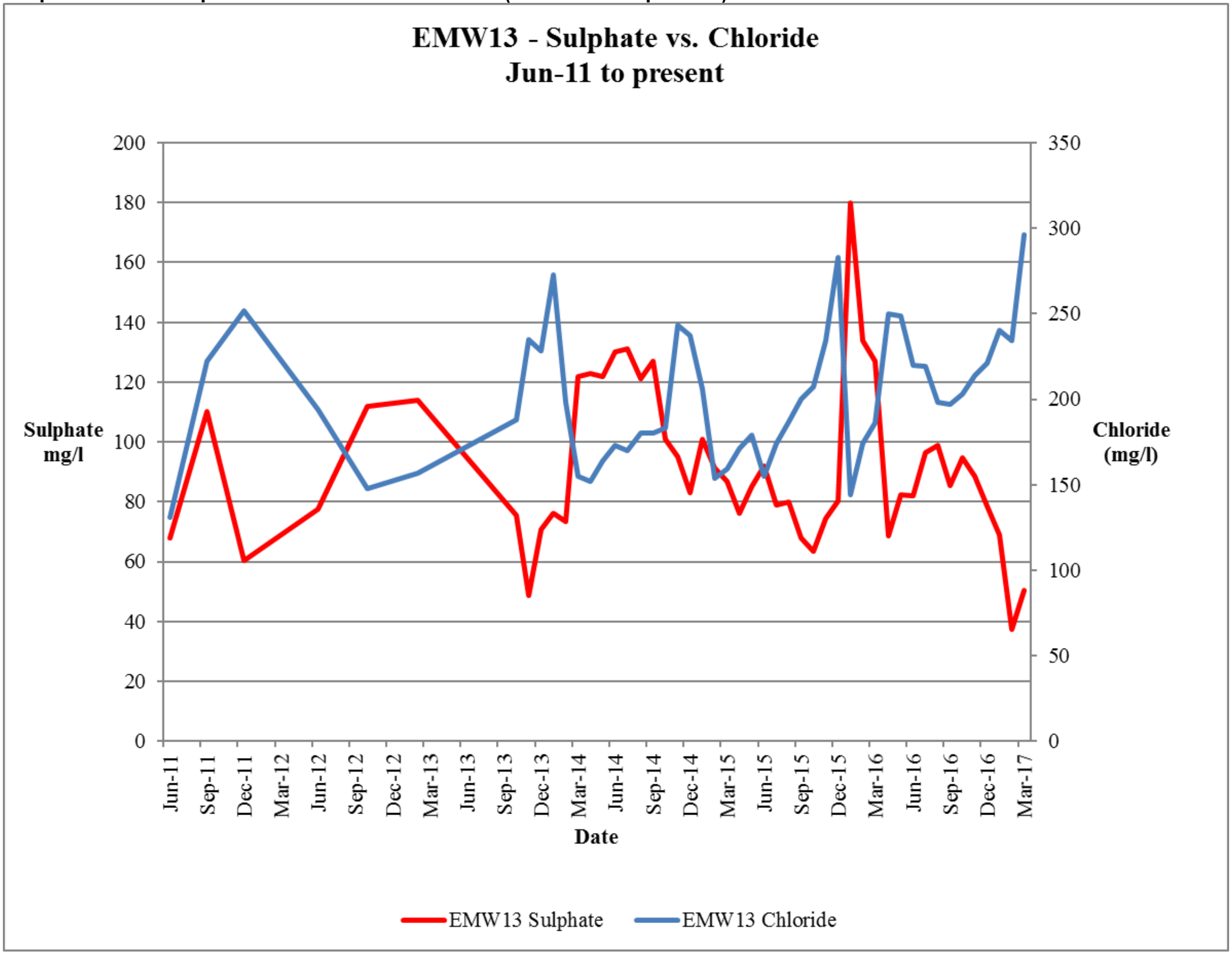
Graph 2.19: Sulphate and Chloride in EMW03 (June 2011 to present)



Note: Axes values are different between Graphs 2.19, 2.20 and 2.21.

At EMW03 during Quarter 1 2017, there was an overall increase in both chloride and sulphate concentrations as shown below in Graph 2.19. However, on most occasions, as chloride concentrations increase, sulphate concentrations do decrease indicating impacts from landfill leachate at this location. The relationship is most pronounced from 2013 to 2015 and in 2016, both chloride and sulphate concentrations have shown a general decrease since June (this may relate to the relatively low rainfall that occurred in the second half of 2016).

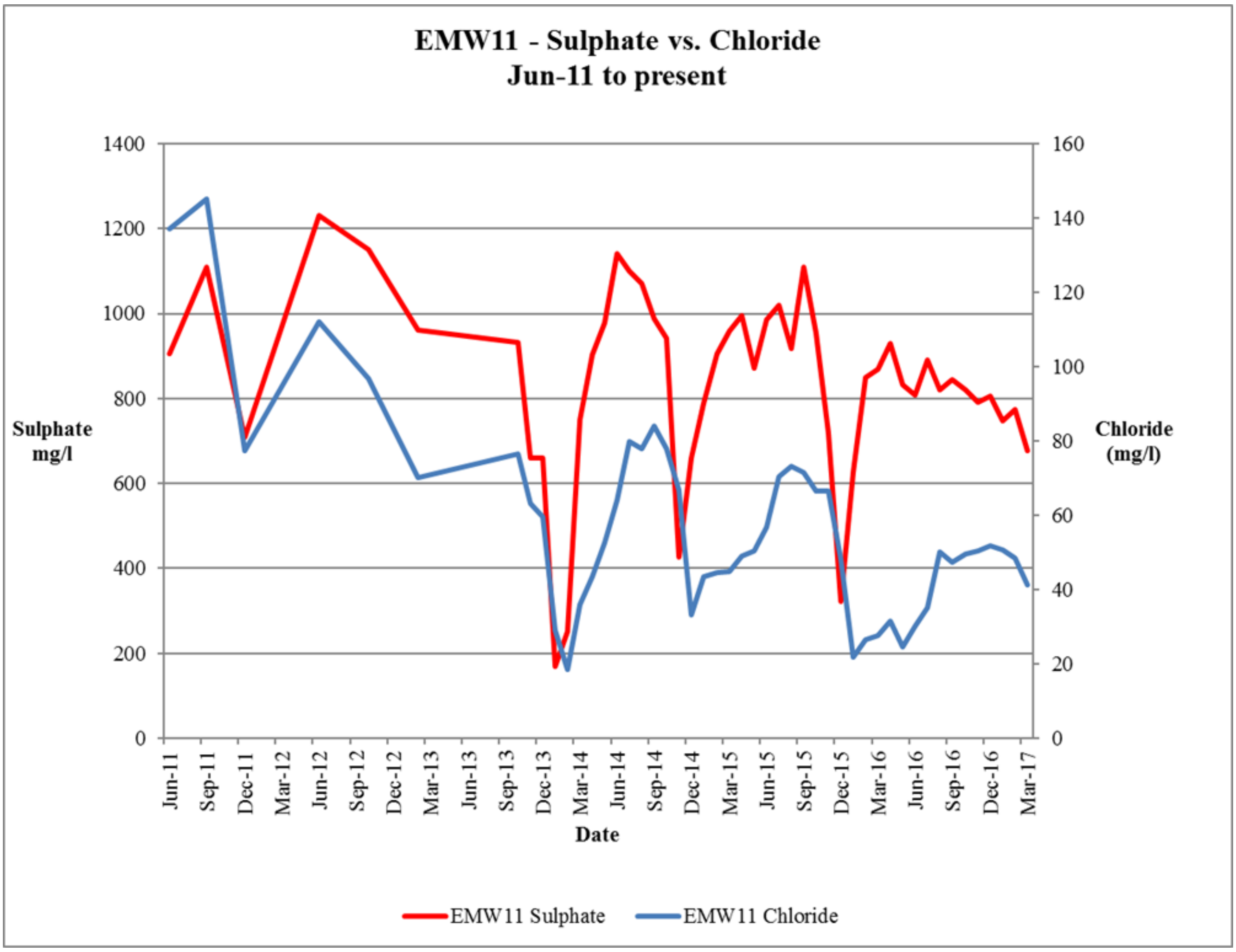
Graph 2.20: Sulphate and Chloride in EMW13 (June 2011 to present)



Note: Axes values are different between Graphs 2.19, 2.20 and 2.21.

In EMW13 a similar pattern to EMW03 is seen although during Quarter 1 2017 in EMW13 it is noted that the concentration of sulphate generally increased whilst chloride decreased as seen in Graph 2.20. As has been seen in the past there is an approximate inverse relationship between chloride and sulphate.

Graph 2.21: Sulphate and Chloride in EMW11 (June 2011 to present)



Note: Axes values are different between Graphs 2.19, 2.20 and 2.21.

In EMW11 there is normally no observed 'inverse' seasonal fluctuation between chloride and sulphate concentrations with concentrations generally showing the same relative increase/decrease over the monitoring period as shown in Graph 2.21. Both chloride and sulphate show the lowest concentrations during the winter when groundwater recharge (and dilution) is higher. EMW11 is unusual for the site as the groundwater from this well has very low chloride concentrations (for a groundwater affected by landfill leachate) but high sulphate concentrations. This would suggest that the source of contamination in this well is different from elsewhere on site; possibly due to different waste types in Zone 2A to the rest of the site (high sulphate concentrations can be associated with construction-type wastes such as gypsum-based plasterboard).

Sulphide

As noted above, under reducing conditions, sulphate may be reduced to sulphide. Sulphide analysis was undertaken once during the quarter in the new wells only in February 2017. Of the 25 new wells sulphide was detected above the LOD (0.02 mg/l) in eleven of them.

On-Site Wells

Sulphide was detected at four borehole locations, namely BH68, BH69, BH72 and BH77, with the highest concentration detected at BH69 at 7.08 mg/l in the eastern corner of the site.

The other three on-site wells in which sulphide was detected above the LOD had concentrations below 1 mg/l. BH68 and BH77 towards the centre of the site both had sulphide concentrations above the LOD. BH77 had the highest concentration at 0.112 mg/l, while bedrock well BH68 had a concentration of 0.025 mg/l. BH72 towards the south of the site near the lined cell had a sulphide concentration of 0.192 mg/l.

Boundary Wells

Six of the new boundary wells had sulphide detections above the LOD. The highest concentration recorded was at northern boundary well DB02 at 0.911 mg/l in March 2017. This is in line with elevations in other determinands recorded at this well and indicates leachate contamination of the groundwater flowing north from the site.

South-east along the boundary, sulphide was also detected at BB02 in February at 0.022 mg/l, with DB05 further south also having a sulphide concentration of 0.022 mg/l. RCBB01 had a sulphide concentration of 0.026 mg/l, with the nearby well DB06 containing 0.031 mg/l of sulphide in February 2017.

The only boundary well outside of Kerdiffstown House lands with a sulphide concentration above the LOD was at DB10 on the southern boundary with a concentration of 0.197 mg/l noted.

Off-Site Wells

Only one off-site well had a sulphide concentration above the LOD during the quarter, namely BB03 located south of the site with a sulphide concentration of 1.18 mg/l.

Arsenic

In certain types of wastes when the pH is low the solubility of many metal and metalloid ions increases and they can become mobilised into the developing leachate. As such, elevated concentrations of trace metals can be indicative of leachate contamination within groundwater. Arsenic has previously been identified in the groundwater above the IGV concentration and is therefore included in the monthly analytical suite. During Quarter 1 of 2017 there were a number of exceedances of the IGV (10 µg/l) and GTV (7.5 µg/l) for arsenic as shown in Table 2.3.

Table 2.3: Quarter 1 2017 Arsenic Exceedances

	GTV	IGV	January 2017	February 2017	March 2017
On-Site Wells					
EMW13	7.5 µg/l	10 µg/l	13 µg/l	11 µg/l	12 µg/l
EMW15			28 µg/l	26 µg/l	25 µg/l
BH26			30 µg/l	29 µg/l	25 µg/l
BH42			11 µg/l	13 µg/l	9 µg/l
BH69			-	27 µg/l	-
BH72			-	15 µg/l	10 µg/l
BH77			-	16 µg/l	-
BH78			-	8.8 µg/l	21 µg/l
Boundary Wells					
EMW03	7.5 µg/l	10 µg/l	15 µg/l	21 µg/l	16 µg/l
EMW19			15 µg/l	12 µg/l	11 µg/l
BB01			-	12 µg/l	11 µg/l
RCBB01			-	24 µg/l	72 µg/l
DB02			-	-	17 µg/l
DB04			-	-	12 µg/l
Off-Site Wells					
EMW28	7.5 µg/l	10 µg/l	45 µg/l	51 µg/l	48 µg/l
RM01			-	16 µg/l	32 µg/l
RM03			-	13 µg/l	8 µg/l
RM04			-	19 µg/l	11 µg/l
RM05			-	-	8 µg/l
DB03			-	8.9 µg/l	-

Exceedance of the IGV is common for all of the wells listed in Table 2.3 which were in place prior to 2016, with the concentrations recorded during the quarter being within previously recorded ranges. Arsenic was also detected above the IGV and/or GTV in a number of the new wells. The highest arsenic concentration recorded in the quarter was at new boundary well RCBB01 in March at 72 µg/l. This represented a large increase on the previous month's arsenic concentration at this location of 24 µg/l.

Potassium

Potassium occurs naturally in groundwater but is also a constituent of landfill leachate. The IGV for potassium has been established at 5mg/l. Graph 2.22 illustrates the concentrations that have been recorded in the overburden monitoring wells.

On-Site Wells

During Quarter 1 of 2017 potassium concentrations above the IGV were detected at all on-site wells except for bedrock well EMW12 in the north and new well BH72 towards the south of the site. All twelve other wells were in exceedance of the IGV during every monitoring round in the quarter.

As observed previously, the highest concentration of potassium was recorded at EMW13 with results increasing through the quarter from 84.8 mg/l to 102 mg/l, significantly above the IGV of 5 mg/l. The potassium concentration has been gradually increasing at this well since September 2016, with the March 2017 concentration being the highest ever recorded at this well. As has always been the case in previous monitoring rounds most of the on-site wells exceeded the IGV of 5 mg/l i.e. EMW11 (41.8 mg/l to 47.7 mg/l), EMW15 (17.6 mg/l to 25.7 mg/l), EMW16 (15.5 mg/l to 20.8 mg/l), BH26 (35.8 mg/l to 48.3 mg/l) and BH42 (16.0 mg/l to 18.5 mg/l).

In the case of the new on-site wells all were in exceedance of the IGV for potassium except for BH72 ranging from less than the LOD of 3.6 mg/l (the reporting limit was raised for this sample due to interference) to 1.15 mg/l. The highest potassium concentration in the new on-site wells was recorded at BH69 at 45 mg/l in February 2017. BH71 had a potassium concentration above the IGV at 32.2 mg/l and 30.1 mg/l in February and March respectively, which was higher than the result recorded at nearby well BH42. Samples from BH70 in the lower yard had potassium concentrations of 21 mg/l to 22.1 mg/l during the quarter.

Towards the centre of the site, bedrock well BH68 had a potassium concentration of 17.7 mg/l and 19.9 mg/l, BH77 at 22.9 mg/l and 26 mg/l, and BH78 at 7.62 mg/l and 7.92 mg/l for February and March, 2017.

Boundary Wells

The IGV of 5 mg/l for potassium was exceeded in three of the thirteen boundary wells during the first quarter of 2017, all located on the north or north-east boundary of the site. The highest concentration was recorded at northern boundary well DB02 at 75.7 mg/l in March, a comparable concentration to that of nearby on-site well EMW13.

Further south-east along the boundary, the potassium concentration at DB04 was noted to be 6.55 mg/l in March 2017. Further south again along the boundary, EMW03 had a potassium concentration ranging from 19.8 mg/l to 33.7 mg/l. EMW03 has been consistently above the IGV since monitoring began, with ranges measured during the quarter within the previously recorded range (18.5 mg/l to 61.6 mg/l) and below the maximum value recorded here in June 2011.

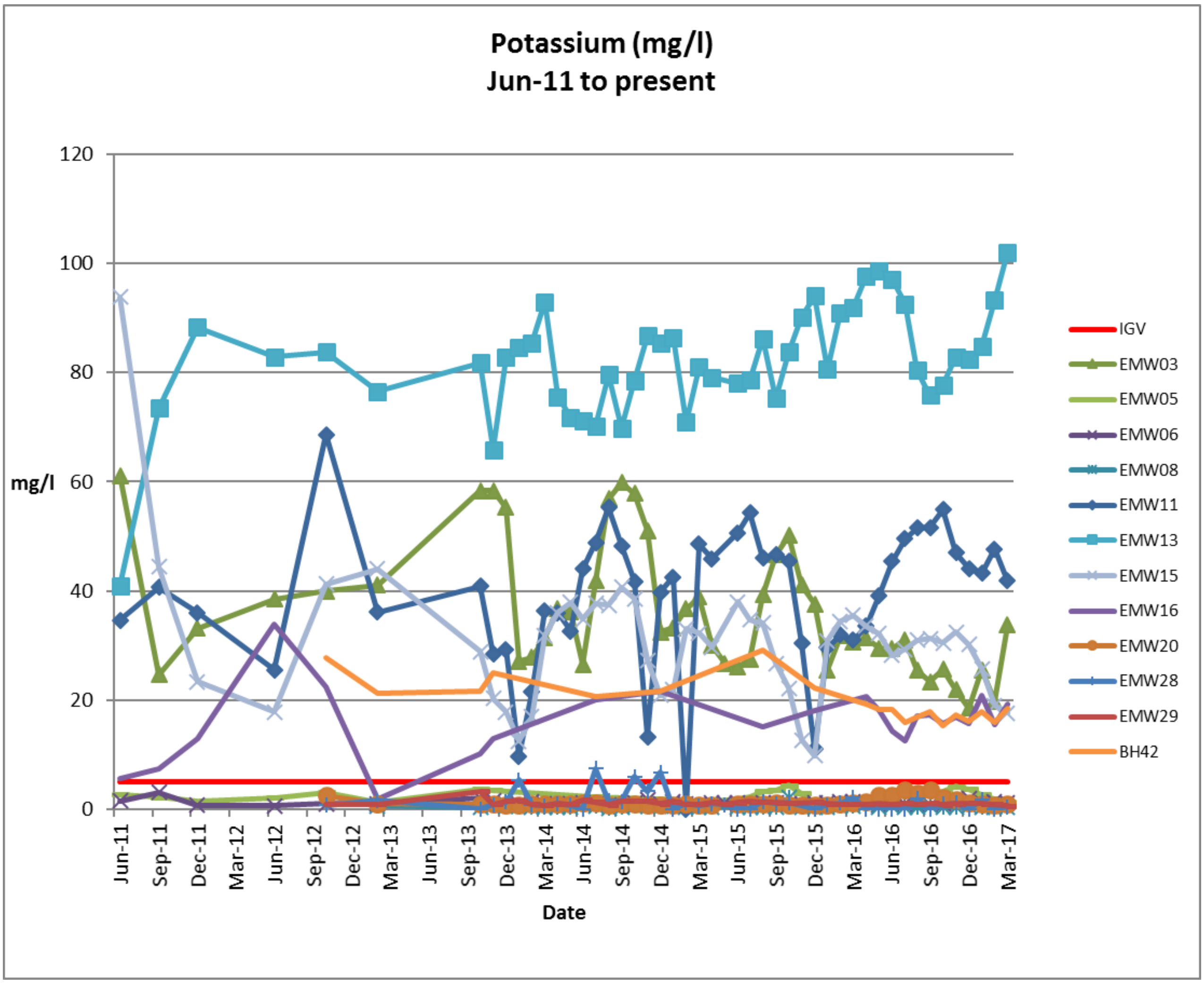
The potassium concentration at bedrock well EMW19 decreased below the IGV of 5 mg/l in January 2017, the first time it has been below the IGV since March 2016. The concentration during the quarter decreased from 4.82 mg/l in January to 3.32 mg/l in March 2017. None of the other boundary wells were in exceedance of the IGV during the quarter.

Off-Site Wells

As is generally the case, potassium concentrations at off-site wells remained below the IGV of 5 mg/l for most wells. Only one off-site well had a potassium concentration above the IGV during Quarter 1 2017, namely DB03. DB03 is located north of the site behind Kerdiffstown House and has displayed evidence of leachate contamination during the quarter. The potassium concentration measured during the quarter was 7.69 mg/l in February and 8.24 mg/l in March.

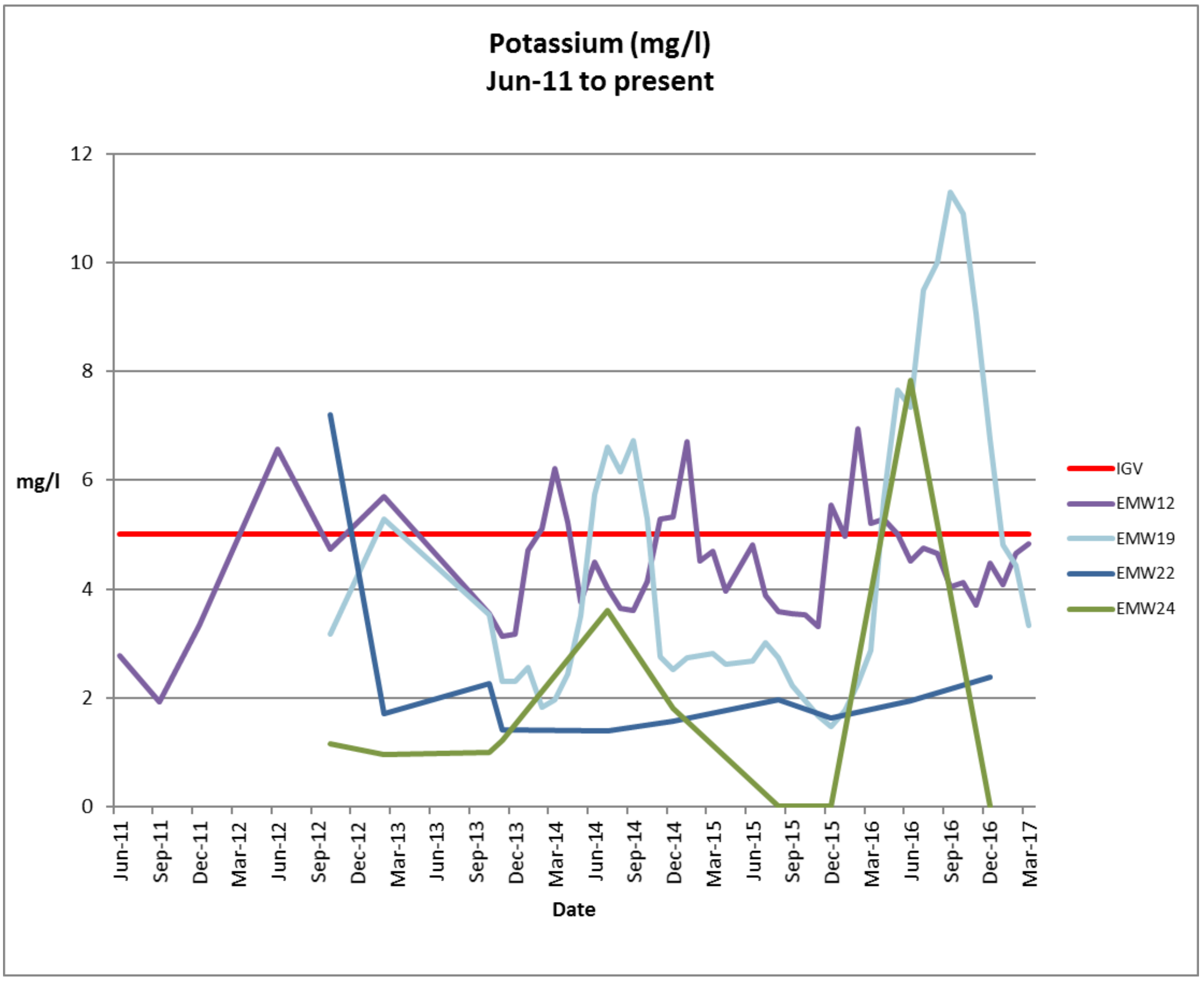
All other off-site wells had potassium concentrations below the IGV throughout Quarter 1. The highest potassium concentration of the remaining wells was recorded at EMW05 near the Morell River in January at 2.73 mg/l. The concentration decreased here through the quarter to 1.91 mg/l in February and 1.45 mg/l in March.

Graph 2.22: Potassium in Overburden Monitoring Wells (June 2011 to present)



Note: Axes values are different between Graphs 2.22 and 2.23.

Graph 2.23: Potassium in Bedrock Monitoring Wells (June 2011 to present)



Note: Axes values are different between Graphs 2.22 and 2.23.

Total Organic Carbon (TOC)

Total organic carbon (TOC) is one of the key parameters that are tested on landfill sites such as Kerdiffstown to establish the overall organic content of leachates and groundwater. There is no guideline value assigned for TOC other than 'there should be no abnormal change in recorded concentrations'. The results are presented in Table A.5.

The highest TOC concentration during the whole of the first quarter of 2017 was at BH26 in Zone 1 at 104 mg/l in February. This is consistent with previous high TOC results for this well with concentrations from 54 mg/l to 114 mg/l recorded since January 2016. High TOC concentrations have also been observed at on-site well EMW13 which is situated close to BH26 to the north of the site. A TOC concentration range of 47.5 mg/l to 92.6 mg/l was recorded during the quarter which is within the range for this well of between 30.9 mg/l and 124 mg/l. These would be viewed as "abnormal" given the likely background concentrations of less than 10 mg/l as recorded in several other boreholes.

During the quarter, boundary well EMW03 ranged from 10.6 mg/l to 20.9 mg/l. At EMW03, the TOC concentration tends to fluctuate with a marked decrease observed in January 2014 (11.6 mg/l); concentrations subsequently increased up to October 2014 (49.1 mg/l) albeit with a small fall recorded in June 2014. Since June 2015 there was a rise in concentration from around 14 mg/l with the concentration in November 2015 observed at 56 mg/l. From November 2015 to January 2016 the concentration fell again to 14 mg/l. However, the TOC concentration was largely stable from February to July 2016 (range of 25.5 to 30 mg/l) before falling to the current concentration.

The TOC value recorded at new southern boundary well DB10 increased dramatically between February (0.8 mg/l) and March (90.2 mg/l), with the March result being the highest of all of the boundary and off-site wells. All other locations, with the exception of EMW03 already discussed, had concentrations below 10 mg/l.

Biochemical Oxygen Demand (BOD)

When biodegradable organic matter (including organic waste) is present in waters it provides nutrients for the growth of bacteria and other microorganisms causing them to multiply and, where bacterial numbers are sufficient causing a depletion of dissolved oxygen in the water. The BOD (5 day) test is a measure of the amount of oxygen consumed by microorganisms in breaking down the organic matter.

All of the results are presented in Table A.5. BOD values in the monitoring wells are presented in Table 2.4 for those wells that were above the applicable[12] LOD. 36 of the 40 wells sampled during Quarter 1 2017 recorded BOD values above the LOD in at least one monitoring round.

During the quarter the highest concentration was recorded in new on-site well BH69 at 17 mg/l in February. BH26 also had a relatively high BOD at 11 mg/l in March. Two of the new boundary wells also recorded relatively high BOD concentrations, namely DB02 at 15 mg/l and DB04 at 14 mg/l, both in March. All other wells had concentrations of less than 10 mg/l throughout the quarter.

Table 2.4: Quarter 1 2017 BOD Detections

Well	Jan	Feb	Mar
On-Site Wells (mg/l)			
EMW13	4	8	6
EMW15	<1	2	<1
EMW16	<1	1	2
BH26	3	8	11
BH42	<1	4	1
BH68	-	2	<1
BH69	-	17	-
BH70	-	4	<1
BH71	-	4	<1
BH72	-	3	<1
BH77	-	9	<1
BH78	-	4	<1

Well	Jan	Feb	Mar
Boundary Wells (mg/l)			
EMW03	2	4	7
EMW06	<1	<1	1
EMW19	1	2	<1
BB01	-	2	6
RCBB01	-	2	4
BB02	-	1	2
BB04	-	1	3
DB02	-	-	15
DB04	-	-	14
DB05	-	<1	4
DB06	-	5	4
DB08	-	<1	3
DB10	-	2	1

Well	Jan	Feb	Mar
Off-Site Wells (mg/l)			
EMW05	<1	2	5
EMW08	1	<1	<1
EMW28	2	1	3
EMW29	<1	1	2
RM02	-	<1	1
RM03	-	<1	5
RM04	-	1	3
RM05	-	4	<1
RM06	-	<1	6
BB03	-	<1	3
DB03	-	<1	2

Cyanide

Cyanide is a reactive, highly toxic entity which in excessive amount will cause mortality rapidly to humans and to fish. Cyanide was detected above the LOD (0.009 mg/l) in four wells during Quarter 1 of 2017, all located on-site (EMW11, EMW12, EMW13 and BH69). All of the other 36 wells sampled during the quarter had no cyanide above the LOD.

[12] The laboratory adjusts the applicable LOD depending on the dilution factor required as a result of interference in the sample such as silt of high chloride.

EMW11 and EMW12 had cyanide concentrations above the LOD in January only. 0.22 mg/l was detected at EMW11, the first cyanide detection here since February 2015 and the highest since the peak in June 2014 at 0.135 mg/l. 0.019 mg/l was detected at EMW12, the first detection here since June 2014 when 0.124 mg/l was detected. Cyanide was detected at EMW13 in March for the first time since June 2014 also, at a concentration just at the LOD of 0.009 mg/l. The only other detection was at new well BH69 where cyanide was detected just at the LOD of 0.009 mg/l in February.

Trace Metals/Elements

In certain types of wastes when the pH is low the solubility of many metal ions increases and therefore they can become mobilised into the developing leachate. As such, elevated concentrations of trace metals can be indicative of leachate contamination within groundwater.

Results for trace metals and metalloids during Quarter 1 of 2017 are presented in Table A.3. There were a number of exceedances of the respective IGVs/GTVs for these metals, which are summarised in Table 2.5 below. Only the new wells in February 2017 were monitored for these elements except for arsenic which was monitored at all wells on all sampling occasions.

Table 2.5: Trace Metal and Metalloid Exceedances in Quarter 1 2017

Parameter	Lower of IGV/GTV (mg/l)	Number of exceedances	Maximum result (mg/l)	Location of maximum result
Arsenic	0.0075	42	0.051	EMW28 (off-site)
Barium	0.1	15	1.74	DB02 (boundary)
Boron	0.75	2	3.19	DB03 (off-site)
Cadmium	0.00375	2	0.0286	DB02 (boundary)
Chromium	0.03	2	0.042	BH72 (on-site) & DB02 (boundary)
Copper	0.03	8	0.361	DB02 (boundary)
Lead	0.01	9	0.368	DB02 (boundary)
Mercury	0.0001	7	0.001	BH78 (on-site)
Nickel	0.015	10	0.317	DB02 (boundary)
Zinc	0.1	6	0.778	DB02 (boundary)

The majority of the maximum results were recorded at northern boundary well DB02, with the IGV/GTV exceeded for the majority of elements. There were also a few maxima recorded on site at BH72 and BH78, and boron was at its maximum at off-site well DB03, near to DB02.

Organic Compounds

Groundwater samples from the new wells sampled during the February 2017 monitoring round were analysed for an extended suite comprising VOCs, SVOCs, PAHs, TPH, phenols, formaldehyde, acid herbicides and organo-chlorine pesticides.

The results for organic compounds are summarised below and the data are shown in Table A.6.

Polycyclic Aromatic Hydrocarbons (PAHs)

PAH results are shown in Table A.6a. The larger biannual suite of testing was only carried out on the new wells during Quarter 1 of 2017. As can be seen in the table below PAHs were detected in ten of the new wells during the quarter. The highest detection was near the centre of the site in BH77 at 1.25 µg/l, while a further four wells exceeded the IGV of 0.1µg/l (results in bold in the table). There were no PAHs detected at any off-site wells.

PAHs were detected in the following monitoring wells:

Total PAHs (µg/l) Quarter 1 2017							
On-Site Wells			***Boundary Wells***			***Off-Site Wells***	
BH69	**0.87**		RCBB01	**0.665**		None	
BH70	0.02		BB04	0.054			
BH71	**0.567**		DB05	0.022			
BH77	**1.25**		DB08	0.04			
BH78	**0.142**		DB10	0.028			

Total Petroleum Hydrocarbons (TPH)

TPH (as measured by the VPH/EPH C5-C44 analysis) is reported in the majority of the new monitoring boreholes to be below the LOD. TPH was only detected in two on-site samples located towards the centre of the site. These were BH77 with a concentration of 13 µg/l and BH78 with a concentration of 21 µg/l.

Semi Volatile Organic Compounds (SVOCs)

Excluding phenols (see below for consideration of phenolic compounds), SVOCs were absent in the groundwater samples.

Volatile Organic Compounds (VOCs)

As with the SVOCs, VOCs were absent in the groundwater samples obtained from the new wells.

Phenolic Compounds

Phenol (identified within the SVOC suite) was reported above analysis detection limits in 15 of the 23 wells sampled during the quarter. It was detected in on-site, boundary and off-site wells above the IGV of 0.5 µg/l as laid out below:

Total Phenol (µg/l) Quarter 1 2017							
On-Site Wells			***Boundary Wells***			***Off-Site Wells***	
BH68	5.7		RCBB01	7.7		BB03	60.2
BH70	1.2		BB01	14.9		RM01	7.5
			BB02	10.1		RM02	10.6
			BB04	4.1		RM03	3.3
			DB05	6.7		RM06	11.3
			DB08	60.6		DB03	18.8
			DB10	20.6			

With respect to the speciated phenol analysis which is undertaken as part of the extended sampling suite, phenolic compounds were identified in 15 of the 23 samples taken from the new wells. Figure 9 shows an overview of the distribution of speciated phenols in the new wells in February 2017. The highest total phenol concentration from the speciated analysis was at monitoring well DB08 at the eastern boundary with Foley's field at 60.6 µg/l.

Formaldehyde

During Quarter 1 of 2017, formaldehyde was detected in seven of the new monitoring wells. This included on-site, boundary and off-site wells. The only on-site well was BH69 at 0.079 mg/l. Three boundary wells contained formaldehyde above the LOD, namely BB01 (0.067 mg/l), RCBB01 (0.129 mg/l) and DB06 (0.088 mg/l). There were also three off-site wells where formaldehyde was detected, namely the wells adjacent to the Morell River, RM01 (0.038 mg/l), RM04 (0.11 mg/l) and RM06 (0.045 mg/l).

Herbicides & Pesticides

The groundwater samples from the new wells were analysed for a standard suite of acid herbicides and organo-chlorine pesticides. During Quarter 1 of 2017, four compounds typically detected at other wells in the past were detected above the respective laboratory detection limits. These are discussed below and Figure 10 provides an overview of the distribution of mecoprop on and off site in February 2017.

Mecoprop is an active ingredient in many broadleaf weed killers and has been detected in past monitoring events. For the Quarter 1 monitoring round of the new wells, mecoprop was detected in eleven wells. It was detected at a concentration in excess of the IGV of 10 µg/l at a single location (DB02 at 19.1 µg/l) with all other detections below 1 µg/l. Mecoprop was detected at wells on site (BH70, BH71 and BH77), off-site (RM03, RM04, RM06 and DB03) and at the boundary with Kerdiffstown House (BB01, RCBB01 and DB02).

Dichlobenil is also used for weed control. It was reported at trace concentrations in six of the new well groundwater samples; specifically on-site monitoring wells BH69 (37 ng/l), BH70 (30 ng/l), BH71 (11 ng/l), BH77 (2 ng/l) and BH78 (5 ng/l), as well as boundary well DB02 (22 ng/l).

Another compound, dieldrin, was detected at BH71 at a concentration of 7 µg/l and at BH78 at a concentration of 11 µg/l during the quarter. There were no detections of this compound in boundary or off-site wells. A common use of dieldrin was as a soil insecticide prior to 1970. There is no IGV associated with dieldrin.

Chlopyralid was detected at two wells during the quarter in on-site location BH71 at a concentration of 0.36 µg/l, exceeding the IGV of 0.1 µg/l. It was also detected at off-site location BB03 at a concentration of 0.09 µg/l, below the IGV. This broadleaf weed killer had been detected in wells during previous monitoring rounds.

2.2.2.2 Comparison of Results against Proposed DQRA Trigger Levels

The analytical results collected over the past 12 months have been compared to the trigger levels presented in the November 2014 groundwater DQRA report. Trigger levels were proposed in the DQRA for a small number of determinands in a small number of wells. These trigger levels have not been formally adopted in any licence or other regulatory document. In Quarter 1 2017, trigger levels were not exceeded in any of the wells as shown in Table 2.6.

Table 2.6: Comparison of Quarter 1 2017 Results against DQRA Trigger Levels

Determinand	Concentration (Last 12 months) (mg/l)		Concentration Range (mg/l) (Quarter 1 2017)	Trigger Level (mg/l)	Comment
	Min	Max			
EMW03					
Chloride	55.8	114	66.9 to 87.5	237.7	Monitored monthly; no exceedances
Ammoniacal nitrogen	17.7	47	17.7 to 38.3	130.7	Monitored monthly; no exceedances
Phenol	<0.0001	**0.00078**	N/A	0.0001	Monitored twice since Jan 2016; one exceedance in **June 2016**
Mecoprop	0.00162	0.00292	N/A	0.032	Monitored twice since Jan 2016; no exceedances
EMW05					
Chloride	9.7	29.1	10.6 to 19.4	57.3	Monitored monthly, no exceedances
Ammoniacal nitrogen	<0.06	1.58	<0.06 to 0.91	3.7	Monitored monthly, no exceedances
Phenol	<1e-4	<1e-4	N/A	0.00028	Monitored twice since Jan 2016; not detected above LOD
Mecoprop	0.00035	0.0005	N/A	0.00153	Monitored twice since Jan 2016; no exceedances
EMW08					
Chloride	4.8	12.3	7.6 to 9.7	15.4	Monitored monthly; no exceedances
Ammoniacal nitrogen	<0.06	**0.62**	All 0.11	0.4	Monitored monthly; one exceedance: **April 2016**
Phenol	<1e-4	**0.00053**	N/A	0.0001	Monitored twice since Jan 2016, one exceedance in **June 2016**
Mecoprop	<4e-5	<4e-5	N/A	0.00004	Monitored twice since Jan 2016, not detected above LOD
EMW20					
Chloride	19.5	**39.1**	19.6 to 20.6	22.6	Monitored monthly; 8 exceedances: **April, May, June, July, August, September, October, November 2016**
Ammoniacal nitrogen	0.78	**3.06**	0.78 to 0.89	1.4	Monitored monthly; 7 exceedances: **April, May, June, July, August, September, October, November 2016**
Phenol	<1e-4	<1e-4	N/A	0.0001	Monitored twice since Jan 2016; no exceedances.
Mecoprop	0.00004	**0.00033**	N/A	0.00023	Monitored twice since Jan 2016; one exceedance in **June 2016**

N/A – Not analysed

2.3 Laboratory Analytical Results – Surface Water

In Quarter 1 2017, grab water samples were collected each month from the Morell River and canal feeder, a total of seven locations upstream and downstream of the landfill (as shown on Figure 3) in order to assess any changes in water quality as a result of leachate generated from the waste materials on site. A sample of water from the site's surface water runoff discharge pipe was also collected.

The samples were analysed for the same suite of analytes as the groundwater samples. The inorganic results are presented in Table A.4. Results of analysis of COD, BOD and TOC are presented in Table A.5.

The EPA's HydroNet was consulted to determine flows in the Morell River on the sampling dates during Quarter 1 of 2017. Table 2.7 summarises the flow data for the three months. As the table shows there was considerable variation between the flows during the different sampling events, changing from low in January to high in February, before reducing to a more average flow in March 2017.

Table 2.7: Quarter 1 2017 Morell Flow Data

Date	Flow	Q-Value*	Comment
30 January 2017	0.45 m^3/s	Q76	Low flow (exceeded 76% of the time)
28 February 2017	0.705 m^3/s	Q37	High flow (exceeded 37% of the time)
20 March 2017	0.668 m^3/s	Q43	Average flow (exceeded 43% of the time)

* Q values calculated from daily flows from 2009 onwards

Ammoniacal Nitrogen

Morell River

As seen in Table 2.8, ammoniacal nitrogen was not detected above the LOD (LOD) (0.06 mg/l) in any sample taken from the Morell River with the exception of January at SW02 (0.08 mg/l). This detection is unusual, with ammoniacal nitrogen only being detected one other time at this monitoring point (0.2 mg/l in September 2015). The location of this monitoring point being just downstream from the confluence with the Hartwell, as well as there being low flows in the river in January, may be the reason for the concentration observed. The ammoniacal nitrogen concentration during the two subsequent sampling rounds were below the LOD. It has almost consistently been the case since monitoring began in the Morell that ammoniacal nitrogen is not detected above the LOD upstream or downstream of the site.

Canal Feeder

Ammoniacal nitrogen concentrations have been elevated at SW13 since monitoring commenced in October 2013. The concentration decreased from 3.16 mg/l to 0.79 mg/l during Quarter 1 2017, decreasing from 3.5 mg/l in December 2015, the highest concentration here since June 2015. Ammoniacal nitrogen was below the LOD in the other canal feeder sampling point SW11 for the whole quarter as is generally the case at this location.

Ammoniacal nitrogen concentrations fluctuate at the site discharge as was recorded during Quarter 1 2017. The concentration was 0.1 mg/l in January, dropping to below the LOD in February, and increasing again to 0.07 mg/l in March 2017. These concentrations are well within previously recorded ranges, with the peak for this location being 0.3 mg/l detected in January 2015.

Table 2.8: Quarter 1 2017 Surface Water Ammoniacal Nitrogen Results

Water Body	Sampling Location	Ammoniacal Nitrogen (mg/l)			Orientation from site
		Jan	Feb	Mar	
Morell River	SW01	<0.06	<0.06	<0.06	Upstream SE
	SW02	**0.08**	<0.06	<0.06	Upstream E
	SW03	<0.06	<0.06	<0.06	Adjacent E
	SW03A	<0.06	<0.06	<0.06	Adjacent E
	SW05	<0.06	<0.06	<0.06	Downstream NE
Canal Feeder	SW13	**3.16**	**1.58**	**0.79**	Upstream S
	Site Discharge	**0.1**	<0.06	**0.07**	Adjacent to S
	SW11	<0.06	<0.06	<0.06	Downstream SW

TOC

Results of TOC analysis are presented in Table A.5 and summarised below in Table 2.9.

The determination of TOC is complementary to the oxygen demand analyses (biochemical and chemical) discussed below and, in strict terms, it is a better indicator of organic content in that it is a direct measurement of carbon.

Morell River

TOC results were noted to vary only slightly as the river passes the site as shown in Table 2.9, with the concentration remaining steady between all five monitoring points. The only exception to this was in January 2017 when there was a substantial increase in TOC at SW02, with the concentration increasing from 1 mg/l at SW01 to 6.8 mg/l at SW02 and then reducing again to 1 mg/l at SW03. The January concentration in SW02 was the highest recorded since June 2016. This spike in TOC in January may have been as a result of input from the Hartwell in combination with the low flow in the river at the time. In January and February 2017 the TOC concentration upstream at SW01 was slightly higher than at SW05, while SW05 was slightly higher than SW01 in March. Generally, all TOC concentrations were low as has been the case in previous monitoring rounds.

Aside from the high concentration at SW02, there was a generally increasing concentration in the river through the quarter, with March concentrations marginally higher than January. This is potentially as a result of increasing rainfall through the quarter.

Canal Feeder

Through Quarter 1 2017 the TOC at upstream point SW13 decreased month on month, from 8.1 mg/l in January to 5.9 mg/l in March 2017. These results are generally higher than the 2016 concentrations which averaged about 4 mg/l, but remain below the highest concentration recorded here of 10.4 mg/l in March 2014.

During Quarter 1 2017, the TOC concentration in the canal feeder decreased between SW13 upstream and SW11 downstream. The TOC concentration at SW11 ranged from 2.6 to 4 mg/l during the quarter, typical results for this sampling point. Similarly the TOC concentration at the Site Discharge was typical for this monitoring point, ranging from 1.5 mg/l to 2.1 mg/l during the quarter.

Table 2.9: Quarter 1 2017 Surface Water TOC Results

Water Body	Sampling Location	TOC (mg/l)			Orientation from site
		Jan	Feb	Mar	
Morell River	SW01	1	1.2	1.8	Upstream SE
	SW02	6.8	1	2	Upstream E
	SW03	1	1.2	1.9	Adjacent E
	SW03A	0.8	1.1	1.9	Adjacent E
	SW05	0.9	1	1.9	Downstream NE
Canal Feeder	SW13	8.1	6.3	5.9	Upstream S
	Site Discharge	2.1	1.5	1.9	Adjacent to S
	SW11	3.3	2.6	4	Downstream SW

BOD and COD

Results of BOD and COD analysis are presented in Table A.5 and summarised below in Table 2.10. The BOD concentrations in rivers often increase during periods of heavy rain and high river flows as organic matter is washed in from the land and farmyards.

Morell River

Results for the samples obtained from the Morell River in December 2016 were below the LOD of 1 mg/l in every sampling round in Quarter 1 2017. This is similar to previous rounds. With respect to COD the pattern varied throughout the quarter as the river flowed past the site. In January, as with TOC, there was a large jump in COD at SW02 from below the LOD (11 mg/l) to 45 mg/l, again likely due to a combination of input from the Hartwell and the low flows. The COD decreased to below LOD at SW03 and remained low, increasing slightly to 13 mg/l at SW05. There was no COD detected above LOD during February, while the COD decreased from 31 mg/l at SW01 to below the LOD at SW02 to SW05 in March.

Canal Feeder

The highest concentrations of BOD through the whole quarter were recorded at SW13, upstream of the site discharge point. The highest of these was 3 mg/l recorded in January and February 2017. BOD was recorded as below the LOD (1 mg/l) in March 2017. The BOD was lower downstream of the site discharge with all results below the LOD throughout the quarter.

A notably high COD concentration was recorded in the site discharge in January 2017 (88 mg/l). This is the highest COD recorded at this monitoring point since July 2014. Despite this high concentration, the COD downstream at SW11 was 19 mg/l, a reduction on December 2016. At SW13 there was also a reduction compared to December 2016, from 67 mg/l to 25 mg/l. All monitoring points were below the LOD (11 mg/l) in February but increased in March 2016, with SW13 upstream recording 20 mg/l, a lower concentration than SW11 downstream at 24 mg/l. The site discharge had the lowest concentration in March 2017 at 13 mg/l.

Table 2.10:Quarter 1 2017 Surface Water BOD & COD Results

Water Body	Sampling Location	BOD (mg/l)			COD (mg/l)			Orientation from site
		Jan	Feb	Mar	Jan	Feb	Mar	
Morell River	SW01	<1	<1	<1	<11	<11	31	Upstream SE
	SW02	<1	<1	<1	45	<11	<11	Upstream E
	SW03	<1	<1	<1	<11	<11	<11	Adjacent E
	SW03A	<1	<1	<1	<11	<11	<11	Adjacent E
	SW05	<1	<1	<1	13	<11	<11	Downstream NE
Canal Feeder	SW13	3	3	<1	25	<11	20	Upstream S
	Site Discharge	<1	<1	<1	88	<11	13	Adjacent to S
	SW11	<1	<1	<1	19	<11	24	Downstream SW

Iron and Manganese

Iron and manganese results are summarised below in Table 2.11. The LOD for iron is 0.23 mg/l, and for manganese is 0.007 mg/l.

Morell River

There were unusually high concentrations of iron and manganese measured upstream during Quarter 1 of 2017. At SW01 in March 2017, iron was detected above the LOD for the first time since October 2013 at 1.22 mg/l, the highest ever iron concentration at this monitoring point. Manganese was similarly elevated in March 2017 at 0.2 mg/l, the highest concentration at this monitoring point since October 2013.

At SW02, just upstream of the site, there were also elevated concentrations of iron and manganese detected. Iron concentrations fluctuated over the quarter and were found to be elevated at 1.1 mg/l in January and 1.4 mg/l in March 2017, with the concentration below the LOD in February. The March concentration was the highest recorded at this point since March 2016. Manganese was only elevated in January 2017 at 0.172 mg/l (the highest ever recorded here, with February and March being back down to more commonly recorded concentrations (0.007 mg/l to 0.057 mg/l). The locations adjacent and downstream of the site (SW03 to SW05) showed no elevation in either iron or manganese during the quarter.

Canal Feeder

Upstream at SW13, iron and manganese both decreased from their respective peaks recorded in December 2016. Iron decreased during the quarter from December's 7.4 mg/l to 1.13 mg/l in March 2017. Similarly manganese dropped during the quarter from 1.9 mg/l in December to 0.288 mg/l by March 2017.

Downstream at SW11, there was also elevated iron and manganese detected in December 2016, with both being at their highest concentration since October 2015. As at SW13, both also decreased during the quarter. The iron concentration fell from 1.6 mg/l in December to below LOD in March 2017, while manganese decreased from 0.33 mg/l in December to 0.064 mg/l in February 2017 before increasing again slightly to 0.072 mg/l in March.

There were also iron and manganese spikes detected at the site discharge, with the January results being the highest recorded here since January 2015. Iron increased from below LOD in December 2016 to 4.53 mg/l in January 2017, before reducing again in February and March to 0.64 mg/l. At the same time, manganese also increased greatly from below the LOD in December 2016 to 0.609 mg/l in January 2017. This then decreases again to 0.088 mg/l in February before increasing slightly to 0.159 mg/l in March 2017.

Table 2.11: Quarter 1 2017 Surface Water Iron & Manganese Results

Water Body	Sampling Location	Iron (mg/l)			Manganese (mg/l)			Orientation from site
		Jan	Feb	Mar	Jan	Feb	Mar	
Morell River	SW01	<0.23	<0.23	1.22	<0.007	0.01	0.2	Upstream SE
	SW02	1.1	<0.23	1.14	0.172	0.013	0.016	Upstream E
	SW03	<0.23	<0.23	<0.23	<0.007	0.02	0.019	Adjacent E
	SW03A	<0.23	<0.23	<0.23	<0.007	0.012	0.018	Adjacent E
	SW05	<0.23	<0.23	<0.23	<0.007	0.018	0.018	Downstream NE
Canal Feeder	SW13	2.42	2.58	1.13	1.55	0.547	0.288	Upstream S
	Site Discharge	4.53	0.78	0.64	0.609	0.088	0.159	Adjacent to S
	SW11	0.73	<0.23	<0.23	0.147	0.064	0.072	Downstream SW

Sulphate

Sulphate results are summarised below in Table 2.12.

Morell River

There were unusually high concentrations of sulphate measured at some monitoring points in the Morell River during March 2017. Generally during Quarter 1 of 2017 there was little variation in sulphate across the sampling points, however during March 2017 there was a spike in sulphate at SW02 (61.2 mg/l) located just upstream of the site where the Hartwell joins the Morell. The sulphate reduced back down at SW03 (20.6 mg/l) and SW03A (18.5 mg/l) before spiking again at SW05 (40.7 mg/l), the furthest monitoring point downstream of the site. In the case of both SW02 and SW05, these concentrations are the highest ever recorded at these locations and represent dramatic increases in both. Neither of these concentrations were in exceedance of either the IGV for sulphate (200 mg/l) or the drinking water limit of 250 mg/l.

Sulphate results during January and February 2017 were as normal, ranging between 13.5 mg/l and 19.0 mg/l, with little variation between months or between monitoring locations.

Canal Feeder

Sulphate concentrations in the canal feeder stream were highest upstream at SW13 throughout the quarter. As can be seen in the table below, the sulphate concentration was greatly reduced downstream at SW11 compared to the upstream results, a trend that is often seen in this waterbody. Sulphate concentrations at the Site Discharge remained well below that recorded in the canal feeder stream, as has generally been the case in the past.

Table 2.22: Quarter 1 2017 Surface Water Sulphate Results

Water Body	Sampling Location	Sulphate (mg/l)			Orientation from site
		Jan	Feb	Mar	
Morell River	SW01	16.6	17.5	18.8	Upstream SE
	SW02	13.5	18.1	61.2	Upstream E
	SW03	18.2	17.0	20.6	Adjacent E
	SW03A	17.9	17.1	18.5	Adjacent E
	SW05	19.0	17.0	40.7	Downstream NE
Canal Feeder	SW13	22.8	56.5	41.4	Upstream S
	Site Discharge	<4.4	6.9	5.1	Adjacent to S
	SW11	10.7	28.8	28.2	Downstream SW

Chloride

Chloride results for the surface water samples are shown in Table 2.13.

Morell River

Following an unusually elevated chloride concentration upstream at SW01 in December 2016, the chloride concentrations were back to more normal concentrations for SW01 during Quarter 1 2017 (14.1 mg/l to 18.5 mg/l). As with several other results previously discussed (ammoniacal nitrogen, TOC and COD) there was an increase in chloride at SW02 in January 2017 compared to the upstream sample at SW01. The chloride concentration (22.4 mg/l) was the highest measured at that point since February 2015. As with the other determinands, the chloride spike had reduced again by the next sampling point downstream (SW03). This suggests that there was likely an input from the Hartwell in combination with the low flow which was being seen at SW02 during January. This type of spike at SW02 was not seen during the rest of the quarter.

There is typically very little variation in chloride concentrations in the Morell River when comparing upstream to downstream concentrations as indicated in Graph 2.24. Generally the chloride concentrations are found to be slightly higher downstream than upstream, a trend which was seen throughout Quarter 1 2017. However, this trend was more pronounced than usual in February 2017, when there was a relatively large increase recorded between SW01 (18.5 mg/l) and SW05 (22.1 mg/l). This large increase was not recorded again in March 2017, when the increase was only very marginal between upstream and downstream (14.1 mg/l to 14.2 mg/l). The March results were very low at all sampling points in the Morell River, with SW02, SW03 and SW03A recording their lowest ever chloride concentrations.

Canal Feeder

Upstream at SW13, the chloride concentration increased through the quarter from 66.9 mg/l to 132 mg/l. These increases are well within the previously recorded range, and well below the peak of 351 mg/l recorded in February 2015. The increase is likely to be caused by the increasing rainfall through the quarter washing road salt into the stream upstream of the site as has been seen in past winters.

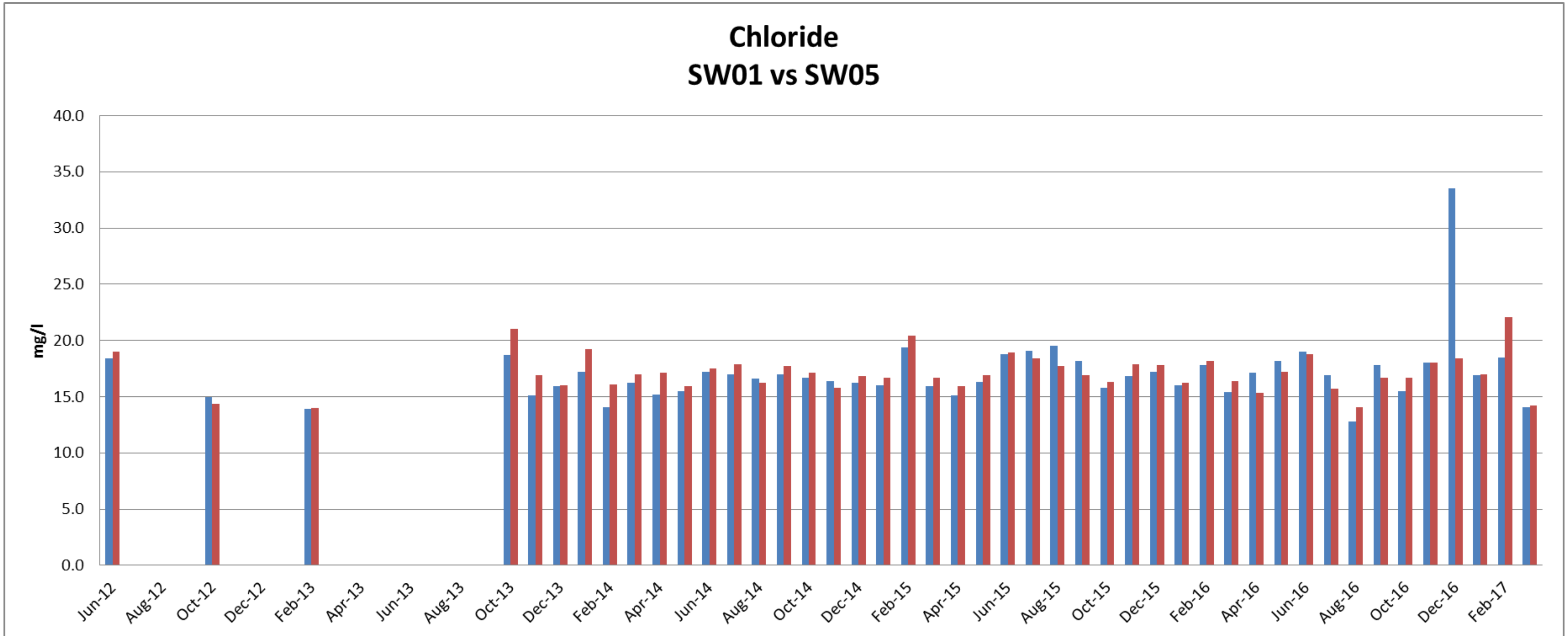
The chloride concentrations did not follow a similar pattern downstream at SW11 where they increased between January and February (50 mg/l to 99.7 mg/l) before decreasing slightly in March (88.7 mg/l). Throughout the quarter the chloride concentrations were consistently higher upstream at SW13 than downstream at SW11, as has usually been the case.

The chloride concentration in the site discharge was lower than the samples from the canal feeder as is generally the case. It decreased through the quarter, from 12.8 mg/l in January to below the LOD (3.7 mg/l) in March 2017.

Table 2.13:Quarter 1 2017 Surface Water Chloride Results

Water Body	Sampling Location	Chloride (mg/l)			Orientation from site
		Jan	Feb	Mar	
Morell River	SW01	16.9	18.5	14.1	Upstream SE
	SW02	22.4	19.6	13.7	Upstream E
	SW03	16.7	19.4	14.2	Adjacent E
	SW03A	16.7	19.3	13.9	Adjacent E
	SW05	17	22.1	14.2	Downstream NE
Canal Feeder	SW13	66.9	113	132	Upstream S
	Site Discharge	12.8	4.9	<3.7	Adjacent to S
	SW11	50	99.7	88.7	Downstream SW

Graph 2.24: **Chloride in Morell River – Upstream (SW01) vs downstream (SW05) (June 2012 to Present)**



	Jun-12	Oct-12	Feb-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15
SW01	18.	15.	13.	18.	15.	15.	17.	14.	16.	15.	15.	17.	17.	16.	17.	16.	16.	16.	16.	19.	15.	15	16
SW05	19.	14.	14.	21.	16.	16.	19.	16.	17.	17.	15.	17.	17.	16.	17.	17.	15.	16.	16.	20.	16.	16	17

	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	
SW01	19	19	20	18	16	17	17	16	18	15	17	18	19	17	13	18	16	18	34	17	19	14	
SW05	19	18	18	17	16	18	18	16	18	16	15	17	19	16	14	17	17	18	18	17	22	14	

2.4 Potential Pollutant Linkages

The groundwater CSM for Zone 1, considering contaminant sources, pathways and receptors is presented in Figure 6 and summarised below.

Overall the CSM largely remains the same to that identified during previous groundwater monitoring rounds as well as the DQRA

Source

The ultimate source for contamination observed at the site is the waste that has been deposited across the site. As water percolates through waste in the uncapped areas of the landfill, leachate will be produced and monitoring of on-site monitoring wells (current and previous) shows clear evidence of leachate impacted groundwater within the overburden deposits beneath the site. However, on-site observations and earlier calculations of leachate generation would indicate that the wastes are currently not fully saturated and a large proportion of rainfall that enters the waste soaks into the waste rather than generates leachate. However, this may change in the future and as the wastes become saturated more leachate will be produced.

A further source of leachate generation will be groundwater flowing through the wastes. Assessment of site investigation data shows that an area of waste in the north-western area in Zone 1 is likely to be up to 5m below the groundwater table. There will be leaching directly from this waste into groundwater. Level data indicates a clear increase in groundwater levels within the overburden during the period from November 2013 through to March 2014 (acknowledging that levels drop again in March) as increased infiltration occurs across the site. More recent groundwater level data indicates a relatively stable level within the overburden. It is also noted that while an increase in groundwater levels increases the potential for direct leaching of contaminants from the waste mass into shallow groundwater, the increased flow of groundwater through the shallow aquifer caused by higher infiltration rates also has the effect of “diluting” leachate strength as evidenced by the decrease in chloride concentrations in monitoring wells installed along or near the north-eastern boundary during the period of higher water levels.

Pathways

The groundwater quality data collected during Quarter 1 of 2017 shows that leachate contaminated groundwater is present on the site’s northern and north-eastern boundary and groundwater level data indicates that groundwater is flowing from the site northwards and north-eastwards towards the Morell River. This is consistent with previous observations at the site. The pathway for leachate migration is via the landfill base and any subsequent natural routes connected to the receptor. These routes are considered to be movement of contaminants through the unsaturated zone to the groundwater underlying the site and subsequent movement of the contaminants within groundwater.

The pattern of groundwater flow between the site and the canal feeder suggest there is limited potential for leachate migration from the site through shallow groundwater although it should be noted that there is a direct connection to the site via a surface water drain. The groundwater therefore presents a pathway from the site to the river. If contamination were to enter the river, then the river could also act as a pathway with the water being diverted from the river to the Grand Canal or flowing into the River Liffey.

It is noted, however, greatly elevated contaminant concentrations are not observed in groundwater samples from off-site monitoring wells closer to the river and it is possible that attenuation processes are reducing the concentrations of contaminants as they migrate from the site.

Receptors

Based on the groundwater flow direction and contaminant distribution, the principal receptor being considered for the identified contamination is the Morell River, situated to the east of the site. Other surface water features to the east of the site associated with the Palmerstown Golf Club and the canal feeder ditch in the west may also be receptors for groundwater. If contamination were to enter the Morell River then receptors downstream of the river, including abstractions from the River Liffey, may be at risk.

The groundwater itself should also be considered as a receptor although to the east of the site where there is limited potential for use of the groundwater due to the relatively narrow strip of land between the site and the river, this may be considered more a pathway than a receptor. Groundwater can be regarded as potential receptors as future users of groundwater may seek to use this resource (while some of the golf courses in the area have abstraction wells for irrigation there are no known users of drinking water wells locally). It should be noted that while there is clearly impacted groundwater within the overburden deposits directly beneath the site, there is limited evidence of impact in the underlying bedrock.

Current monitoring has shown that while there is contamination in the groundwater beneath the site and near to the north-east site boundary, to date this has not migrated to the river to result in significant impacts on any surface waters as observed through the comparison of upstream and downstream samples collected from an extended network of monitoring points.

3. Summary, Conclusions and Recommendations

3.1 Summary and Conclusions

3.1.1 Groundwater Results

Groundwater quality data for the first quarter of 2017 was largely consistent with results obtained during previous sampling rounds completed between June 2011 and December 2016. In February and March of Quarter 1 2017, there were a number of the newly drilled wells which were sampled as well as the fifteen wells sampled every month. The results of these samples, combined with the existing data from the older wells has aided in further understanding of leachate movement from the site.

On-site during Quarter 1 of 2017, the wells exhibiting the highest concentrations of the key leachate indicators are located within the Zone 1 area of the site, namely BH26 towards the centre of Zone 1 and EMW13 in the north of Zone 1. Groundwater sampled from these wells has consistently been elevated in key determinands such as ammoniacal nitrogen and chloride since monitoring began. This has culminated in the highest ever recorded ammoniacal nitrogen (213 mg/l) and chloride (296 mg/l) concentrations at EMW13 in March 2017. Sampling from wells installed in 2016 has indicated that there is potential migration of contamination from this area of the site northwards with boreholes DB02 and DB02 showing signs of contamination off-site to the north of Zone 1.

Another part of the site which tends to exhibit evidence of leachate contamination is along the lower north-eastern boundary in Zone 2B and Zone 4. In particular during the quarter, EMW16 and new well BH69 had concentrations of ammoniacal nitrogen and chloride well in excess of the IGVs. EMW16 has been consistently in exceedance of both the ammoniacal nitrogen IGV (0.12 mg/l) and chloride IGV (30 mg/l) since monitoring began (ranging from 0.33 mg/l to 14.2 mg/l for ammoniacal nitrogen and 135 mg/l to 238 mg/l for chloride), while BH69 had an elevated ammoniacal nitrogen concentration at 19.9 mg/l in February 2017 and a slightly elevated chloride concentration at 35.4 mg/l. EMW15 also displays evidence of leachate contamination with ammoniacal nitrogen ranging from 7.31 mg/l to 10.8 mg/l and chloride ranging from 29.4 mg/l to 38.4 mg/l during the quarter.

There are also a number of wells in the central south-eastern part of the site (Zone 4) which similarly display elevated key leachate indicators. BH42 is consistently in exceedance of the IGV for ammoniacal nitrogen and fluctuates around the IGV for chloride, increasing from below it in January 2017 (23.2 mg/l) to above it in March (38.4 mg/l). Two new wells near to BH42 sampled during the quarter had similar exceedances of the IGVs. BH71 just north of BH42 ranged from 6.75 mg/l to 7.21 mg/l in ammoniacal nitrogen, and from 40.9 mg/l to 46.3 mg/l in chloride. BH70 in the lower yard of Zone 4, ranged from 6.52 mg/l to 6.73 mg/l in ammoniacal nitrogen and 32.6 mg/l to 33.7 mg/l in chloride.

As noted above, a number of boundary wells located just outside the northern site boundary also exhibit evidence of leachate contamination where new boundary well DB02 and new off-site well DB03 both have ammoniacal nitrogen and chloride concentrations above the IGV. DB02 and DB03 both have elevated ammoniacal nitrogen concentrations, with 1.36 mg/l at DB02 and the concentration in DB03 (located behind Kerdiffstown House) ranging from 6.38 mg/l to 6.96 mg/l. DB02 at the site boundary had the highest chloride concentration of all wells outside the site (294 mg/l). Results at these two wells strongly indicate the migration of leachate from Zone 1 of the site to the north, following the approximate northerly/north-easterly flow of groundwater. This migration appears to be localised to the area just north of the site boundary around DB02 and DB03 as wells further north (EMW22 and EMW23) have recorded markedly lower chloride and ammoniacal nitrogen concentrations in the past (generally below the IGV). Similarly, EMW24 to the north-east has also recorded lower concentrations, again generally remaining below the IGV, particularly in recent years.

As well as at the northern boundary, there is also evidence of localised leachate migration from the north-east in the vicinity of EMW03. This well generally exceeds the IGV in both ammoniacal nitrogen and chloride, with the Quarter 1 results continuing that trend, ranging from 17.7 mg/l to 38.3 mg/l in ammoniacal nitrogen (the highest of all wells outside of the site) and 55.8 to 87.5 mg/l in chloride. The leachate migration from this part of the site appears to be localised as there is no contamination recorded at wells nearby to the north (EMW06 and BB02) and to the south (DB05).

Further south along the boundary, adjacent to the Zone 2B and Zone 4 boundary, there is also some minor evidence of leachate contamination in the groundwater exiting the site. During Quarter 1 of 2017 this shows up as ammoniacal nitrogen concentrations in excess of the IGV at BB01, RCBB01, EMW19 and BB04. However, the chloride concentrations tend to be below or only marginally above the IGV in this area.

Apart from DB03 which was previously discussed, evidence of impact to the groundwater at off-site wells is minimal indicating that groundwater contamination is remaining localised. Of particular interest are the wells located between the site and the Morell River. Most wells have key leachate indicators below the IGVs, and indeed below the respective LOD in many cases. A regular exception to this is at EMW20 adjacent to the Morell River, where the ammoniacal nitrogen concentration is consistently in excess of the IGV (0.78 mg/l to 0.89 mg/l during the quarter). However chloride concentrations are rarely in excess of the chloride IGV. A number of the new wells located between the site and the river also had ammoniacal nitrogen concentrations above the IGV during the quarter, namely RM03, RM04 and RM06, with RM04 containing the highest concentrations from 0.84 mg/l to 1.45 mg/l. Only RM03 was also in excess of the chloride IGV (33.6 mg/l to 38.4 mg/l). To date there has been no evidence of leachate contamination in the Morell River adjacent to these wells.

3.1.2 Surface Water Results

Monitoring of surface water samples from the Morell River and canal feeder has been undertaken at key strategic locations during the monthly monitoring rounds to assess whether the landfill is having an adverse impact upon water quality within these water bodies.

Morell River

The analytical results from the surface water samples collected during the first quarter of 2017 indicate that water quality in the Morell River is generally good. This has also been the case during previous monitoring rounds since 2011. Water quality in the downstream samples was very similar to water quality in the respective upstream samples. The main exception to this is in chloride concentration. In general chloride concentrations upstream of the site are lower than those downstream, a trend seen throughout the quarter. In the majority of cases the increase in chloride is very small, and there continues to be no ammoniacal nitrogen detected above the LOD (0.06 mg/l) downstream of the site. There was no significant increase in the key leachate indicators (ammoniacal nitrogen, chloride and alkalinity) between the respective upstream and downstream samples. However there were unusual sulphate spikes recorded both upstream of the site at SW02 and downstream of the site at SW05 in March 2017. The elevated concentrations were not mirrored in the monitoring locations in between (SW03 and SW03A). The April 2017 results will be looked at closely to determine if this may be a new trend emerging.

Canal Feeder

During Quarter 1 of 2017, the concentrations in most determinands were higher upstream at SW13 than downstream at SW11. This has generally been the case in the past in this stream. There were increased concentrations in a number of determinands upstream during the quarter, namely chloride, ammoniacal nitrogen, potassium, alkalinity, sodium and calcium. There were also unusually high concentrations of iron and manganese upstream at SW13. Concentrations downstream at SW11 are lower indicating that there is no impact to the stream from the landfill site, with much of the contamination coming from elsewhere, in particular road run-off.

3.2 Recommended Way Forward

The observations from the monitoring indicate broadly similar conditions to those encountered previously and the previously defined groundwater CSM largely remains valid. It should be noted that the waste materials in the northern area of the site remain uncapped (and unlined) while the site remains in its current state. Therefore, increased leachate generation within this area of the site can be reasonably anticipated in the future as the wastes become increasingly saturated through progressive rainfall infiltration. This may in turn lead to increased potential for off-site migration of a plume of groundwater contaminated by landfill leachate towards the Morell River.

On the above basis and whilst remediation proposals are being developed, it is recommended that regular monthly groundwater sampling and analysis is continued in line with the recommendations made within the Groundwater Management Plan. In light of the results obtained from sampling of the new 2016 wells, it is recommended that a number of these wells are added to the monthly sampling regime, replacing a number of the established wells. The table below lays out the recommended changes to be made to the monitoring regime and the justification for these changes.

Well to be Added	Justification
BH68	Elevated conductivity recorded in February and March 2017. Monitoring of bedrock to determine that there is no widespread impact in the bedrock aquifer in the vicinity of Zone 2A and Zone 3. No other bedrock well in this area.
BB02	Given impacts observed at overburden wells along Zone 1's eastern boundary, monitoring of the bedrock to determine no widespread impact in the bedrock at this location should be undertaken.
DB02	There were elevated ammoniacal nitrogen and chloride concentrations in this well in March 2017 and there is no other monitoring well along the site's northern boundary monitoring the overburden deposits.
DB03	There were elevated ammoniacal nitrogen and chloride concentrations in February and March 2017 and the borehole had the highest mecoprop concentration of all new monitoring wells. There is no other monitoring well in this area north of the site monitoring the overburden deposits.
Well to be Removed	**Justification**
BH12	On-site bedrock monitoring well for which the historical data have not shown any sign of leachate contamination with ammoniacal nitrogen below the LOD and chloride concentrations generally being low.
EMW06	Groundwater from this well records a perched groundwater body and has never given any elevated results despite being on the site's north-eastern boundary where adjacent wells show impact from leachate.
EMW08	The area around this well is adequately covered by other monitoring wells in addition to relatively consistent results over the past four years of monthly monitoring.
EMW28	Although off-site to the south and up-gradient of the site, there have been low concentrations of ammoniacal nitrogen detected, but this has not been shown to be influenced by the site.

4. Glossary of Abbreviations

BOD	Biochemical Oxygen Demand (mg/l)
C&D	Construction & Demolition
COD	Chemical Oxygen Demand (mg/l)
COPC	Contaminants of Potential Concern
CSM	Conceptual Site Model
DO	Dissolved Oxygen (mg/l)
DQRA	Detailed Quantitative Risk Assessment
EC	Electrical Conductivity (µS/cm)
Eh	Redox potential or oxidation reduction potential (mV)
EIS	Environmental Impact Statement
Fe	Iron
GTV	Groundwater Threshold Value (S.I No. 9 of 2010)
HDPE	High Density Polyethylene
IGV	Interim Groundwater Value
LOD	Limit of Detection
mAOD	metres above Ordnance Datum
Mn	Manganese
N	Nitrogen
NO_2	Nitrite
NO_3	Nitrate
PAH	Polycyclic Aromatic Hydrocarbon
SVOC	Semi volatile Organic Compound
TIC	Tentatively Identified Compound
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
VOC	Volatile Organic Compound

Appendix A. Tables

Table A.1: Sampling and Analysis Inventory (Quarter 1 2017)

A.1a: January 2017

A.1b: February 2017

A.1c: March 2017

Table A.1a - Sample Inventory

Analytical Suite	EMW03	EMW05	EMW06	EMW08	EMW11	EMW12D	EMW13	EMW15	EMW16	EMW19D	EMW20	EMW28	EMW29	BH26	BH42	Samples obtained
pH, conductivity	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Anions & Cations	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Metals	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Free, total cyanide	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Alkalinity	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
COD, TOC	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15

Analytical Suite	SW01	SW02	SW03	SW03A	SW05	Site Discharge	SW11	SW13	Total
pH, conductivity	x	x	x	x	x	x	x	x	8
Anions & Cations	x	x	x	x	x	x	x	x	8
Metals (incl. Fe, Mn)	x	x	x	x	x	x	x	x	8
Free, total cyanide	x	x	x	x	x	x	x	x	8
Alkalinity	x	x	x	x	x	x	x	x	8
COD, TOC	x	x	x	x	x	x	x	x	8

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Major Ions: Ca, Mg, K, Na, SO_4, Cl, PO_4, NO_3, Alkalinity, Ammoniacal Nitrogen
Metals: Fe, Mn, As

Table A.1b - Sample Inventory

Analytical Suite	EMW03	EMW05	EMW06	EMW08	EMW11	EMW12D	EMW13	EMW15	EMW16	EMW19D	EMW20	EMW28	EMW29	BH26	BH42	Samples obtained
pH, conductivity	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Anions & Cations	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Metals	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Free, total cyanide	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Alkalinity	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
COD, TOC	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15

Analytical Suite	SW01	SW02	SW03	SW03A	SW05	Site Discharge	SW11	SW13	Total
pH, conductivity	x	x	x	x	x	x	x	x	8
Anions & Cations	x	x	x	x	x	x	x	x	8
Metals (incl. Fe, Mn)	x	x	x	x	x	x	x	x	8
Free, total cyanide	x	x	x	x	x	x	x	x	8
Alkalinity	x	x	x	x	x	x	x	x	8
COD, TOC	x	x	x	x	x	x	x	x	8

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Major Ions: Ca, Mg, K, Na, SO_4, Cl, PO_4, NO_3, Alkalinity, Ammoniacal Nitrogen
Metals: Fe, Mn, As

NEW WELLS 2016

Analytical Suite	RM01	RM02	RM03	RM04	RM05	RM06	DB03	DB05	DB06	DB08	DB10	BB01	RCBB01	BB02	BB03	BB04	BH68	BH69(50)	BH70	BH71	BH72	BH77	BH78	Total
pH, conductivity	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	23
Anions & Cations	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	23
Metals	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	23
Free, total cyanide	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	23
VPH/EPH >C5 - C44	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	23
Alkalinity	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	23
COD, BOD, TOC	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	23
SVOCs with TICs	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	22
VOCs with TICs	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	23
Formaldehyde	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	23
Pesticides	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	22
PAHs	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	23
Speciated phenols	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	23

Major Ions: Ca, Mg, K, Na, SO_4, Cl, F, PO_4, NO_3, NO_2, Alkalinity, Ammoniacal Nitrogen
Metals: Fe, Mn, As, Ba, Be, B, Cd, Cr, Cu, Pb, Se, Hg, Ni, V, Zn, Al, Sb
SVOC - Semi-Volatile Organic Compound
VOC - Volatile Organic Compound
TICs - Tentatively Identified Compounds
TPH - Total Petroleum Hydrocarbons
Pesticides comprises acid herbicides and organo-chlorine pesticides
Speciated phenols - Catechol,Total Cresol, Total Xylenol, Naphthol, Phenol

Table A.1c - Sample Inventory

Analytical Suite	EMW03	EMW05	EMW06	EMW08	EMW11	EMW12D	EMW13	EMW15	EMW16	EMW19D	EMW20	EMW28	EMW29	BH26	BH42	Samples obtained
pH, conductivity	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Anions & Cations	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Metals	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Free, total cyanide	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
Alkalinity	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
COD, TOC	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15

Analytical Suite	SW01	SW02	SW03	SW03A	SW05	Site Discharge	SW11	SW13	Total
pH, conductivity	x	x	x	x	x	x	x	x	8
Anions & Cations	x	x	x	x	x	x	x	x	8
Metals (incl. Fe, Mn)	x	x	x	x	x	x	x	x	8
Free, total cyanide	x	x	x	x	x	x	x	x	8
Alkalinity	x	x	x	x	x	x	x	x	8
COD, TOC	x	x	x	x	x	x	x	x	8

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Major Ions: Ca, Mg, K, Na, SO_4, Cl, PO_4, NO_3, Alkalinity, Ammoniacal Nitrogen
Metals: Fe, Mn, As

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Analytical Suite	RM01	RM02	RM03	RM04	RM05	RM06	DB02	DB03	DB04	DB05	DB06	DB08	DB10	BB01	RCBB01	BB02	BB03	BB04	BH68	BH70	BH71	BH72	BH77	BH78	Total
pH, conductivity	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	24
Anions & Cations	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	24
Metals	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	24
Free, total cyanide	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	24
VPH/EPH >C5 - C44							x																		1
Alkalinity	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	24
COD, BOD, TOC	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	24
SVOCs with TICs							x																		1
VOCs with TICs							x																		1
Formaldehyde							x																		1
Pesticides							x																		1
PAHs							x																		1
Speciated phenols							x																		1

Major Ions: Ca, Mg, K, Na, SO_4, Cl, F, PO_4, NO_3, NO_2, Alkalinity, Ammoniacal Nitrogen
Metals: Fe, Mn, As, Ba, Be, B, Cd, Cr, Cu, Pb, Se, Hg, Ni, V, Zn, Al, Sb
SVOC - Semi-Volatile Organic Compound
VOC - Volatile Organic Compound
TICs - Tentatively Identified Compounds
TPH - Total Petroleum Hydrocarbons
Pesticides comprises acid herbicides and organo-chlorine pesticides
Speciated phenols - Catechol,Total Cresol, Total Xylenol, Naphthol, Phenol

Table A.2: Field-Based Measurements and Readings (Quarter 1 2017)

A.2a: January 2017

A.2b: February 2017

A.2c: March 2017

Table A.2a - Groundwater Field Parameters and Observations

Piezometer	DTGW (mbct) - 2016	Depth to Base (mbct)	Casing Top Elevation (mAOD)	Groundwater Elevation (mAOD) January 2017	Temp (°C)	DO (mg/l)	Specific Conductivity (µS/cm)	Field pH (-)	Eh (mV)	Comment / Purged Volume
EMW02	1.45	5.90	81.06	79.61						
EMW03	8.60	16.20	86.26	77.66	11.3	0.2	1519.9	6.7	-3.3	
EMW04	3.37	7.25	83.72	80.35						
EMW05	1.56	5.82	79.78	78.22	10.0	0.3	688.9	6.9	+6.9	
EMW06	4.82	7.23	87.20	82.38	11.2	8.4	522.9	7.2	+127.3	
EMW07	2.20	5.65	81.02	78.82						
EMW08	1.53	4.91	80.24	78.71	9.7	0.4	554.7	7.0	-54.1	
EMW11	19.49	22.42	97.93	78.44	11.4	3.8	1947.9	6.7	+224.4	
EMW12	15.11	19.42	91.88	76.77	13.3	6.2	1014.6	7.0	+234.6	
EMW13	15.91	19.60	95.43	79.52	17.3	0.2	3244.2	6.8	-103.2	
EMW14	Dry	22.73	100.81	Dry						
EMW15	13.45	17.89	92.09	78.64	15.6	0.2	1163.2	6.9	-98.3	
EMW16	12.66	17.98	92.24	79.58	13.9	0.3	2143.9	6.5	+43.5	
EMW17	12.96	20.72	92.93	79.97						
EMW18	2.46	6.14	81.01	78.55						
EMW19	2.75	15.85	80.75	78.00	11.5	0.3	685.2	7.0	-79.9	
EMW20	1.85	6.34	80.52	78.67	10.4	1.9	553.8	7.1	-57.1	
EMW21	4.47	6.82	82.36	77.89						
EMW22	12.17	23.65	88.19	76.02						
EMW23	9.27	14.76	88.51	79.24						
EMW24	16.44	26.11	93.24	76.80						
EMW27	1.15	15.20	82.21	81.06						
EMW28	1.48	8.14	82.52	81.04	10.3	0.5	701.4	6.8	-51.0	
EMW29	0.58	7.83	82.14	81.56	9.8	0.4	826.8	6.9	+70.4	
EMW30	12.06	11.81	91.25	79.19						
EMW31	1.60	6.39	80.30	78.70						
EMW32	2.98	11.45	81.53	78.55						
EMW33	1.68	5.71	81.53	79.85						
BH26	27.49	36.28	106.59	79.10	28.3	0.8	3267.8	6.6	-81.3	
BH36B	35.51	39.02	113.40	77.89						
BH39B	Dry	13.84	97.58	Dry						
BH40B	Dry	16.30	94.76	Dry						
BH42	3.69	10.10	82.77	79.08	11.7	0.2	1104.7	7.1	-66.1	
BH2	8.17	8.42	92.89	84.72						
BH6	1.85	2.38	81.13	79.28						
BH7	2.09	5.04	81.11	79.02						
GW1D	14.35	18.90	92.20	77.85						
GW2S	2.23	11.28	80.98	78.75						

Notes:
µS/cm - micro Siemens per centimetre
mAOD 0 metres above ordnance datum
DTGW - Depth to ground water **mbct** - metres below casing top
EMW18-EMW42 inclusive top of casing height is ground surface +0.3m

Table A.2b - Groundwater Field Parameters and Observations

Piezometer	DTGW (mbct) - 2017	Depth to Base (mbct)	Casing Top Elevation (mAOD)	Groundwater Elevation (mAOD) February 2017	Temp (°C)	DO (mg/l)	Specific Conductivity (µS/cm)	Field pH (-)	Eh (mV)	Comment / Purged Volume
EMW02	1.24	5.90	81.06	79.82						
EMW03	8.55	16.20	86.26	77.71	11.4	0.2	1298.4	6.7	+4.6	
EMW04	3.39	7.25	83.72	80.33						
EMW05	1.51	5.82	79.78	78.27	9.6	0.5	653.5	6.9	+9.5	
EMW06	4.86	7.23	87.20	82.34	11.2	5.7	518.9	7.1	+130.5	
EMW07	2.16	5.65	81.02	78.86						
EMW08	1.45	4.91	80.24	78.79	9.3	0.2	565.4	7.0	-37.9	
EMW11	19.48	22.42	97.93	78.45	11.8	6.9	2016.0	6.7	+284.3	
EMW12	15.01	19.42	91.88	76.87	13.6	6.2	1034.7	7.1	+249.6	
EMW13	15.93	19.60	95.43	79.50	17.1	0.2	3570.3	6.8	-76.6	
EMW14	Dry	22.73	100.81	Dry						
EMW15	13.41	17.89	92.09	78.68	15.1	0.4	1136.6	7.0	-97.2	
EMW16	12.64	17.98	92.24	79.60	14.0	0.2	2144.7	6.5	+45.1	
EMW17	12.95	20.72	92.93	79.98						
EMW18	2.41	6.14	81.01	78.60						
EMW19	2.69	15.85	80.75	78.06	11.5	0.2	638.1	7.0	-81.9	
EMW20	1.78	6.34	80.52	78.74	10.2	0.3	578.7	7.1	-73.2	
EMW21	4.62	6.82	82.36	77.74						
EMW22	12.09	23.65	88.19	76.10						
EMW23	9.28	14.76	88.51	79.23						
EMW24	16.28	26.11	93.24	76.96						
EMW27	1.21	15.20	82.21	81.00						
EMW28	1.53	8.14	82.52	80.99	10.2	0.2	709.6	6.8	-59.7	
EMW29	0.63	7.83	82.14	81.51	9.6	0.2	912.3	6.8	+228.9	
EMW30	11.97	11.81	91.25	79.28						
EMW31	1.61	6.39	80.30	78.69						
EMW32	2.94	11.45	81.53	78.59						
EMW33	1.80	5.71	81.53	79.73						
BH26	27.50	36.28	106.59	79.09	28.2	0.7	3358.9	6.6	-62.0	
BH36B	35.46	39.02	113.40	77.94						
BH39B	Dry	13.84	97.58	84.72						
BH40B	Dry	16.30	94.76	Dry						
BH42	3.58	10.10	82.77	79.19	11.6	0.1	1244.5	7.1	-65.2	
BH2	8.17	8.42	92.89	84.72						
BH6	1.74	2.38	81.13	79.39						
BH7	2.05	5.04	81.11	79.06						
GW1D	14.32	18.90	92.20	77.88						
GW2S	2.12	11.28	80.98	78.86						
RM01	1.25	7.81	79.50	78.25	7.8	0.2	578.2	7.2	+17.6	
RM02	1.45	6.50	79.72	78.27	7.4	3.5	535.8	7.4	+180.6	
RM03	1.15	5.46	80.22	79.07	9.4	0.2	960.5	6.9	+254.1	
RM04	1.44	7.32	80.45	79.01	9.7	1.8	645.3	7.1	-40.3	
RM05	1.49	7.00	80.80	79.31	8.2	0.2	535.0	7.4	+14.7	
RM06	1.93	6.12	81.07	79.14	8.7	1.1	547.1	7.2	-69.9	
DB01	17.66	18.60	94.98	77.32						
DB02(50)	13.74	14.29	93.18	79.44						
DB02(19)	#VALUE!	21.41	93.18	-						
DB03	8.12	13.62	87.93	79.81	9.7	0.1	1049.9	6.9	+107.1	
DB04	Dry	8.93	88.13	Dry						
DB05	2.72	7.15	80.70	77.98	8.6	3.8	598.2	6.9	-18.0	
DB06	2.19	7.36	81.17	78.98	10.4	0.2	521.9	7.2	-85.3	
DB07	Dry	8.76	92.91	Dry						
DB08	12.58	19.30	92.22	79.64	10.3	0.3	584.9	7.2	+223	
DB08A	Dry	10.50	92.22	Dry						
DB09	4.51	5.59	92.19	87.68	10.0	9.6	370.7	7.3	+159.6	
DB10	1.99	5.25	90.24	88.25	8.6	8.1	494.6	7.3	+81.4	
DB12	Dry	7.53	93.58	Dry						
DB14	Dry	8.76	96.73	Dry						
DB15	Dry	7.06	100.26	Dry						
BB01	2.25	7.30	81.21	78.96	10.6	0.2	662.7	7.0	-89.1	
RCBB01	2.41	20.00	81.14	78.73	11.1	0.1	747.6	7.0	-71.5	
BB02	10.93	26.92	87.36	76.43	11.3	7.5	666.6	7.1	+174.2	
BB03	14.20	28.73	92.75	78.55	10.4	4.5	525.2	7.2	+205.2	
BB04	1.97	16.80	81.82	79.85	11.0	0.2	719.6	7.0	+254.9	
BH60	Dry	15.17	96.51	Dry						
BH61	#VALUE!	22.45	102.78	-						
BH62	Dry	17.46	107.10	Dry						
BH63	#VALUE!	31.08	112.06	-						
BH64	Dry	8.07	100.35	Dry						
BH65	13.23	14.71	96.14	82.91						
BH66	6.66	7.04	97.47	90.81						
BH67	Dry	15.64	109.77	Dry						
BH68	16.27	32.30	94.80	78.53	13.7	0.1	1223.6	6.7	+258.4	
BH69(19)	13.18	14.96	93.62	80.44						
BH69(50)	10.57	11.79	93.62	83.05	14.1	0.2	2698.6	6.8	-76.2	
BH70	1.58	7.28	81.14	79.56	9.2	0.8	996.2	7.1	-53.3	
BH71	0.59	6.12	82.75	82.16	9.3	0.1	1497.0	8.0	-87.5	
BH72	4.33	10.72	85.27	80.94	10.6	0.1	646.0	7.2	-7.4	
BH73	Dry	9.01	92.66	Dry						
BH75	4.42	5.49	96.16	91.74						
BH76	12.57	12.71	95.08	82.51						
BH77	9.24	10.04	96.28	87.04	12.9	0.8	804.3	6.6	+135.5	
BH78	2.10	5.40	86.72	84.62	9.0	0.3	538.3	7.2	+71.9	
BH79	Dry	7.11	87.08	Dry						
BH80	4.96	5.23	86.04	81.08						

Notes:
µS/cm - micro Siemens per centimetre
mAOD 0 metres above ordnance datum
DTGW - Depth to ground water **mbct** - metres below casing top
EMW18-EMW42 inclusive top of casing height is ground surface +0.3m

Table A.2c - Groundwater Field Parameters and Observations

Piezometer	DTGW (mbct) - 2017	Depth to Base (mbct)	Casing Top Elevation (mAOD)	Groundwater Elevation (mAOD) March 2017	Temp (°C)	DO (mg/l)	Specific Conductivity (µS/cm)	Field pH (-)	Eh (mV)	Comment / Purged Volume
EMW02	0.91	5.90	81.06	80.15						
EMW03	8.31	16.20	86.26	77.95	11.4	0.4	1894	6.6	200.6	
EMW04	3.31	7.25	83.72	80.41						
EMW05	1.37	5.82	79.78	78.41	10.1	1.3	568.5	7.0	5.8	
EMW06	4.54	7.23	87.20	82.66	10.8	7.0	487.6	7.1	169.3	
EMW07	2.00	5.65	81.02	79.02						
EMW08	1.30	4.91	80.24	78.94	9.0	0.3	534.2	6.9	-35.1	
EMW11	19.24	22.42	97.93	78.69	11.4	7.5	1636.0	6.8	308.8	
EMW12	14.62	19.42	91.88	77.26	13.4	6.6	965.1	7.0	94.5	
EMW13	15.84	19.60	95.43	79.59	17.0	0.2	3281.3	6.8	-73.0	
EMW14	Dry	22.73	100.81	79.95						
EMW15	13.20	17.89	92.09	78.89	15.1	0.2	867.2	7.0	-89.9	
EMW16	12.39	17.98	92.24	79.85	13.5	0.2	2100.9	6.5	55.8	
EMW17	12.67	20.72	92.93	80.26						
EMW18	2.24	6.14	81.01	78.77						
EMW19	2.51	15.85	80.75	78.24	11.1	0.2	565.1	7.0	-75.6	
EMW20	1.63	6.34	80.52	78.89	9.8	0.2	553.3	7.1	-81.3	
EMW21	4.54	6.82	82.36	77.82						
EMW22	11.84	23.65	88.19	76.35						
EMW23	9.15	14.76	88.51	79.36						
EMW24	15.89	26.11	93.24	77.35						
EMW27	1.08	15.20	82.21	81.13						
EMW28	1.60	8.14	82.52	80.92	9.6	0.5	649.5	6.8	-46.9	
EMW29	0.43	7.83	82.14	81.71	9.4	0.5	783.2	6.9	144.2	
EMW30	11.68	11.81	91.25	79.57						
EMW31	1.38	6.39	80.30	78.92						
EMW32	2.99	11.45	81.53	78.54						
EMW33	1.58	5.71	81.53	79.95						
BH26	27.41	36.28	106.59	79.18	28.0	0.9	3063.3	6.6	-69.1	
BH36B	35.38	39.02	113.40	78.02						
BH39B	Dry	13.84	97.58	Dry						
BH40B	Dry	16.30	94.76	Dry						
BH42	3.29	10.10	82.77	79.48	10.6	1.0	1252.8	7.0	-57.5	
BH2	8.11	8.42	92.89	84.78						
BH6	1.42	2.38	81.13	79.71						
BH7	1.70	5.04	81.11	79.41						
GW1D	14.04	18.90	92.20	78.16						
GW2S	1.79	11.28	80.98	79.19						
RM01	1.27	7.81	79.50	78.23	8.2	0.1	550.5	7.1	-5.1	
RM02	1.50	6.50	79.72	78.22	8.4	4.7	494.3	7.4	77.3	
RM03	1.10	5.46	80.22	79.12	9.7	0.3	866.9	6.9	252.4	
RM04	1.39	7.32	80.45	79.06	9.7	2.0	592.6	7.1	213.1	
RM05	1.43	7.00	80.80	79.37	8.5	0.2	507.4	7.3	0.7	
RM06	1.84	6.12	81.07	79.23	8.9	1.3	512.8	7.1	-53.2	
DB01	17.34	18.60	94.98	77.64						
DB02(50)	13.65	14.29	93.18	79.53						
DB02(19)	15.87	21.41	93.18	77.31	14.7	2.3	3447.7	6.9	3.1	Narrow tubing installed - hand pumped
DB03	8.02	13.62	87.93	79.91	9.9	0.2	1033.0	6.9	52.7	
DB04	Dry	8.93	88.13	82.18	13.1	4.4	913.0	6.7	302.8	
DB05	1.65	7.15	80.70	79.05	9.0	5.1	565.2	6.9	127.4	
DB06	1.97	7.36	81.17	79.20	10.3	0.3	500.4	7.2	-51.9	
DB07	Dry	8.76	92.91	Dry						
DB08	12.35	19.30	92.22	79.87	10.4	0.7	545.6	7.2	283.0	
DB08A	Dry	10.50	92.22	Dry						
DB09	4.22	5.59	92.19	87.97	11.7	10.1	438.5	7.3	271.1	
DB10	1.88	5.25	90.24	88.36	9.0	9.0	456.6	7.3	187.4	
DB12	Dry	7.53	93.58	Dry						
DB14	No access	8.76	96.73	No access						No access due to barbed wire and gate lock
DB15	Dry	7.06	100.26	Dry						
BB01	2.02	7.30	81.21	79.19	10.4	0.1	570.1	7.0	-80.3	
RCBB01	2.19	20.00	81.14	78.95	11.2	0.4	711.9	7.0	-66.2	
BB02	10.66	26.92	87.36	76.70	11.3	6.8	621.9	7.1	165.1	
BB03	14.03	28.73	92.75	78.72	10.8	3.2	496.7	7.2	300.4	
BB04	1.81	16.80	81.82	80.01	11.0	0.5	687.3	7.0	153.7	
BH60	Dry	15.17	96.51	Dry						
BH61	Dry	22.45	102.78	Dry						
BH62	17.27	17.46	107.10	89.83						
BH63	Dry	31.08	112.06	Dry						
BH64	Dry	8.07	100.35	Dry						
BH65	14.02	14.71	96.14	82.12						
BH66	6.46	7.04	97.47	91.01						
BH67	Dry	15.64	109.77	Dry						
BH68	16.00	32.30	94.80	78.80	13.9	0.2	1161.1	6.7	342.9	
BH69(19)	13.86	14.96	93.62	79.76						
BH69(50)	10.55	11.79	93.62	83.07						
BH70	1.40	7.28	81.14	79.74	9.9	0.2	900.2	7.1	-48.5	
BH71	0.64	6.12	82.75	82.11	9.9	0.1	1361.1	8.1	-114.3	
BH72	4.08	10.72	85.27	81.19	10.6	0.2	581.3	7.2	17.6	
BH73	Dry	9.01	92.66	Dry						
BH75	4.91	5.49	96.16	91.25						
BH76	12.46	12.71	95.08	82.62						
BH77	9.09	10.04	96.28	87.19	14.1	1.4	863.5	6.6	118.8	
BH78	2.22	5.40	86.72	84.50	9.9	1.0	514.7	7.0	67.5	
BH79	Dry	7.11	87.08	Dry						
BH80	4.90	5.23	86.04	81.14						

Notes:
µS/cm - micro Siemens per centimetre
mAOD 0 metres above ordnance datum
DTGW - Depth to ground water **mbct** - metres below casing top
EMW18-EMW42 inclusive top of casing height is ground surface +0.3m

Table A.3: Inorganic Compounds in Groundwater

Table A.3 - Results of Laboratory Analysis of Groundwater for Inorganic Compounds

					Monthly			Monthly			Monthly			Monthly			Monthly			Monthly			Monthly			Monthly		
Analyte	**Frequency**	**Units**	**IGV**	**GTV**	**EMW03**			**EMW05**			**EWM06**			**EWM08**			**EMW11**			**EMW12**			**EMW13**			**EMW15**		
Sampling Date					Jan-17	Feb-17	Mar-17	Jan-17	Feb-17	Mar-17	Jan-17	Feb-17	Mar-17	Jan-17	Feb-17	Mar-17	Jan-17	Feb-17	Mar-17	Jan-17	Feb-17	Mar-17	Jan-17	Feb-17	Mar-17	Jan-17	Feb-17	Mar-17
Calcium , Total as Ca	M	mg/l	200	-	211	213	264	171	152	155	123	130	137	124	129	134	360	380	346	193	213	211	197	191	193	184	157	151
Magnesium, Total as Mg	B	mg/l	50	-																								
Potassium , Total as K	M	mg/l	5	-	25.5	19.8	33.7	2.73	1.91	1.45	1.16	1.33	1.2	0.37	0.48	0.4	43.2	47.7	41.8	4.08	4.65	4.83	84.8	93.2	102	25.7	19	17.6
Sodium , Total as Na	M	mg/l	150	150	59.9	45.1	99.5	14.4	12.5	9.66	2.54	3.01	3.27	4.2	4.31	4.74	66.9	71.5	47.9	23.1	25.2	25.4	224	234	287	39.8	32.2	29
Alkalinity as CaCO3	M	mg/l	-	-	830	687	1070	446	376	382	332	332	321	333	334	343		494	491	270	261	253	1660	1580	1780	430	434	415
Sulphate as SO4	M	mg/l	200	187.5	59.2	50.8	79.5	8.5	8.3	8	12.5	7.9	9.5	4.8	<4.4	4.5	747	775	676	320	330	355	69	37.4	50.4	171	125	107
Chloride as Cl	M	mg/l	30	24-187.5	66.9	55.8	87.5	19.4	15	10.6	7.1	9.9	6.9	9.7	8.3	7.6	50.8	48.5	41.3	29.4	30	28.5	240	234	296	38.4	32.7	29.4
Nitrate as NO3*	M	mg/l	25	37.5	22.1	15.9	154	3.8	<3.1	4.5	36.1	<3.1	<3.1	<3.1	<3.1	<3.1	90.1	57.2	37.2	34.3	28.4	31	6.1	4.8	<3.1	<3.1	<3.1	<3.1
Ammoniacal Nitrogen as N#	M	mg/l	0.12	0.05-0.14	21.3	17.7	38.3	0.91	0.66	<0.06	<0.06	<0.06	<0.06	0.11	0.11	0.11	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	191		213	10.8	8.7	7.31
Nitrite as NO2*	B	mg/l	0.10	0.38																								
Phosphates , Total as PO4*	B	mg/l	0.03	0.035																								
Boron, Total as B	B	mg/l	1	0.75																								
Sulphide as S	B	mg/l	-	-																								
Iron , Total as Fe	M	mg/l	0.2	-	28.9	55.1	38.6	4.36	4.21	3.54	1.21	1.85	1.99	3.77	4.3	4.09	0.77	0.68	0.64	<0.23	<0.23	<0.23	11.5	10.4	11.9	14.4	12.5	10.5
Manganese , Total as Mn	M	mg/l	0.05	-	1.45	1.53	1.89	0.664	0.765	0.546	0.249	0.356	0.396	0.764	0.795	0.804	0.081	0.075	0.073	0.016	0.008	0.015	1	0.889	0.944	4.57	3.79	3.76
Arsenic, Total as As	M	µg/l	10	7.5	15	21	16	5	4	2	2.1	2	2	3	3	3.2	<1	<1	<1	<1	<1	<1	13	11	12	28	26	25
Barium, Total as Ba	B	µg/l	100	-																								
Beryllium, Total as Be	B	µg/l	-	-																								
Cadmium , Total as Cd	B	µg/l	5	3.75																								
Chromium , Total as Cr	B	µg/l	30	37.5																								
Copper, Total as Cu	B	µg/l	30	1500																								
Lead , Total as Pb	B	µg/l	10	18.75																								
Mercury, Total as Hg	B	µg/l	0.1	0.75																								
Nickel , Total as Ni	B	µg/l	20	15																								
Selenium, Total as Se	B	µg/l	-	-																								
Vanadium , Total as V	B	µg/l	-	-																								
Zinc, Total as Zn	B	µg/l	100	-																								
Cyanide, Total	M	µg/l	-	-	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	22	<9	<9	19	<9	<9	<9	<9	9	<9	<9	<9

49 Concentration exceeds IGV

35 35 Concentration exceeds GTV

* Concentration converted into concentration to correspond with IGV and GTV concentrations:

IGV is for ammonia (as ammonium, reported as NH3 and this has been compared to ammonical-N results. IGV/GTVs converted to appear as N in this table

Phosphate as P → Phosphate as PO4 [Conversion Factor = 95/31]

Freq* = Monthly or bi annual Parameter

LOD VALUE symbol removed for graphs

Table A.3 - Results of Laboratory Analysis of Groundwater for Inorganic Compounds

Analyte	Frequency	Units	IGV	GTV	EMW16 (Monthly)			EMW19 (Monthly)			EMW20 (Monthly)			EMW28 (Monthly)			EMW29 (Monthly)			BH26 (Monthly)			BH42 (Monthly)		
Sampling Date					**Jan-17**	**Feb-17**	**Mar-17**	**Jan-17**	**Feb-17**	**Mar-17**	**Jan-17**	**Feb-17**	**Mar-17**	**Jan-17**	**Feb-17**	**Mar-17**	**Jan-17**	**Feb-17**	**Mar-17**	**Jan-17**	**Feb-17**	**Mar-17**	**Jan-17**	**Feb-17**	**Mar-17**
Calcium , Total as Ca	M	mg/l	200	-	353	348	379	121	119	115	108	113	125	163	248	175	185	195	182	142	124	203	214	248	271
Magnesium, Total as Mg	B	mg/l	50	-																					
Potassium , Total as K	M	mg/l	5	-	20.8	15.5	19.2	4.82	4.44	3.32	0.89	0.85	0.91	1.73	<1.80	0.48	0.99	0.89	0.62	48.3	35.8	42.6	17.8	16	18.5
Sodium , Total as Na	M	mg/l	150	150	124	111	137	14.7	14.2	12.7	8.99	9.17	9.97	6.53	7.06	5.35	15.3	15.4	15.2	260	197	294	26.1	23.8	37.6
Alkalinity as CaCO3	M	mg/l	-	-	820	792	896	346	320	312	493	302	315		463	511		425	399	1460	1550	1430	312	415	11.2
Sulphate as SO4	M	mg/l	200	187.5	405	398	443	54.8	34.6	44.9	<4.4	4.9	14.3	11.3	<4.4	31.23	100	116	87.1	17.7	5.9	21.8	391	458	499
Chloride as Cl	M	mg/l	30	24-187.5	161	157	167	23.1	21.5	19.8	19.6	20.6	19.7	19.9	21.5	35.9	25.2	25.3	26.8	408	406	418	23.2	26.6	38.4
Nitrate as NO3*	M	mg/l	25	37.5	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	29.7	<3.1	<3.1	<3.1	10.7	8.7	17.8	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1
Ammoniacal Nitrogen as N[#]	M	mg/l	0.12	0.05-0.14	6.64	5.98	7.73	2.21	1.94	1.53	0.79	0.78	0.89	0.5	0.61	0.55	<0.06	<0.06	<0.06	144	138	134	3.31	3.45	4.1
Nitrite as NO2*	B	mg/l	0.10	0.38																					
Phosphates , Total as PO4*	B	mg/l	0.03	0.035																					
Boron, Total as B	B	mg/l	1	0.75																					
Sulphide as S	B	mg/l	-	-																					
Iron , Total as Fe	M	mg/l	0.2	-	1.63	3.19	1.58	10.8	9.14	8.59	5.8	6.16	8.64	18.2	29.6	20.9	0.26	0.6	0.42	5.83	5.58	10.4	5.32	7.58	6.02
Manganese , Total as Mn	M	mg/l	0.05	-	4.23	4.03	4.76	1.11	1.08	0.964	1.04	1.09	1.21	1.08	1.83	1.02	0.051	0.11	<0.007	1.7	1.68	2.46	4.46	5.64	5.59
Arsenic, Total as As	M	µg/l	10	7.5	3	4	3	15	12	11	3	3	3	45	51	48	<1	<1	<1	30	29	25	11	13	9
Barium, Total as Ba	B	µg/l	100	-																					
Beryllium, Total as Be	B	µg/l	-	-																					
Cadmium , Total as Cd	B	µg/l	5	3.75																					
Chromium , Total as Cr	B	µg/l	30	37.5																					
Copper, Total as Cu	B	µg/l	30	1500																					
Lead , Total as Pb	B	µg/l	10	18.75																					
Mercury, Total as Hg	B	µg/l	0.1	0.75																					
Nickel , Total as Ni	B	µg/l	20	15																					
Selenium, Total as Se	B	µg/l	-	-																					
Vanadium , Total as V	B	µg/l	-	-																					
Zinc, Total as Zn	B	µg/l	100	-																					
Cyanide, Total	M	µg/l	-	-	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9

	49	Concentration exceeds IGV
35	35	Concentration exceeds GTV

* Concentration converted into concentration to correspond with IGV and GTV concentrations:

[#] IGV is for ammonia (as ammonium, reported as NH3 and this has been compared to ammonical-

Phosphate as P → Phosphate as PO4 [Conversion Factor = 95/31]

Freq* = Monthly or bi annual Parameter

LOD VALUE symbol removed for graphs

Table A.3 - Results of Laboratory Analysis of Groundwater for Inorganic Compounds

					New 2016		New 2016		New 2016		New 2016		New 2016		New 2016		New 2016		New 2016		New 2016		New 2016		New 2016		New 2016	New 2016	
Analyte	**Frequency**	**Units**	**IGV**	**GTV**	**RM01**		**RM02**		**RM03**		**RM04**		**RM05**		**RM06**		**BB01**		**RCBB01**		**BB02**		**BB03**		**BB04**		**DB02**	**DB03**	
Sampling Date					**Feb-17**	**Mar-17**	**Feb-17**	**Mar-17**	**Feb-17**	**Mar-17**	**Feb-17**	**Mar-17**	**Feb-17**	**Mar-17**	**Feb-17**	**Mar-17**	**Feb-17**	**Mar-17**	**Feb-17**	**Mar-17**	**Feb-17**	**Mar-17**	**Feb-17**	**Mar-17**	**Feb-17**	**Mar-17**	**Mar-17**	**Feb-17**	**Mar-17**
Calcium , Total as Ca	M	mg/l	200	-	125	122	113	113	198	176	177	149	107	105	120	112	136	118	132	145	117	121	253	226	120	121	1300	618	502
Magnesium, Total as Mg	B	mg/l	50	-	10.9		10.5		16.6		12.6		9.4		9.9		11.3		11.6		23.2		96		14.4		88.3	29.9	
Potassium , Total as K	M	mg/l	5	-	0.97	0.93	1.34	1.47	2.36	2.12	1.62	0.98	1.21	1.24	1.05	0.92	4.17	3.22	3.02	3.02	1.66	1.95	<1.80	<3.6	2.57	2.34	75.7	7.69	8.24
Sodium , Total as Na	M	mg/l	150	150	11	10.9	8.65	9.73	40.2	40.4	12.6	11.6	8.51	8.34	8.73	7.52	14.6	11.6	15.1	16.5	17.1	18.8	3.27	<6.00	24.5	31.4	205	46.8	66.6
Alkalinity as CaCO3	M	mg/l	-	-	309	312	291	274	506	486	358	366	268	277	270	283	360	316	355	365	355	338	392	352	354	367	4610	1020	1000
Sulphate as SO4	M	mg/l	200	187.5	12.3	18.8	18.3	20.6	69.7	63.7	22.3	18.7	23.8	24.2	7.3	9.4	19.4	10.16	44.5	38.5	38.3	39.4	18.8	25.7	36.7	45.1	27.58	55.5	57.1
Chloride as Cl	M	mg/l	30	24-187.5	20.3	18.3	17.2	16.3	38.4	33.6	22.3	22.1	18.4	18.7	19.1	18.6	20.5	21.7	23.8	30.3	39.7	42.5	10.1	22.9	31.6	36.4	294	111	123
Nitrate as NO3*	M	mg/l	25	37.5	<3.1	<3.1	8.9	8.30	<3.1	5.10	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	6.1	7.6	<3.1	4.1	<3.1	<3.1	<3.1	28.5	30.7
Ammoniacal Nitrogen as N#	M	mg/l	0.12	0.05-0.14	0.08	0.09	<0.06	0.06	0.67	0.6	1.45	0.84	<0.06	<0.06	0.33	0.29	1.93	1.75	1.97	1.77	<0.06	<0.06	<0.06	<0.06	0.32	0.23	1.36	6.38	6.96
Nitrite as NO2*	B	mg/l	0.10	0.38	<0.28		<0.28		<0.28		<0.28		<0.28		<0.28		<0.28		<0.28		<0.28		<0.28		<0.28		<0.28	0.63	
Phosphates , Total as PO4*	B	mg/l	0.03	0.035	5.52		0.77		2.08		5.52		<0.37		1.29		2.57		4.60		1.16		11.65		0.89		8.89	5.21	
Boron, Total as B	B	mg/l	1	0.75	<0.23		<0.23		0.32		<0.23		<0.23		<0.23		0.29		<0.23		<0.23		<2.30		<0.23		<4.6	3.19	
Sulphide as S	B	mg/l	-	-	<0.020		<0.020		<0.02		<0.020		<0.020		<0.020		<0.020		0.026		0.022		1.18		<0.020		0.911	<0.020	
Iron , Total as Fe	M	mg/l	0.2	-	13.9	29.7	2.95	4.21	6.88	4.05	22.9	13.9	0.77	2.96	5.61	4.64	11.8	9.26	19.9	51.8	1.77	1.49	8.65	7.82	1.34	0.56	29.7	18.2	13.6
Manganese , Total as Mn	M	mg/l	0.05	-	0.673	0.707	0.412	0.286	0.79	0.48	1.8	0.865	0.257	0.345	1.58	1.36	1.05	0.934	1.32	1.55	0.688	0.489	4.83	3.92	1.07	0.831	21.4	5.16	3.72
Arsenic, Total as As	M	µg/l	10	7.5	16	32	3.6	5.6	13	8	19	11	2.1	8	4.9	5	12	11	24	72	3.5	3	7.4	5	1.6	<1	17	8.9	7
Barium, Total as Ba	B	µg/l	100	-	154		68		81		189		70		117		151		250		38		339		47		1740	400	
Beryllium, Total as Be	B	µg/l	-	-	<2.1		<2.1		<2.1		<2.1		<2.1		<2.1		<2.1		<2.1		<2.1		<2.1		<2.1		<42	<21	
Cadmium , Total as Cd	B	µg/l	5	3.75	<0.6		<0.6		<0.6		0.6		<0.6		<0.6		<0.6		<0.6		<0.6		<6		<0.6		28.6	<0.6	
Chromium , Total as Cr	B	µg/l	30	37.5	<2		3		4		8		<2		<2		4		3		2		<20		5		42	<20	
Copper, Total as Cu	B	µg/l	30	1500	<1.9		4.9		10		16		<1.9		5		6.1		5.5		6.6		33		12		361	71	
Lead , Total as Pb	B	µg/l	10	18.75	<6		9		<6		23		<6		<6		8		<6		11		<60		<6		368	<60	
Mercury, Total as Hg	B	µg/l	0.1	0.75	<0.1		<0.1		<0.1		<0.1		<0.1		<0.1		<0.1		<0.1		0.15		<0.1		<0.1		<0.01	0.54	
Nickel , Total as Ni	B	µg/l	20	15	<3		6		11		15		5		<3		12		10		14		87		8		317	<30	
Selenium, Total as Se	B	µg/l	-	-	4.8		6.5		0.9		8.5		<0.8		<0.8		<0.8		<0.8		<0.8		<0.8		<0.8		25.3	<0.8	
Vanadium , Total as V	B	µg/l	-	-	<4		<4		5		11		<4		<4		4		4		<4		<40		<4		<80	<40	
Zinc, Total as Zn	B	µg/l	100	-	<18		20		40		70		<18		<18		30		40		60		511		<18		778	<180	
Cyanide, Total	M	µg/l	-	-	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9

49 Concentration exceeds IGV

35 Concentration exceeds GTV

* Concentration converted into concentration to correspond with IGV and GTV concentrations:

IGV is for ammonia (as ammonium, reported as NH3 and this has been compared to ammonical-

Phosphate as P → Phosphate as PO4 [Conversion Factor = 95/31]

Freq* = Monthly or bi annual Parameter

LOD VALUE symbol removed for graphs

Table A.3 - Results of Laboratory Analysis of Groundwater for Inorganic Compounds

					New 2016	New 2016		New 2016		New 2016		New 2016		New 2016		New 2016		New 2016		New 2016		New 2016		New 2016	
Analyte	Frequency	Units	IGV	GTV	DB04	DB05		DB06		DB08		DB10		BH68		BH70		BH71		BH72		BH77		BH78	
Sampling Date					Mar-17	Feb-17	Mar-17	Feb-17	Mar-17	Feb-17	Mar-17	Feb-17	Mar-17	Feb-17	Mar-17	Feb-17	Mar-17	Feb-17	Mar-17	Feb-17	Mar-17	Feb-17	Mar-17	Feb-17	Mar-17
Calcium , Total as Ca	M	mg/l	200	-	3900	164	161	102	109	103	102	592	773	202	215	173	160	315	298	454	144	179	199	131	155
Magnesium, Total as Mg	B	mg/l	50	-		5.4		8.7		24.7		24.6		16.2		16.6		15.1		26.5		5.4		5.1	
Potassium , Total as K	M	mg/l	5	-	6.55	0.75	0.38	1.29	1.36	2.55	2.33	1.81	4.04	17.7	19.9	22.1	21	32.2	30.1	<3.60	1.15	22.9	26	7.92	7.62
Sodium , Total as Na	M	mg/l	150	150	48.9	7.38	5.86	8.57	9.52	16.9	15.6	4.77	4.92	18.6	21.3	31.7	31.3	49.2	42.1	27.6	15.6	13	16.2	9.65	6.85
Alkalinity as CaCO3	M	mg/l	-	-	12700	410	349	285	318	312	302	1380	2210	573	539	351	359	152	135	1060	732	415	488	221	286
Sulphate as SO4	M	mg/l	200	187.5	106	10.3	18.8	<4.4	7.16	17.2	19.5	26.99	15	221	231	230	201	774	769	25.7	30.7	136	87.2	111	83.1
Chloride as Cl	M	mg/l	30	24-187.5	17.5	12.7	12.2	18.6	22.5	30.4	30.3	18.3	20.7	22.7	25.1	32.6	33.7	46.3	40.9	19.9	25.8	10.7	11.4	10.7	9.4
Nitrate as NO3*	M	mg/l	25	37.5	11.4	<3.1	<3.1	12.9	<3.1	<3.1	<3.1	<3.1	<3.1	18	21.8	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1
Ammoniacal Nitrogen as N#	M	mg/l	0.12	0.05-0.14	<0.06	<0.06	<0.06	0.65	0.65	<0.06	<0.06	<0.06	0.58	<0.06	<0.06	6.73	6.52	6.75	7.21	0.15	0.22	0.43	1.58	0.09	0.27
Nitrite as NO2*	B	mg/l	0.10	0.38		<0.28		<0.28		<0.28		<0.28		<0.28		<0.28		<0.28		<0.28		<0.28		<0.28	
Phosphates , Total as PO4*	B	mg/l	0.03	0.035		4.29		2.05		<0.37		<3.7		0.98		<0.37		<0.37		<7.35		1.90		0.86	
Boron, Total as B	B	mg/l	1	0.75		<0.23		<0.23		<0.23		<2.30		<0.23		0.29		0.45		<4.60		<0.23		<0.23	
Sulphide as S	B	mg/l	-	-		0.022		0.031		<0.020		0.197		0.025		<0.020		<0.020		0.192		0.112		<0.020	
Iron , Total as Fe	M	mg/l	0.2	-	27.4	3.55	1.76	7.15	7.07	0.42	0.55	16.4	25.7	1.91	0.91	2.03	2.14	0.68	0.7	69.4	16.5	10.7	3.87	7.9	22.3
Manganese , Total as Mn	M	mg/l	0.05	-	34.9	0.699	0.428	1.03	1.06	0.433	0.495	4.58	6.61	0.679	0.361	4.81	4.47	0.657	0.407	9.74	2.42	0.925	1.8	0.444	0.492
Arsenic, Total as As	M	µg/l	10	7.5	12	4.3	4	5.6	6	<0.0010	<1	4.6	7.2	3.7	2.7	4.3	4.6	5.9	5.6	15	10	16	7.3	8.8	21
Barium, Total as Ba	B	µg/l	100	-		115		109		36		194		45		108		48		575		193		83	
Beryllium, Total as Be	B	µg/l	-	-		<2.1		<2.1		<2.1		<21		<2.1		<2.1		<2.1		<42		<2.1		<2.1	
Cadmium , Total as Cd	B	µg/l	5	3.75		1.1		<0.6		<0.6		<6		<0.6		<0.6		<0.6		14.5		2.2		1.2	
Chromium , Total as Cr	B	µg/l	30	37.5		5		4		<2		<20		3		<2		4		42		19		7	
Copper, Total as Cu	B	µg/l	30	1500		8.4		11		<1.9		36		8.5		<1.9		7.5		282		88		40	
Lead , Total as Pb	B	µg/l	10	18.75		10		14		<6		<60		8		<6		<6		230		197		55	
Mercury, Total as Hg	B	µg/l	0.1	0.75		<0.1		<0.1		<0.1		0.31		<0.1		<0.1		<0.1		0.23		0.18		1	
Nickel , Total as Ni	B	µg/l	20	15		17		12		7		<30		17		10		15		126		43		21	
Selenium, Total as Se	B	µg/l	-	-		1.5		<0.8		<0.8		<0.8		<0.8		<0.8		<0.8		1		1.6		<0.8	
Vanadium , Total as V	B	µg/l	-	-		7		4		<4		<40		<4		<4		<4		<80		19		9	
Zinc, Total as Zn	B	µg/l	100	-		40		60		<18		<180		50		<18		20		529		316		200	
Cyanide, Total	M	µg/l	-	-	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9

49 Concentration exceeds IGV

35 | 35 Concentration exceeds GTV

* Concentration converted into concentration to correspond with IGV and GTV concentrations:

IGV is for ammonia (as ammonium, reported as NH3 and this has been compared to ammonical-

Phosphate as P → Phosphate as PO4 [Conversion Factor = 95/31]

Freq* = Monthly or bi annual Parameter

LOD VALUE symbol removed for graphs

Table A.4: Inorganic Compounds in Surface Water

Table A.4 - Inorganic Compounds in Surface Water

Analyte	Freq	Units	Fresh Water EQS (AA)	SW01			SW02			SW03			SW03A		
Sampling Date				**Jan-17**	**Feb-17**	**Mar-17**	**Jan-17**	**Feb-17**	**Mar-17**	**Jan-17**	**Feb-17**	**Mar-17**	**Jan-17**	**Feb-17**	**Mar-17**
Calcium , Total as Ca	M	mg/l	-	**101**	**105**	**128**	**79.2**	**107**	**114**	**100**	**106**	**114**	**102**	**98.1**	**113**
Magnesium, Total as Mg	B	mg/l	-												
Potassium , Total as K	M	mg/l	-	**1.05**	**1.16**	**1.13**	**4.01**	**1.37**	**2.48**	**1.17**	**1.41**	**1.17**	**1.2**	**1.26**	**1.19**
Sodium , Total as Na	M	mg/l	-	**7.63**	**8.1**	**8.66**	**9.15**	**8.93**	**9.19**	**8.11**	**9.32**	**8.88**	**8.65**	**8.22**	**8.77**
Alkalinity as CaCO3	M	mg/l	-	**248**	**274**	**305**	**212**	**268**	**291**	**241**	**274**	**290**	**252**	**266**	**289**
Sulphate as SO4	M	mg/l	-	**16.6**	**17.5**	**18.8**	**13.5**	**18.1**	**61.2**	**18.2**	**17**	**20.6**	**17.9**	**17.1**	**18.5**
Chloride as Cl	M	mg/l	-	**16.9**	**18.5**	**14.1**	**22.4**	**19.6**	**13.7**	**16.7**	**19.4**	**14.2**	**16.7**	**19.3**	**13.9**
Nitrate as NO3*	M	mg/l	-	**13.8**	**14.1**	**12.1**	**7.3**	**12.3**	**10.6**	**11.4**	**11.8**	**10.5**	**11.2**	**12**	**10.6**
Ammoniacal Nitrogen as N[#]	M	mg/l	-	<0.06	<0.06	<0.06	**0.08**	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Nitrite as NO2*	B	mg/l	-												
Phosphates , Total as PO4*	B	mg/l	-												
Boron, Total as B	B	mg/l	-												
Fluoride as F	B	mg/l	-												
Iron , Total as Fe	M	mg/l	-	<0.23	<0.23	**1.22**	**1.1**	<0.23	**1.14**	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23
Manganese , Total as Mn	M	mg/l	-	<0.007	**0.01**	**0.2**	**0.172**	**0.013**	**0.016**	<0.007	**0.02**	**0.019**	<0.007	**0.012**	**0.018**
Arsenic, Total as As	M	µg/l	25	<1	<1	**1.2**	**2.5**	<1	<1	<1	<1	<1	<1	<1	<1
Barium, Total as Ba	B	µg/l	-												
Beryllium, Total as Be	B	µg/l	-												
Cadmium , Total as Cd	B	µg/l	0.2												
Chromium , Total as Cr	B	µg/l	5												
Copper, Total as Cu	B	µg/l	5												
Lead , Total as Pb	B	µg/l	7.2												
Nickel , Total as Ni	B	µg/l	20												
Selenium, Total as Se	B	µg/l	-												
Vanadium , Total as V	B	µg/l	-												
Zinc, Total as Zn	B	µg/l	50												
Cyanide, Total	M	µg/l	-	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9

Table A.4 - Inorganic Compounds in Surface Water

Analyte	Freq	Units	Fresh Water EQS (AA)	SW05			Site Discharge			SW11			SW13		
Sampling Date				**Jan-17**	**Feb-17**	**Mar-17**	**Jan-17**	**Feb-17**	**Mar-17**	**Jan-17**	**Feb-17**	**Mar-17**	**Jan-17**	**Feb-17**	**Mar-17**
Calcium , Total as Ca	M	mg/l	-	**98.4**	**108**	**111**	**41.3**	**27.1**	**26.7**	**69.7**	**115**	**128**	**160**	**148**	**134**
Magnesium, Total as Mg	B	mg/l	-												
Potassium , Total as K	M	mg/l	-	**1.16**	**1.36**	**1.2**	**1.78**	**1.63**	**1.37**	**2.33**	**3.76**	**3.29**	**3.55**	**3.4**	**2.86**
Sodium , Total as Na	M	mg/l	-	**8.23**	**10.6**	**8.71**	**1.2**	**2.54**	**1.97**	**27**	**53**	**50.3**	**38.3**	**55**	**78.4**
Alkalinity as CaCO3	M	mg/l	-	**273**	**268**	**285**	**109**	**67.9**	**60.8**	**202**	**295**	**303**	**424**	**349**	**310**
Sulphate as SO4	M	mg/l	-	**19**	**17**	**40.7**	<4.4	**6.9**	**5.1**	**10.7**	**28.8**	**28.2**	**22.8**	**56.5**	**41.4**
Chloride as Cl	M	mg/l	-	**17**	**22.1**	**14.2**	**12.8**	**4.9**	<3.7	**50**	**99.7**	**88.7**	**66.9**	**113**	**132**
Nitrate as NO3*	M	mg/l	-	**11.3**	**11.8**	**10.9**	<3.1	<3.1	<3.1	<3.1	**6.5**	**5.3**	<3.1	<3.1	<3.1
Ammoniacal Nitrogen as N[#]	M	mg/l	-	<0.06	<0.06	<0.06	**0.1**	<0.06	**0.07**	<0.06	<0.06	<0.06	**3.16**	**1.58**	**0.79**
Nitrite as NO2*	B	mg/l	-												
Phosphates , Total as PO4*	B	mg/l	-												
Boron, Total as B	B	mg/l	-												
Fluoride as F	B	mg/l	-												
Iron , Total as Fe	M	mg/l	-	<0.23	<0.23	<0.23	**4.53**	**0.78**	**0.64**	**0.73**	<0.23	<0.23	**2.42**	**2.58**	**1.13**
Manganese , Total as Mn	M	mg/l	-	<0.007	**0.018**	**0.018**	**0.609**	**0.088**	**0.159**	**0.147**	**0.064**	**0.072**	**1.55**	**0.547**	**0.288**
Arsenic, Total as As	M	µg/l	25	<1	<1	<1	**6**	**2**	**2**	**1.4**	<1	**1.1**	**7.2**	**5**	**3.3**
Barium, Total as Ba	B	µg/l	-												
Beryllium, Total as Be	B	µg/l	-												
Cadmium , Total as Cd	B	µg/l	0.2												
Chromium , Total as Cr	B	µg/l	5												
Copper, Total as Cu	B	µg/l	5												
Lead , Total as Pb	B	µg/l	7.2												
Nickel , Total as Ni	B	µg/l	20												
Selenium, Total as Se	B	µg/l	-												
Vanadium , Total as V	B	µg/l	-												
Zinc, Total as Zn	B	µg/l	50												
Cyanide, Total	M	µg/l	-	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9

Table A.5: TOC, COD and BOD in Groundwater and Surface Water

Table A.5 - TOC & COD in Groundwater & Surface Water

Analyte	Units	IGV	GTV	EWM03		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	14.8	10.6	20.9
COD (Total)	mg/l	-	-	74	113	124
BODS + ATU	mg/l			2	4	7

Analyte	Units	IGV	GTV	EMW05		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	2.8	2.1	1.2
COD (Total)	mg/l	-	-	42	30	35
BODS + ATU	mg/l			<1	2	5

Analyte	Units	IGV	GTV	EMW06		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	<0.7	1.4	<0.7
COD (Total)	mg/l	-	-	20	29	42
BODS + ATU	mg/l			<1	<1	1

Analyte	Units	IGV	GTV	EMW08		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	1.2	1.8	1.8
COD (Total)	mg/l	-	-	37	13	19
BODS + ATU	mg/l			1	<1	<1

Analyte	Units	IGV	GTV	EMW11		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	8.8	9	7.1
COD (Total)	mg/l	-	-	38	52	44
BODS + ATU	mg/l			<1	<1	<1

Analyte	Units	IGV	GTV	EMW12D		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	2.5	2.4	1.8
COD (Total)	mg/l	-	-	<11	<11	12
BODS + ATU	mg/l			<1	<1	<1

Analyte	Units	IGV	GTV	EMW13		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	47.5	92.6	71
COD (Total)	mg/l	-	-	360	371	458
BODS + ATU	mg/l			4	8	6

Analyte	Units	IGV	GTV	EMW15		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	6.6	7.1	5.9
COD (Total)	mg/l	-	-	37	33	40
BODS + ATU	mg/l			<1	2	<1

Table A.5 - TOC & COD in Groundwater & Surface Water

Analyte	Units	IGV	GTV	EMW16		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	19.9	16.2	20.7
COD (Total)	mg/l	-	-	87	110	95
BODS + ATU				<1	1	2

Analyte	Units	IGV	GTV	EMW19		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	2.8	2.8	3
COD (Total)	mg/l	-	-	16	13	21
BODS + ATU	mg/l			1	2	<1

Analyte	Units	IGV	GTV	EMW20		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	1.6	1.1	3.7
COD (Total)	mg/l	-	-	15	12	24
BODS + ATU	mg/l			<1	<1	<1

Analyte	Units	IGV	GTV	EMW28		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	6.5	6.1	6
COD (Total)	mg/l	-	-	121	184	179
BODS + ATU	mg/l			2	1	3

Analyte	Units	IGV	GTV	EMW29		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	2.7	3.1	2.3
COD (Total)	mg/l	-	-	15	16	12
BODS + ATU	mg/l			<1	1	2

Analyte	Units	IGV	GTV	BH26		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	80.5	104	101
COD (Total)	mg/l	-	-	447	487	505
BODS + ATU	mg/l			3	8	11

Analyte	Units	IGV	GTV	BH42		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	7.6	8.6	12
COD (Total)	mg/l	-	-	42	104	94
BODS + ATU	mg/l			<1	4	1

Analyte	Units	IGV	GTV	RM01		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		1.3	1.4
COD (Total)	mg/l	-	-		<11	16
BODS + ATU	mg/l				<1	<1

Table A.5 - TOC & COD in Groundwater & Surface Water

Analyte	Units	IGV	GTV	RM02		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		0.9	1.1
COD (Total)	mg/l	-	-		<11	15
BODS + ATU	mg/l				<1	1

Analyte	Units	IGV	GTV	RM03		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		4.6	4.8
COD (Total)	mg/l	-	-		40	31
BODS + ATU	mg/l				<1	5

Analyte	Units	IGV	GTV	RM04		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		1.9	1.7
COD (Total)	mg/l	-	-		86	62
BODS + ATU	mg/l				1	3

Analyte	Units	IGV	GTV	RM05		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		1.8	1.2
COD (Total)	mg/l	-	-		<11	<11
BODS + ATU	mg/l				4	<1

Analyte	Units	IGV	GTV	RM06		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		1.1	0.9
COD (Total)	mg/l	-	-		15	17
BODS + ATU	mg/l				<1	6

Analyte	Units	IGV	GTV	BB01		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		2.5	2.2
COD (Total)	mg/l	-	-		47	21
BODS + ATU	mg/l				2	6

Analyte	Units	IGV	GTV	RCBB01		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		3.5	3
COD (Total)	mg/l	-	-		52	32
BODS + ATU	mg/l				2	4

Table A.5 - TOC & COD in Groundwater & Surface Water

Analyte	Units	IGV	GTV	BB02		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		1	<0.7
COD (Total)	mg/l	-	-		21	47
BODS + ATU	mg/l				1	2

Analyte	Units	IGV	GTV	BB03		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		2.5	<0.7
COD (Total)	mg/l	-	-		144	440
BODS + ATU	mg/l				<1	3

Analyte	Units	IGV	GTV	BB04		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		1.9	1.3
COD (Total)	mg/l	-	-		32	<11
BODS + ATU	mg/l				1	3

Analyte	Units	IGV	GTV	DB02		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-			2
COD (Total)	mg/l	-	-			362
BODS + ATU	mg/l					15

Analyte	Units	IGV	GTV	DB03		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		2.6	2.4
COD (Total)	mg/l	-	-		196	380
BODS + ATU	mg/l				<1	2

Analyte	Units	IGV	GTV	DB04		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-			1.7
COD (Total)	mg/l	-	-			6000
BODS + ATU	mg/l					14

Analyte	Units	IGV	GTV	DB05		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		1.2	0.9
COD (Total)	mg/l	-	-		56	26
BODS + ATU	mg/l				<1	4

Analyte	Units	IGV	GTV	DB06		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		2.1	1.4
COD (Total)	mg/l	-	-		<11	19
BODS + ATU	mg/l				5	4

Table A.5 - TOC & COD in Groundwater & Surface Water

Analyte	Units	IGV	GTV	DB08		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		0.8	1.3
COD (Total)	mg/l	-	-		<11	39
BODS + ATU	mg/l				<1	3

Analyte	Units	IGV	GTV	DB10		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		0.8	90.2
COD (Total)	mg/l	-	-		227	304
BODS + ATU	mg/l				2	1

Analyte	Units	IGV	GTV	BH68		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		2.4	2.1
COD (Total)	mg/l	-	-		44	32
BODS + ATU	mg/l				2	<1

Analyte	Units	IGV	GTV	BH69(50)		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		28.5	
COD (Total)	mg/l	-	-		316	
BODS + ATU	mg/l				17	

Analyte	Units	IGV	GTV	BH70		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		6	5.9
COD (Total)	mg/l	-	-		23	24
BODS + ATU	mg/l				4	<1

Analyte	Units	IGV	GTV	BH71		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		15.3	12.7
COD (Total)	mg/l	-	-		59	44
BODS + ATU	mg/l				4	<1

Analyte	Units	IGV	GTV	BH72		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		1.1	<0.7
COD (Total)	mg/l	-	-		196	174
BODS + ATU	mg/l				3	<1

Analyte	Units	IGV	GTV	BH77		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		4.7	4.1
COD (Total)	mg/l	-	-		248	43
BODS + ATU	mg/l				9	<1

Table A.5 - TOC & COD in Groundwater & Surface Water

Analyte	Units	IGV	GTV	BH78		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-		4.1	4.3
COD (Total)	mg/l	-	-		87	161
BODS + ATU	mg/l				4	<1

Analyte	Units	IGV	GTV	SW01		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	1	1.2	1.8
COD (Total)	mg/l	-	-	<11	<11	31
BODS + ATU	mg/l			<1	<1	<1

Analyte	Units	IGV	GTV	SW02		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	6.8	1	2
COD (Total)	mg/l	-	-	45	<11	<11
BODS + ATU	mg/l			<1	<1	<1

Analyte	Units	IGV	GTV	SW03		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	1	1.2	1.9
COD (Total)	mg/l	-	-	<11	<11	<11
BODS + ATU	mg/l			<1	<1	<1

Analyte	Units	IGV	GTV	SW03A		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	0.8	1.1	1.9
COD (Total)	mg/l	-	-	<11	<11	<11
BODS + ATU	mg/l			<1	<1	<1

Analyte	Units	IGV	GTV	SW05		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	0.9	1	1.9
COD (Total)	mg/l	-	-	13	<11	<11
BODS + ATU	mg/l			<1	<1	<1

Table A.5 - TOC & COD in Groundwater & Surface Water

Analyte	Units	IGV	GTV	Site Discharge		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	2.1	1.5	1.9
COD (Total)	mg/l	-	-	88	<11	13
BODS + ATU	mg/l			<1	<1	<1

Analyte	Units	IGV	GTV	SW11		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	3.3	2.6	4
COD (Total)	mg/l	-	-	19	<11	24
BODS + ATU	mg/l			<1	<1	<1

Analyte	Units	IGV	GTV	SW13		
				Jan-17	Feb-17	Mar-17
TOC (Filtered)	mg/l	-	-	8.1	6.3	5.9
COD (Total)	mg/l	-	-	25	<11	20
BODS + ATU	mg/l			3	3	<1

Table A.6: Organic Compounds in Groundwater at New Wells

Table A.6 - Organic Compounds in Groundwater & Surface Water

Analyte	Units	IGV	GTV	RM01	RM03	RM04	RM05	RM06	BB01	RCBB01	BB03	DB03	DB05	DB06	DB08	DB10	BH68	BH69(50)	BH70	BH71	BH72	BH77	BH78
Sampling Date				**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**	**Feb-17**
Benzene	ug/l	1.0	0.75	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
Chlorobenzene*	ug/l	1.0	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
Chloroform	ug/l	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
Chloromethane*	ug/l	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
Bromoform*	ug/l	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
1,1-Dichloroethane	ug/l	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
1,2,4-Trimethylbenzene	ug/l	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
1,3,5-Trimethylbenzene*	ug/l	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
Bromodichloromethane*	ug/l	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
Dibromochloromethane*	ug/l	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
Dichloromethane*	ug/l	10	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
cis-1,2-Dichloroethene*	ug/l	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
Hexachlorobutadiene	ng/l	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
1,4-Dichlorobenzene	ug/l	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
Bis (2-chloroisopropyl) ether	ug/l	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<1.0	<1.0	<1.0	<1.0
1,2,4-Trichlorobenzene	ng/l	0.4	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<1.0	<1.0	<1.0	<1.0
Toluene	ug/l	10	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
Ethyl Benzene	ug/l	10	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
m&p-Xylene	ug/l	10	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
Isopropylbenzene*	ug/l	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
Naphthalene*	ug/l	1		<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	N/S	<2.0	<2.0	<2.0	<2.0	<2.0
n-Propylbenzene*	ug/l	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
o-Xylene*	ug/l	10	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	N/S	<1.0	<4.0	<1.0	<1.0	<1.0
Vinyl Chloride*	ug/l	-	0.375	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	N/S	<0.5	<2.0	<0.5	<0.5	<0.5
Dieldrin	ug/l	-	-	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<5	<4	**7**	<4	<4	**11**
Azinphos-methyl*	ug/l	-	-	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.004	<0.002	<0.002	<0.002	<0.002	<0.002
Diazinon*	ug/l	-	-	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	**-**	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.005	<0.003	<0.003	<0.003	<0.003	<0.003
2,3,6 - TBA	ug/l	-	-	<0.05	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	**0.14**	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	N/S	<0.05	<0.05	<0.05	<0.05	<0.05
Benazolin	ug/l	-	-	<0.05	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	**0.09**	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	N/S	<0.05	<0.05	<0.05	<0.05	<0.05
Bentazone	ug/l	-	-	<0.05	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	**0.08**	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	N/S	<0.05	<0.05	<0.05	<0.05	<0.05
Dicamba	ug/l	-	-	<0.05	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	**0.08**	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	N/S	<0.05	<0.05	<0.05	<0.05	<0.05
Formaldehyde	mg/l	-	-	**0.038**	<0.029	**0.11**	<0.029	**0.045**	**0.067**	**0.129**	<0.029	<0.029	<0.029	**0.088**	<0.029	<0.029	<0.029	**0.079**	<0.029	<0.029	<0.029	<0.029	<0.029
Chlopyralid	ug/l	0.1	0.1	<0.05	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	**0.09**	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	N/S	<0.05	**0.36**	<0.05	<0.05	<0.05
Dichlobenil	ng/l	100	100	<2	<2	<2	<2	<2	<2	<2	**-**	<2	<2	<2	<2	<2	<2	**37**	**30**	**11**	<2	**2**	**5**
Dichlorprop	ug/l	0.1	0.1	<0.05	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	**0.07**	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	N/S	**0.06**	<0.15	<0.05	<0.05	<0.05
Triclopyr	ug/l	-	-	<0.05	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	**0.06**	<0.05	<0.05	<0.10	<0.05	<0.05	<0.05	N/S	<0.05	<0.05	<0.05	<0.05	<0.05
Mecoprop	ug/l	10	0.075	<0.04	**0.16**	**0.08**	<0.08	**0.08**	**0.1**	**0.12**	**0.05**	**0.73**	<0.04	<0.08	<0.04	<0.04	<0.04	N/S	**0.7**	**0.69**	<0.04	**0.12**	<0.04
Phenol	ug/l	-	-	<0.10	**8.6**	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	**0.67**	<0.10	**4.6**	**0.7**	<0.10	**4**	**2.1**	<0.10	<0.10	<0.10	<0.10
Total Cresols	ug/l	-	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Phenols	ug/l	0.5	-	<0.50	**8.6**	<0.50	**2.7**	<0.50	<0.50	<0.50	<0.50	<0.50	**0.67**	<0.50	**6.4**	**0.7**	**13**	**26**	**5**	**5.1**	**0.67**	**7**	<0.50
Xylenol, Total	ug/l	-	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	**5.3**	<0.10	<0.10	<0.10	<0.10	<0.10
Total Trimethylphenol	ug/l	-	-	<0.10	<0.10	<0.10	**1.4**	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	**13**	**11**	**2.9**	**5.1**	<0.10	**7**	<0.10
Naphthol	ug/l	-	-	<0.10	<0.10	<0.10	**0.45**	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	**0.57**	<0.10	<0.10	<0.10	<0.10	<0.10

*	Newly detected in December 2016
13.6	Concentration exceeds IG
0.31	Concentration exceeds GTV

Note: Only samples where there was at least one positive detection of the compounds listed are included in this table, and only compounds detected in at least one sample are listed. Refer to the laboratory reports for the full set of results.

Table A.6a: PAHs in Groundwater at New Wells

Table A.6a - PAHs in Groundwater & Surface Water

Analyte	Units	RCBB01	BB04	DB05	DB08	DB10	BH69(50)	BH70	BH71	BH77	BH78
		Feb-16	Feb-16	Feb-16	Feb-16	Feb-16	Feb-16	Feb-16	Feb-16	Feb-16	Feb-16
Acenaphthene	ug/l	<0.04	<0.02	<0.01	<0.01	<0.01	0.09	0.02	0.12	0.182	0.026
Acenaphthylene	ug/l	<0.04	<0.02	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.02
Anthracene	ug/l	<0.04	<0.02	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02	0.049	<0.02
Benzo (a) anthracene	ug/l	<0.04	<0.02	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo (g,h,i) perylene	ug/l	<0.04	<0.02	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo (a) pyrene	ug/l	<0.04	<0.02	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo (b) fluoranthene	ug/l	<0.04	<0.02	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo (k) fluoranthene	ug/l	<0.04	<0.02	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.02
Chrysene	ug/l	<0.04	<0.02	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.02
Dibenz (a,h) anthracene	ug/l	<0.04	<0.02	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.02
Fluoranthene	ug/l	0.359	0.03	0.022	0.014	0.017	0.086	<0.02	0.025	0.099	0.041
Fluorene	ug/l	<0.04	<0.02	<0.01	<0.01	<0.01	0.066	<0.02	0.071	0.187	0.02
Indeno (1,2,3) cd pyrene	ug/l	<0.04	<0.02	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	<0.02
Naphthalene	ug/l	<0.04	<0.02	<0.01	0.017	<0.01	0.44	<0.02	0.283	0.248	<0.02
Phenanthrene	ug/l	0.195	0.024	<0.01	0.01	<0.01	0.148	<0.02	0.067	0.416	<0.02
Pyrene	ug/l	0.111	<0.02	<0.01	<0.01	0.011	0.04	<0.02	<0.02	0.066	0.055
Total PAHs	ug/l	0.665	0.054	0.022	0.04	0.028	0.87	0.02	0.567	1.25	0.142

Appendix B. Figures

Figure 1: Site Location

Drawing number / Rev
32EW5602-009_1/0

KEY:

Former W0047-02 Waste Licence Boundary

Rev	Rev. Date	Purpose of revision	Drawn	Checkd	Rev'd	Apprv'd
0	11/03/2016	FIRST ISSUE	AR	UD	DM	SJM

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Comhairle Contae Chill Dara

Project

KERDIFFSTOWN LANDFILL
SITE REMEDIATION PROJECT

Drawing title

FIGURE 1
SITE LOCATION

Drawing status

FIRST ISSUE

Scale	1:20,000 @ A3	DO NOT SCALE
Jacobs No.	32EW5602	
Client no.		

Drawing number

32EW5602-008_9

Rev

0

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I:\Enviros\Design\PROJECTS\KU\32EW5602\Figures\Task 8\March 2016\32EW5602-008_9.dwg - 11/03/2016 10:07:34 - Figure 1 - alroberts

Figure 2: Site Layout

Drawing number / Rev
32EW5602-008_10/0

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KEY:

- Former W0047-02 Waste Licence Boundary
- Site Buildings
- Site Structures
- Dwellings

0 50 100 150
METRES

Rev	Rev. Date	Purpose of revision	Drawn	Checkd	Rev'd	Apprv'd
0	11/03/2016	FIRST ISSUE	AR	RK	DM	SJM

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FIGURE 2
SITE LAYOUT

Drawing status
FIRST ISSUE

Scale	AS SHOWN
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Drawing number
32EW5602-008_10

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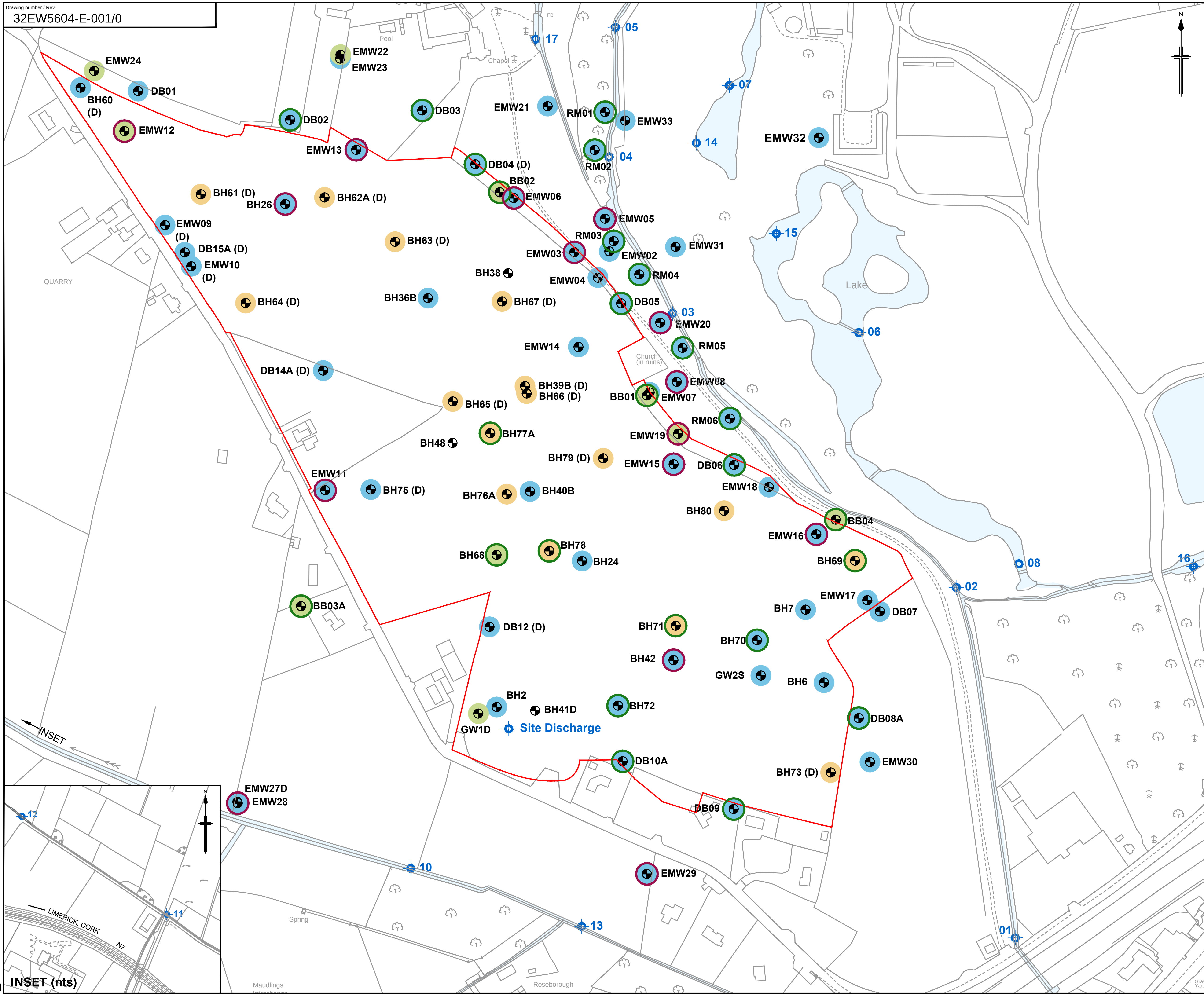
\\Enviros\Design\PROJECTS\KU32EW5602\Figures\Task 8\March 2016\32EW5602-008_10.dwg - 11/03/2016 10:30:56 - Figure 2 - alroberts

Figure 3: Groundwater and Surface Water Monitoring Locations

Drawing number / Rev
32EW5604-E-001/0



KEY:

- Licence Boundary
- Groundwater Monitoring Point
- Surface Water Monitoring Point
- Monthly Wells
- New Wells
- (D) Borehole Dry, January 2017
- Overburden GW
- Bedrock
- In-Waste Boreholes

0 50 100 150
METRES

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FIGURE 3
GROUNDWATER AND SURFACE WATER MONITORING LOCATIONS, QUARTER 1 2017

Drawing status
EIS SUBMISSION

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Jacobs No.	32EW5604	
Client no.	6286	

Drawing number: 32EW5604-E-001
Rev: 0

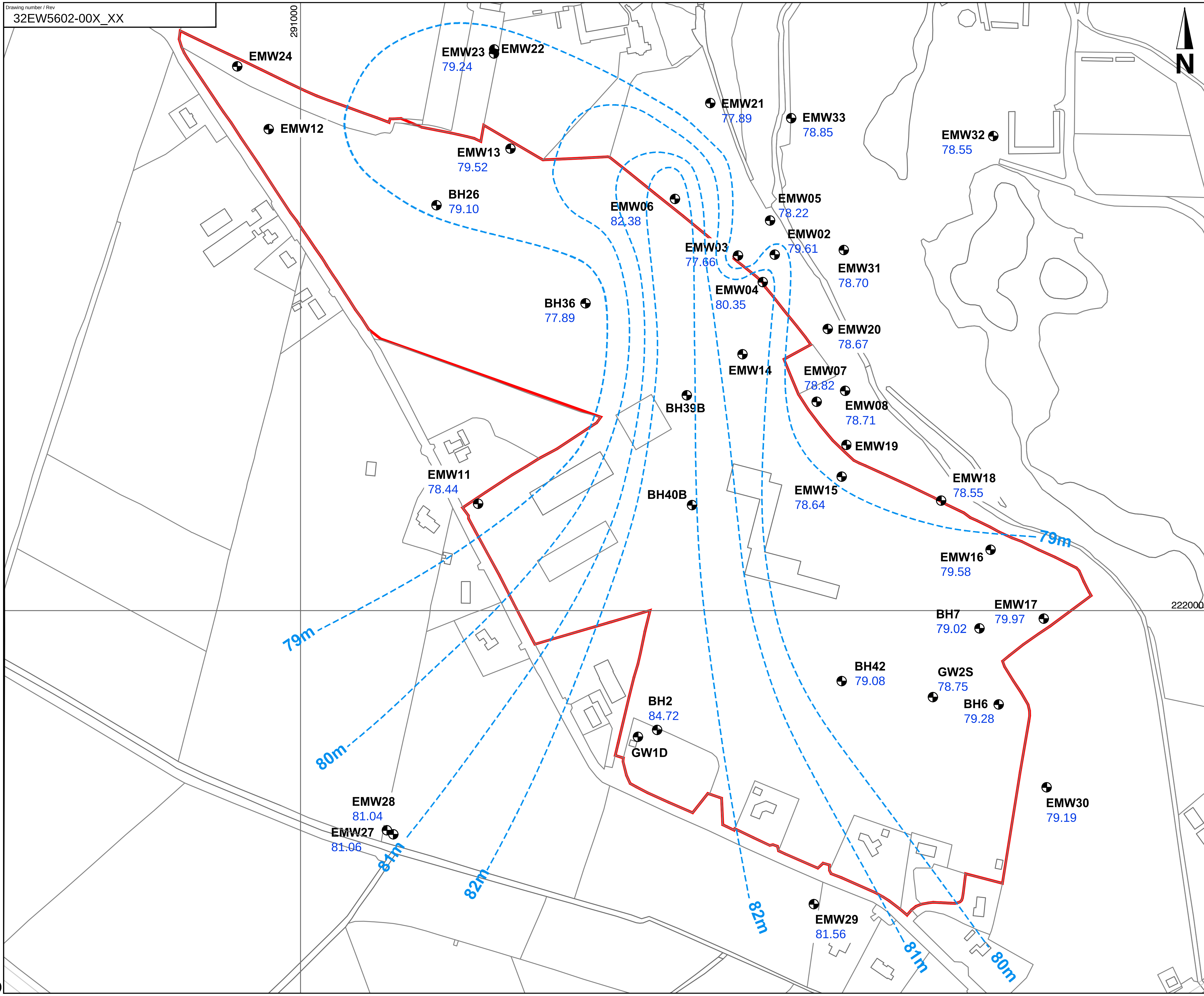
Figure 4: Inferred Shallow Groundwater Flow Regime (Quarter 1 2017)

4a: January 2017

4b: February 2017

4c: March 2017

Drawing number / Rev
32EW5602-00X_XX



KEY:

- Former WA0047-02 Waste Licence Boundary
- Groundwater Monitoring Point
- Inferred Groundwater Contour (mOD)

0 50 100 150
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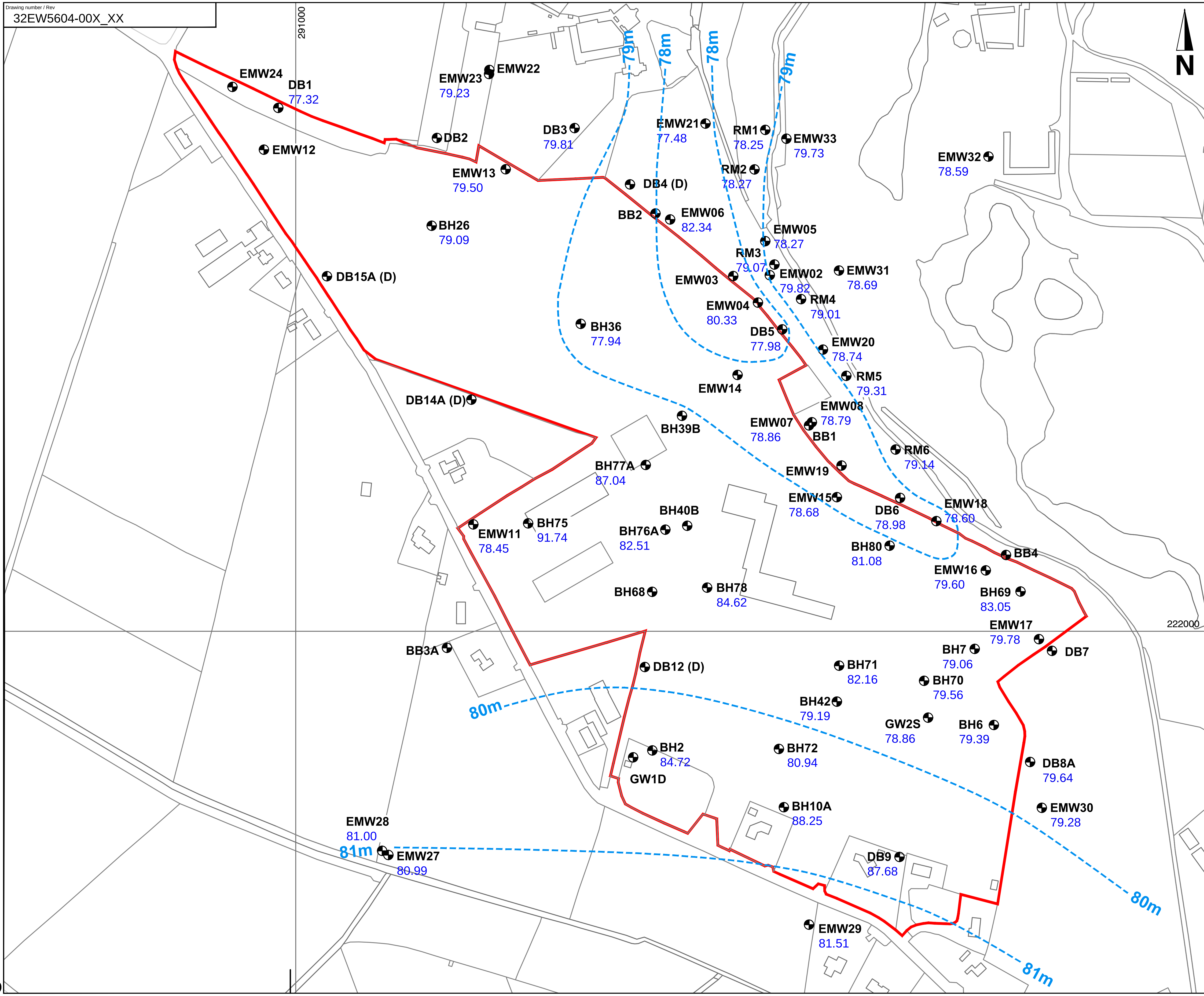
Drawing title
FIGURE 4a
INFERRED SHALLOW GROUNDWATER FLOW REGIME. JANUARY 2017

Drawing status

Scale	AS SHOWN		DO NOT SCALE
Jacobs No.	32EW5602		
Client no.			

Drawing number: 32EW5602-00X_XX
Rev: 0

Drawing number / Rev
32EW5604-00X_XX



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KEY:

- Former WA0047-02 Waste Licence Boundary
- Groundwater Monitoring Point
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Drawing title
FIGURE 4b
INFERRED SHALLOW GROUNDWATER FLOW REGIME. FEBRUARY 2017

Drawing status

Scale	AS SHOWN	DO NOT SCALE
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Client no.		

Drawing number
32EW5604-00X_XX

Rev
0

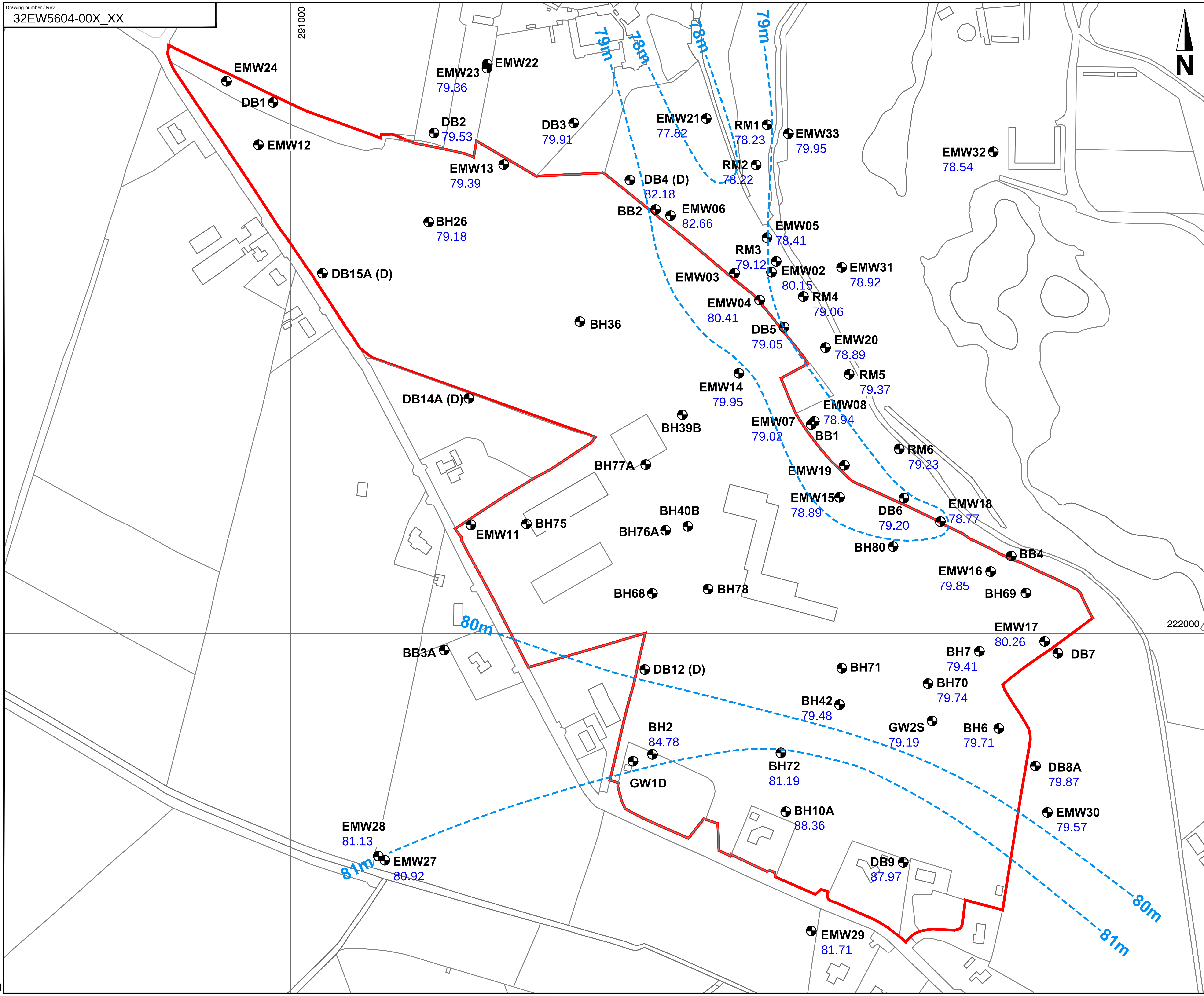

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FIGURE 4c
INFERRED SHALLOW GROUNDWATER FLOW REGIME. MARCH 2017

Drawing status

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Figure 5: Inferred Groundwater Flow Regime in Bedrock (Quarter 1 2017)

5a: January 2017

5b: February 2017

5c: March 2017

Drawing number / Rev
32EW5602-00X_XX

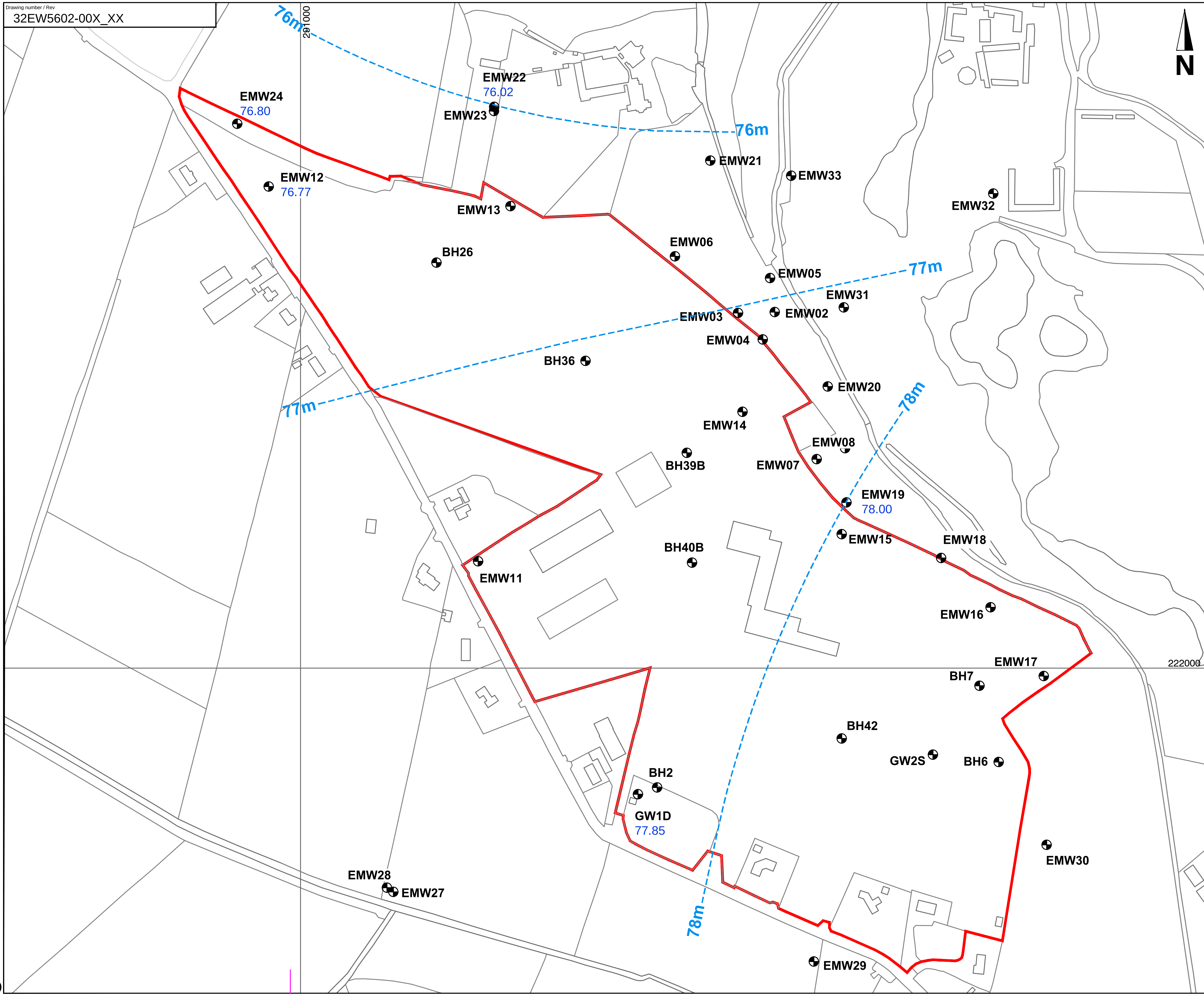

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FIGURE 5a
INFERRED BEDROCK GROUNDWATER FLOW REGIME. JANUARY 2017

Drawing status

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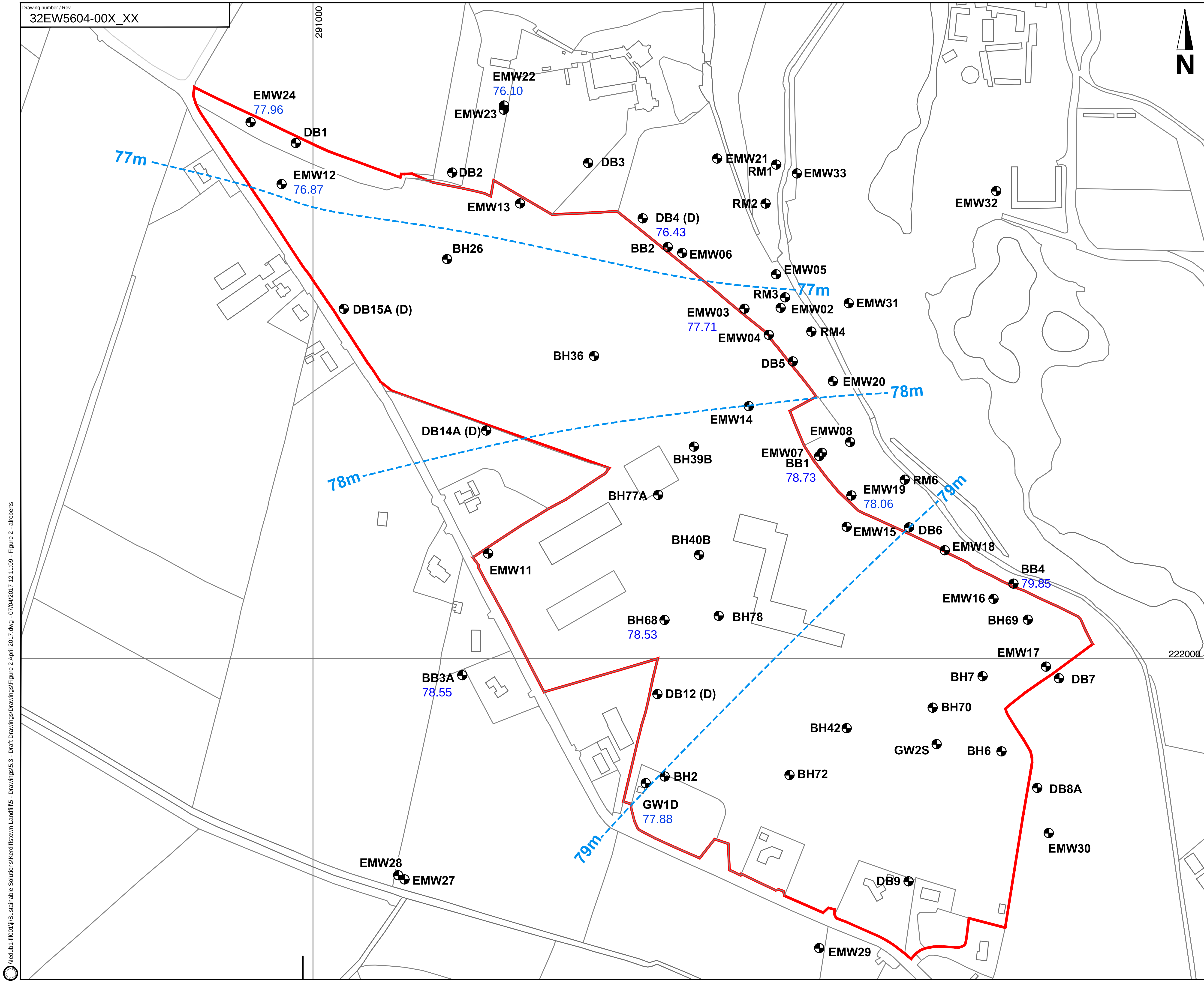

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- Groundwater Monitoring Point
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0 50 100 150
METRES

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Drawing title
FIGURE 5b
INFERRED BEDROCK GROUNDWATER FLOW REGIME. FEBRUARY 2017

Drawing status

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Client no.:
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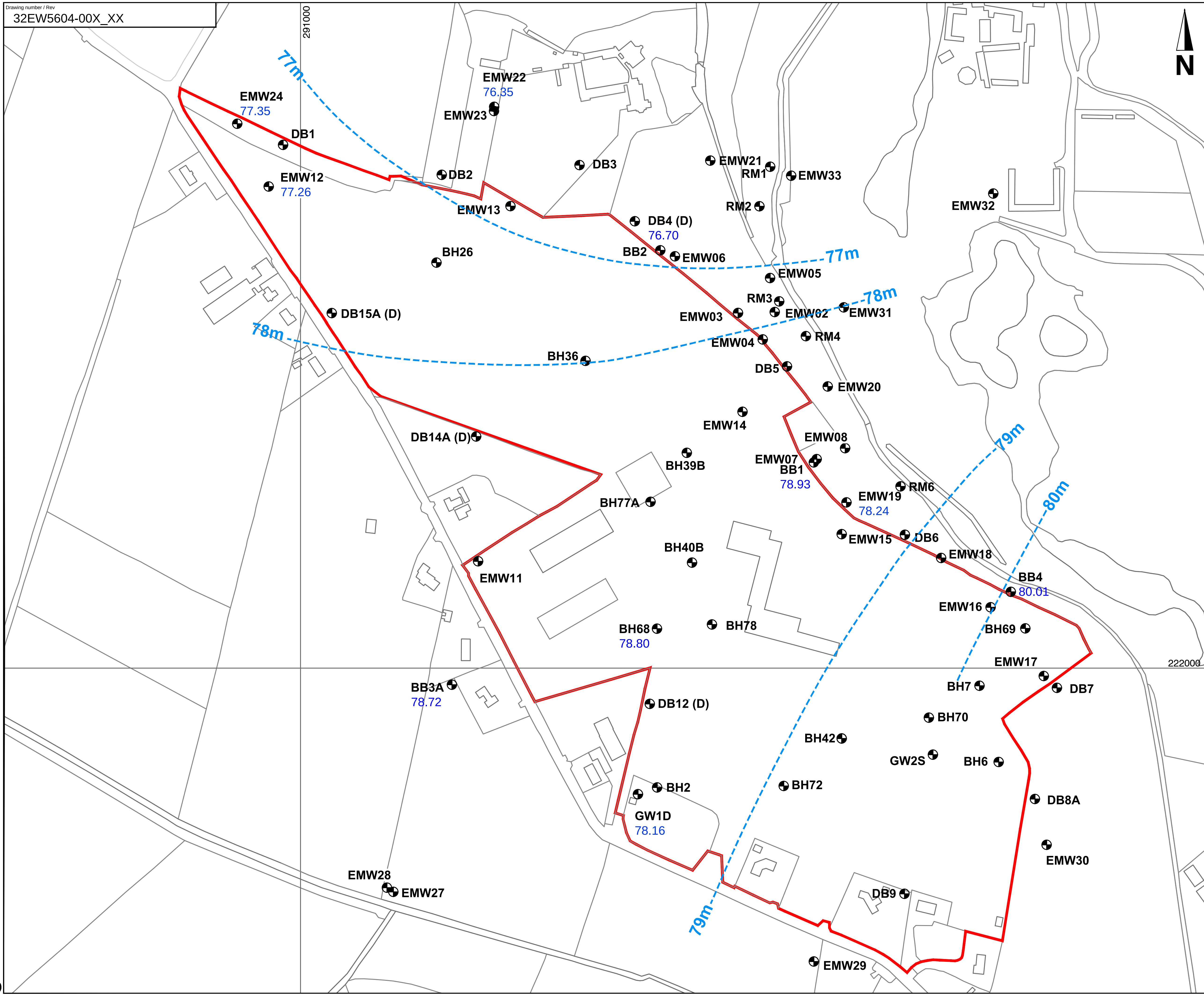

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Drawing title
FIGURE 5c
INFERRED BEDROCK GROUNDWATER FLOW REGIME. MARCH 2017

Drawing status

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